Department of Environment
and Resource Management

Establishing Environmental Values, Water Quality Guidelines and Water Quality Objectives for Fitzroy Basin Waters

Draft for Consultation

December 2010

Tomorrow's Queensland: strong, green, smart, healthy and fair

Toward Q2
Tomorrow's Queensland

Queensland
Government

Prepared by:

Water and Ecosystem Outcomes and Natural Resources and Environment

Department of Environment and Resource Management

In partnership with:

Fitzroy Basin Association Inc.

December 2010

#29314

How to make a submission

The draft reports to develop environmental values and local water quality guidelines are now available for stakeholder and public consultation until 28 February 2011. The draft reports are:

- *Establishing Environmental Values, Water Quality Guidelines and Water Quality Objectives for Fitzroy Basin Waters* (Draft), Department of Environment and Resource Management, October 2010;

- *Environmental Values for the Fitzroy, Community Consultation* (Draft), Fitzroy Basin Association, September 2010; and

- *The economic and social impacts of protecting the environmental values of the Fitzroy Basin waters* (Draft), Marsden Jacob Associates, October 2010.

Submissions must be made, using the submission form, by 28 February 2011.

You can make a submission by:

- email: evinfo@derm.qld.gov.au
- post: General Manager Water Quality and Accounting, Department of Environment and Resource Management, GPO Box 2454, Brisbane 4001.
- fax: 07 3406 2190.

You can download a submission form from the Department of Environment and Resource Management's website at: <www.derm.qld.gov.au>, the Fitzroy River website at <www.fitzroyriver.qld.gov.au>, and the Fitzroy Basin Association's (FBA's) website at <www.fba.org.au> or you can request a copy from the EVs Project Manager at the contact number below.

For further information, please contact the EVs Project Manager on 13 74 68 (13 QGOV)

Acknowledgements

There has been a long-standing commitment to protecting and improving the natural resources of the Fitzroy Basin by a wide range of stakeholders and community in the basin.

The Department of Environment and Resource Management (the department) recognises the Fitzroy Basin Association's (FBA) history and role in working with community members to protect and improve water quality. For this reason, the department has worked collaboratively with the FBA to provide community input to this project to establish environmental values (EVs), water quality guidelines and water quality objectives for Fitzroy Basin waters. FBA's support in arranging all the necessary workshops and meetings is appreciated not only by the department but also the stakeholder and community members who participated in the project.

The project relied on stakeholder and community input to establish waterway uses and values (i.e. EVs). This is a key step in water quality management and will underpin future water quality management activities in the basin. It is also important because some of these stakeholders/landholders will be implementing management actions to help protect and improve water quality. Therefore the role of the 'champions' in attending the round 1 workshop to shape the process for the round 2 workshops, as well as being the lead supporters for FBA in arranging the round 2 workshops, is gratefully acknowledged. Attendees at round 2 workshops gave their time and local knowledge to establish the draft EVs for their waterways. Their support in attending and checking the draft outputs from the workshops is appreciated and acknowledged.

The Fitzroy Basin Elders Committee assisted with organising the workshop with Traditional Owners of the basin. Their assistance and the support of the Traditional Owners who attended the workshop, and provided further inputs after the workshop, is acknowledged.

Finally, the project would not have been successful without the departmental team members who assisted in developing the project plan and implemented and coordinated all necessary tasks to get this to draft report stage. Thanks to all departmental team members.

Executive summary

The Department of Environment and Resource Management has responsibility for administering the *Environmental Protection (Water) Policy 2009,* which provides a framework for protecting Queensland's water environment consistent with ecologically sustainable development, by:

- identifying environmental values for Queensland waters
- deciding water quality guidelines and objectives to enhance and protect those environmental values
- making consistent and equitable decisions about Queensland waters under statutory and non-statutory frameworks that promote efficient use of resources and best practice environmental management
- involving the community through consultation and education and promoting community responsibility
- providing a basis for comparison of water quality monitoring results with the water quality objectives.

This report addresses the development of environmental values and water quality guidelines for the waters of the Fitzroy Basin in accordance with the provisions of the *Environmental Protection (Water) Policy 2009.*

Severe flooding from prolonged heavy rainfall across the Fitzroy Basin in early 2008 caused the overflow of Fairbairn Dam, inundation of the township of Emerald and flooding of coal mines.

The subsequent discharge of floodwater into the tributaries of the Fitzroy River system adversely affected downstream water quality, particularly elevated electrical conductivity (salinity measure), pH and suspended solids. The elevated salinity resulted primarily from releasing mine-affected floodwater to receiving waters.

In response, the Queensland Government commissioned reports to review water quality issues and the impacts of mining on water quality, and initiated projects to address recommendations in those reports that included:

- developing appropriate conditions in environmental authorities for mine water discharges. The subsequent implementation of the new, more stringent environmental authority conditions, agreed to by all coal mines in the Fitzroy Basin, contributed to an improved environmental outcome following heavy rain in February 2010, compared with 2008
- developing local water quality guidelines to protect the environmental values and inform the subsequent assessment and management of receiving (or ambient) water quality.

In developing local water quality guidelines, the *Environmental Protection (Water) Policy 2009* sets out the provisions to establish environmental values, water quality guidelines and water quality objectives for Queensland waters; including the requirements for consultation and the consideration of the economic and social impacts of protecting the environmental values for the waters.

The Department of Environment and Resource Management in collaboration with the Fitzroy Basin Association conducted stakeholder workshops across the Basin in February and March 2010 to establish draft environmental values for surface and ground waters, and levels of aquatic ecosystem protection. The draft environmental values are at Appendix 3.

Local water quality guidelines for the protection of aquatic ecosystems were developed from available reference site data (that is, sites in good condition) for most Fitzroy catchments. Where local data was not available, the Queensland and Australian water quality guidelines were adopted. The draft water quality guidelines for aquatic ecosystem protection are provided in section 5, and further details are provided in Appendix 5. The collection of additional local reference site data is underway to further refine the local water quality guidelines for aquatic ecosystems protection. Water quality guidelines to support 'human' uses and values (e.g. irrigation, recreation) are also outlined in section 5.

The report also assesses current water quality during base flow for key indicators at a number of sites across the basin. These indicators included electrical conductivity (a measure of salinity) for freshwaters and total nitrogen, total phosphorus, chlorophyll a, turbidity and dissolved oxygen for estuarine waters. In summary, the salinity (electrical conductivity) guideline is currently met at all the freshwater sites, while the estuarine sites are showing some impacts of point source nutrient discharges (for example, treated sewage effluent) near Rockhampton.

As the key water quality management issues in the Fitzroy Basin relate to high flow events (from rural/mining and urban sources), future monitoring projects will develop water quality guidelines for such high flow events. At a Basin-wide scale the dominant source of sediment and nutrient loads are from rural land use; with 50% of the erosion attributable to 17% of the catchment, and increasing ground cover having the greatest impact on reducing sediment and nutrient emissions. However a major source of water quality degradation risk, if not continued to be managed, stems from point source emissions from the mining and energy sectors.

The consultant report considering the social and economic impacts of protecting the environmental values for the Fitzroy Basin waters built on the previous March 2010 report, by the consultant, for the protection of the environmental values for the Great Barrier Reef-catchment waterways and the reef lagoon.

The key findings included that the management of pollution loads into waters provides a wide range of benefits both within those waters, but also in the marine environment adjacent to the catchments in the Fitzroy Basin (part of the Great Barrier Reef). The key socio-economic benefits of achieving the water quality objectives are derived from managing pollution loads and avoiding the costs to businesses and the community (including environmental costs) that would accrue from a further decline in water quality. The key socio-economic costs are the monetary costs of management actions to maintain or improve receiving water quality.

The consultant report underlined the importance of the ecologically sustainable management of the Fitzroy Basin and indicated economic benefits across a number of sectors. Social benefits included the maintenance of human health, the maintenance of social and economic well-being through the protection and expansion of employment opportunities and the maintenance of recreational amenity. Environmental benefits included the maintenance of biodiversity and the protection of aquatic ecosystems and the services they provide.

The consultant report indicated the economic impacts of protecting environmental values were mainly for the:

- reduction of diffuse rural sources of sediments (and associated nutrients). Through the Fitzroy Basin Association a series of agreed actions and investments are already underway to reduce sediment loads from agricultural activities by 750,000 tonnes per annum within 10 years, particularly actions to increase ground cover
- application of water sensitive urban design to address diffuse urban sediment and nutrient emissions from new urban land development and its construction, in accordance with the State Planning Policy for Healthy Waters
- provision of sewerage infrastructure services, upgrades or effluent re-use.

The new environmental authority conditions adopted by all coal mines have been included in the business-as-usual case.
The consultant report found that the available evidence suggests that the grazing industry is already investing up to 2% of their costs in natural resource management, plus any funds accessed via government NRM programs. This is similar to the cost impost on households (via costs of water sensitive urban design and upgrades to wastewater treatment plants) and lifecycle wastewater management costs for mining and gas developments.

The March 2010 consultant report found that the impacts of a ‘do nothing more’ scenario were likely to be further decline in water quality and risks to the Great Barrier Reef, negative impacts on sectors reliant on water quality, particularly domestic tourism, negative impacts on recreation, particularly fishing, and a general loss of ecosystem function.

Following the final consultation round from 6 December 2010 to 28 February 2011, and consideration of the submissions received, the Department of Environment and Resource Management will consider recommending that the environmental values and water quality objectives for the waters of the Fitzroy Basin be included in Schedule 1 of the *Environmental Protection (Water) Policy 2009.*

Contents

How to make a submission ... iii

Acknowledgements ... iv

Executive summary ... v

1 Background ... 1

1.1 Geographic scope for the project ... 2

1.2 Water Quality Management Framework ... 3

1.2.1 Policies ... 3

1.2.2 Process ... 3

1.2.3 National guidelines ... 4

1.2.4 State, regional and local water quality guidelines ... 4

1.3 Project plan ... 5

2 Current understanding ... 6

3 Consultation process ... 9

3.1 Round 1—catchment champions workshop ... 9

3.2 Round 2—catchment workshops and meetings ... 9

3.2.1 Fitzroy Water Quality Advisory Group ... 10

3.2.2 Traditional Owner workshop ... 11

3.2.3 Basin-wide information day ... 11

3.2.4 Improving workshop outputs (March–June 2010) ... 11

3.2.5 Round 3—public review of the draft reports (December 2010–February 2011) ... 11

3.3 Information to support workshop consultations on environmental values ... 12

3.3.1 Human uses and values ... 12

3.3.2 Ecological values ... 12

3.4 Workshop process ... 14

4 Commenting on environmental values ... 15

4.1 Draft environmental values ... 15

4.2 High value (High Ecological Value and Slightly Disturbed) waters ... 17

4.3 Specific waterway ecological characteristics ... 19

5 Water quality guidelines ... 21

5.1 Water quality guidelines for protection of aquatic ecosystems—context and summary table ... 23

5.2 Water quality guidelines for protection of aquatic ecosystems—additional tables ... 25

5.3 Water quality guidelines for human uses and values ... 29

5.3.1 Irrigation and farm use ... 29

5.3.2 Stock watering ... 29

5.3.3 Aquaculture ... 29

5.3.4 Human consumption of aquatic foods ... 29

5.3.5 Recreation and aesthetics ... 29

5.3.6 Drinking water ... 30

5.3.7 Industrial uses ... 30

5.3.8 Cultural and spiritual values ... 30

5.4 Water quality guidelines for human uses and values—summary tables 32
6 Developing water quality objectives from EVs and water quality guidelines 33
6.1 WQOs for high value (HEV and SD) waterways 34
7 Current water quality 35
8 Links to water planning and management 37
8.1 Point sources 39
8.2 Rural diffuse sources 39
8.3 Urban diffuse sources 39
9 Considering economic and social impacts of protecting environmental values 40
9.1 Overview of findings of Marsden Jacob Associates report—The economic and social impacts of protecting the environmental values of the Fitzroy Basin waters 40
9.1.1 Background and study purpose 40
9.1.2 Key findings 40
10 Considering environmental impacts of protecting environmental values 43
11 Monitoring, evaluation and reporting 44
12 Future directions 45
12.1 Scheduling EVs and WQOs 45
12.2 High value waterways 45
12.3 Fitzroy Healthy Waters Management Plan 45
12.4 Water quality guidelines 45
Appendix 1: Conceptual models 47
Appendix 2: Environmental values and sources of information used to assist identification of human uses/values for the Fitzroy Basin 50
Environmental values 50
Process and tools used to assist identification of human uses/values for Fitzroy Basin 52
Sources of information used to assist identification of human uses/values for Fitzroy Basin 56
Irrigation 56
Farm use 56
Stock watering 56
Aquaculture 56
Human consumption of fish/crustaceans 56
Primary recreation 56
Secondary recreation 56
Visual appreciation 56
Drinking water 57
Industrial use 57
Cultural and spiritual values 57
Appendix 3 Draft Environmental Values for the waters of the Fitzroy Basin 59
Appendix 4: High ecological value waters 75
Appendix 5: Developing WQ guidelines for the protection of aquatic ecosystems in the Fitzroy Basin: Phase 1 84
Background 84
Purpose of this report 85

  - Derivation of local/sub-regional water quality guidelines 85
  - The approach used to derive Fitzroy sub-regional guidelines 86
    - Base data 86
    - Defining sub-regions 86
    - Establishing reference sites 87
    - Key water types 89
    - Defining indicators of interest 91
    - Data requirements 93
    - Flow regimes 93
    - Calculating guideline values 93
    - Results and discussion 95
    - References 97
- Attachment 1: Criteria for selection of reference sites for developing water quality guidelines (DERM 2009a) 99
- Appendix 6: Water quality guidelines for ‘human use’ environmental values 101
- Appendix 7: Current water quality 106

1 Background

The Fitzroy Basin includes the Dawson, Comet, Nogoa, Isaac–Connors, Mackenzie and Fitzroy rivers (see Figure 1). Water management in the basin includes managing both flows and water quality. Due to its immense size and fan-like shape, this catchment can produce severe flooding after heavy rainfall.

This occurred in early 2008, causing the overflow of the Fairbairn Dam, inundation of the township of Emerald and flooding of mines in the region. As subsequent discharging of the water from these mines had a negative effect on water quality downstream, the Queensland Government commissioned the following reports:

- Hart (2008). Review of the Fitzroy River Water Quality Issues. Report to the Queensland Premier by Professor Barry Hart. November 2008. <www.fitzroyriver.qld.gov.au>
- DERM (2009). Cumulative Impacts on the Water Quality of Mining Activities in the Fitzroy Basin. Report to the Queensland Government by the Department of Environment and Resource Management. April 2009. <www.fitzroyriver.qld.gov.au>.

The implementation of recommendations of the Cumulative Impacts on the Water Quality of Mining Activities in the Fitzroy Basin was approved by Cabinet on 11 May 2009. It contains the following recommendations:

1. develop appropriate conditions in environmental authorities for mine water discharges
2. develop local water quality (WQ) guidelines
3. develop a model for assessing cumulative impacts across the region.

The Queensland Government has established the Fitzroy Water Quality Advisory Group (FWQAG) to provide advice on implementing recommendations from these government commissioned reports and to be a conduit for information on managing water-related issues in the Fitzroy River Basin. It has also established the Fitzroy River website: <www.fitzroyriver.qld.gov.au>.

This report addresses the development of environmental values and local WQ Guidelines.

Its completion also provides the Department of Environment and Resource Management (the department) with input and support for relevant activities associated with:

- implementation of the regional component of the recommendations of the Hart (2008) report to the Queensland Premier on the review of Fitzroy water quality issues
- support for the Queensland Government's commitments to the Great Barrier Reef (GBR) Water Quality Protection Plan.

The project addresses targets and actions outlined in the Fitzroy Basin Association's (FBA) Water Quality Improvement Report[1] and Central Queensland Strategy for Sustainability—2004 and beyond (CQSS2)[2] by building on existing work and extending environmental values (EVs) and water quality objectives (WQOs) into freshwaters, estuaries and groundwaters. It will also fulfil the requirements for scheduling of EVs and WQOs under the *Environmental Protection (Water) Policy 2009* (EPP (Water)).

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[1] Fitzroy Basin Association (2008). Fitzroy Basin Water Quality Improvement Report. December 2008. <www.fba.org.au>.

[2] Fitzroy Basin Association (2004) Central Queensland Strategy for Sustainability—2004 and beyond. Developed by the Fitzroy Basin Association. May 2004. <www.fba.org.au>.

1.1 Geographic scope for the project

The current project is limited to establishing EVs, WQ Guidelines and WQOs in the freshwater and estuarine waterways and groundwaters of the Fitzroy Basin catchments (see Figure 1).

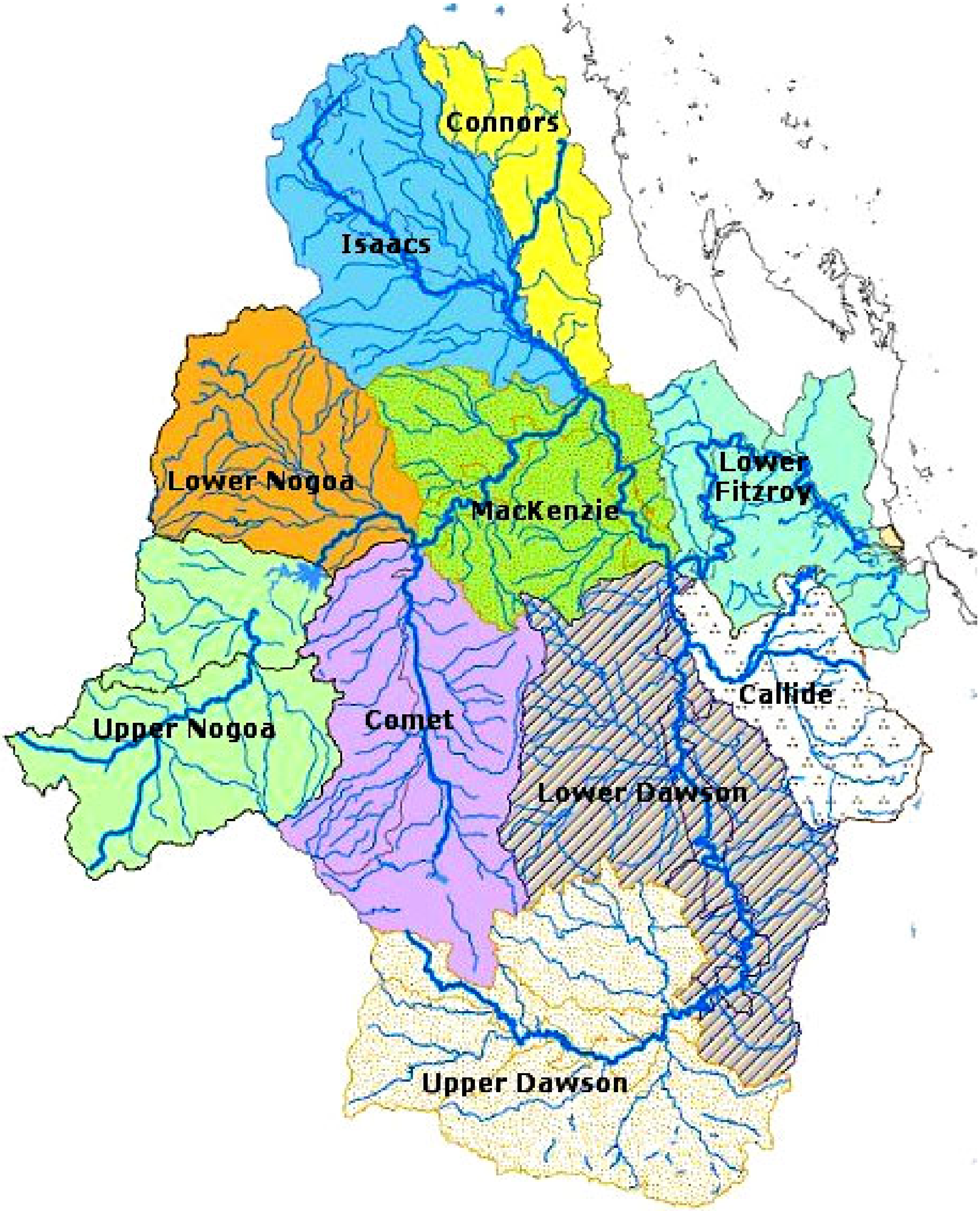

Figure 1: Catchments of the Fitzroy Basin used for consultation on environmental values

1.2 Water Quality Management Framework

The National Water Quality Management Strategy (NWQMS) was adopted by the Australian Government and all state and territory governments in 1992. As part of the more recent Council of Australian Governments' water reform framework, the NWQMS continues to be acknowledged in the National Water Initiative, the current blueprint for water reform in Australia.

Under the NWQMS, the Australian Government and state and territory governments work cooperatively to implement a national approach to improving water quality. The NWQMS provides national guidelines for state/local implementation.

The NWQMS has the following major elements:

1.2.1 Policies

The NWQMS's main policy objective is to achieve the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development. In Queensland, the *Environmental Protection Act 1994* and the *Environmental Protection (Water) Policy 2009* are the key legislative and policy mechanisms to implement the NWQMS.

1.2.2 Process

The key NWQMS process involves the development and implementation of catchment-based water quality management plans, using the water quality (WQ) management framework shown graphically in Figure 2. To comply with the NWQMS, this same process is in the Queensland Government's *Environmental Protection (Water) Policy 2009*. The EPP (Water) (section 24) calls these plans Healthy Waters Management Plans (HWMPs).

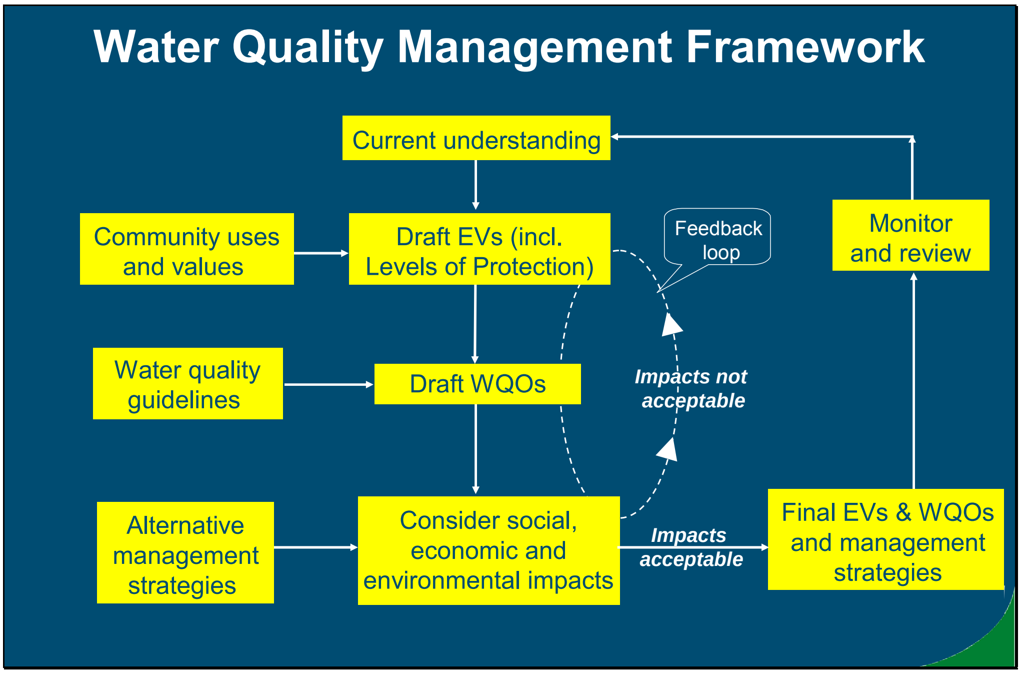

Figure 2: Water Quality Management Framework

To varying levels, regional catchment/natural resource management bodies across Queensland have adopted this process when developing the water quality management components of their natural resource management plans, for example, the Fitzroy Basin Association's (FBA) Central Queensland Strategy for Sustainability 2004 (CQSS2). In addition, water quality improvement plans—which use the same NWQMS/EPP (Water) process—have recently been developed in most of the Great Barrier Reef catchments. The FBA intends to update its water quality management component in the above mentioned document to include elements of a Healthy Water Management Plan (HWMP) for the Fitzroy Basin in the 2010–11 financial year. This will build on recent work in this project, and in the Fitzroy Water Quality Improvement Report and other related work.

1.2.3 National guidelines

The Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand—in some cases, in collaboration with the National Health and Medical Research Council and the Australian Health Ministers Conference—have released WQ Guidelines in support of the NWQMS. The following guidelines have the most relevance to this project:

- Document 4, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000 (also known as the ANZECC WQ Guidelines)
- Document 6, Australian Drinking Water Guidelines, 2004 (as amended).

Although not formally part of the NWQMS, nationally agreed guidelines for recreational water use have been published by the National Health and Medical Council (2008) and these have been considered in conjunction with the NWQMS guidelines in developing WQOs for this project (see section 5).

1.2.4 State, regional and local water quality guidelines

The project has used the relevant NWQMS recommended water quality guideline documents in developing the WQOs for relevant EVs. For aquatic ecosystems, the project has also used the NWQMS recommended approach for developing WQ guidelines, using local reference data as shown in Figure 3 below (reproduced from the ANZECC Water Quality Guidelines (ANZECC and ARMCANZ 2000)[3].

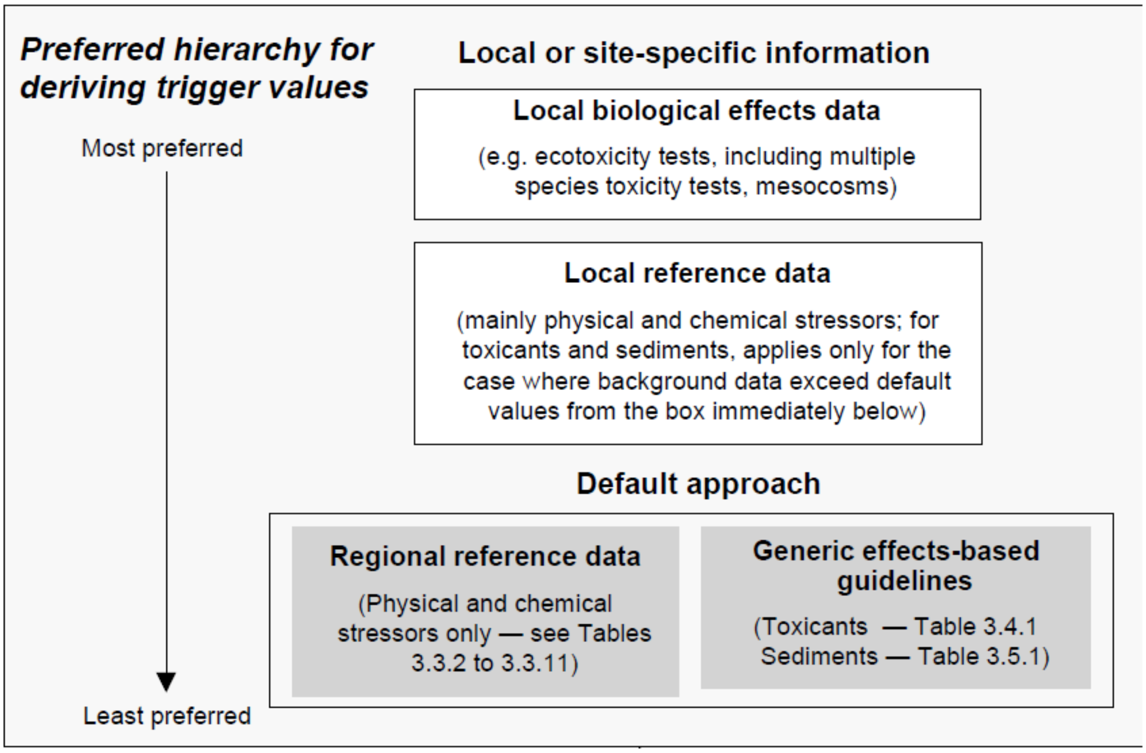

Figure 3: ANZECC guidelines procedure for developing trigger values

(Figure 3.1.2 of ANZECC and ARMCANZ 2000)

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[3] ANZECC and ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Document 4, National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. 2000.

1.3 Project plan

A project plan was developed based on the EPP (Water) legislative requirements for establishing and scheduling EVs and WQOs. This requires that the community (including industry and commerce sectors) are consulted and the economic and social impacts of protecting the EVs are considered. These requirements have been met using the methods outlined below. The consultation process (see section 3 and FBA (2010)[4]) provides stakeholder input on waterway uses and values and also informs the community of the water quality management process, including linkages to related planning and decision making processes. In addition, it provides an opportunity to identify related stakeholder concerns pertaining to water management and explains their role in management actions to improve water quality.

Key components of the project plan are as follows:

Objectives:

1. Establish EVs/WQOs for scheduling under the EPP (Water) for Fitzroy Basin waters. Waters include fresh and estuarine waterways and groundwaters of the Fitzroy Basin.
2. Establish WQ guidelines for the Fitzroy Basin based on best available information (within available timeframe and budget).
3. Schedule waters under the EPP (Water) (separate subsequent process).
4. Link the development of EVs and WQOs to the associated WQ planning and management activities under the Queensland Government's response to the cumulative impact study (DERM 2009) and the Hart (2008) report.

Methodology:

Key aspects of this project conducted in partnership with the FBA were:

1. Identify human use EVs through collation of information in readiness for stakeholder inputs.
2. Identify ecological values of waterways (including high ecological value waters) using available technical information.
3. Establish and implement a process for stakeholder consultation (including stakeholder consultation workshops) to provide for two way information exchange on the above aspects of establishing EVs.
4. Establish best available WQ guidelines (i.e. technically derived numbers) relating to aquatic ecosystem protection (dependent on available timeframe and budget).
5. Establish draft WQOs to protect all identified EVs.
6. Identify the socio-economic implications (both positive and negative) of protecting/improving water quality (covered by a project for the reef water quality improvement plans (WQIPs) and a supplementary report for the Fitzroy Basin).
7. Consult with stakeholders as to the acceptability of the EVs and WQOs (using this report).
8. Document EVs and WQOs for the Fitzroy Basin (final report).
9. Subsequently schedule EVs and WQOs under the EPP (Water) (a subsequent departmental process).

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[4] FBA (2010). Environmental values for the Fitzroy: Community Consultation. Report prepared for the Department of Environment and Resource Management by Fitzroy Basin Association. September 2010.

2 Current understanding

There have been numerous studies and monitoring programs related to understanding the water quality of the Fitzroy Basin. Based on the data and information from the studies, a number of decision support tools (e.g. catchment and receiving water models) have been developed and used to understand, predict and manage water quality in the basin and adjacent coastal waters. These include the Fitzroy Water Quality Improvement Report (FBA 2008); the CQSS2 (FBA 2004); work done in the basin under the National Land and Water Resources Audit and the National Action Plan for Water Quality and Salinity; and research and tools arising from the Coastal Cooperative Research Centre (CRC) program which focused on the Fitzroy Basin as one of its three management areas.

Water quality management is complex. This is even more evident for a catchment the size of the Fitzroy Basin with its associated water quality issues ranging from impacts on its freshwaters, through its estuary to the downstream Great Barrier Reef waters. These issues and impacts also have a temporal component based on the nature of flows in the system that typically vary seasonally from flood events in summer to extended dry periods and low flows for the remainder of the year—and this pattern has its own large inter-annual variations from periods of flood and drought.

However, establishment of EVs for all basin waters will allow WQOs to be determined for all water quality issues i.e. the relevant indicators (water quality parameters) will be decided for the issue, and then using the process detailed in section 6, the relevant WQ guidelines will be used in conjunction with the EVs to determine WQOs for all relevant indicators.

At a basin-wide scale the dominant source of sediment and nutrient loads is from rural land use; with 50% of the erosion attributable to 17% of the catchment, and increasing ground cover having the greatest impact on reducing sediment and nutrient emissions—and the influence of the western areas of the Fitzroy Basin accounting for significantly fewer sediments to the reef, with the majority of loads originating from the floodplains[5]. However a major source of water quality degradation risk stems from point source emissions from the mining and energy sectors.

Contaminants of particular concern from the mining activities include saline waters, mineral releases, process chemicals, acid mine drainage and sediments. Relevant WQ indicators would therefore include salinity (or electrical conductivity), relevant metals, cyanide, pH and suspended solids.

Impacts of agricultural activities on GBR waters relate to sediments, nutrients and pesticides (mainly herbicides). In the Fitzroy Basin, management activities are aimed mainly at reducing sediment and associated nutrient loads from grazing activities and sediment, nutrient and pesticide loads from cropping land uses.

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[5] The economic and social impacts of protecting environmental values in Great Barrier Reef catchment waterways and the reef lagoon. Marsden Jacob Associates, March 2010.

Conceptual (pictorial) models have been an effective tool for presenting and discussing the current understanding of the water quality issues for any waterway. Webster et al (2006)[6] studied the processes involved in the movement of sediments and nutrients through the Fitzroy Basin and Figure 4 shows their conceptual models of the low and high flow scenarios.

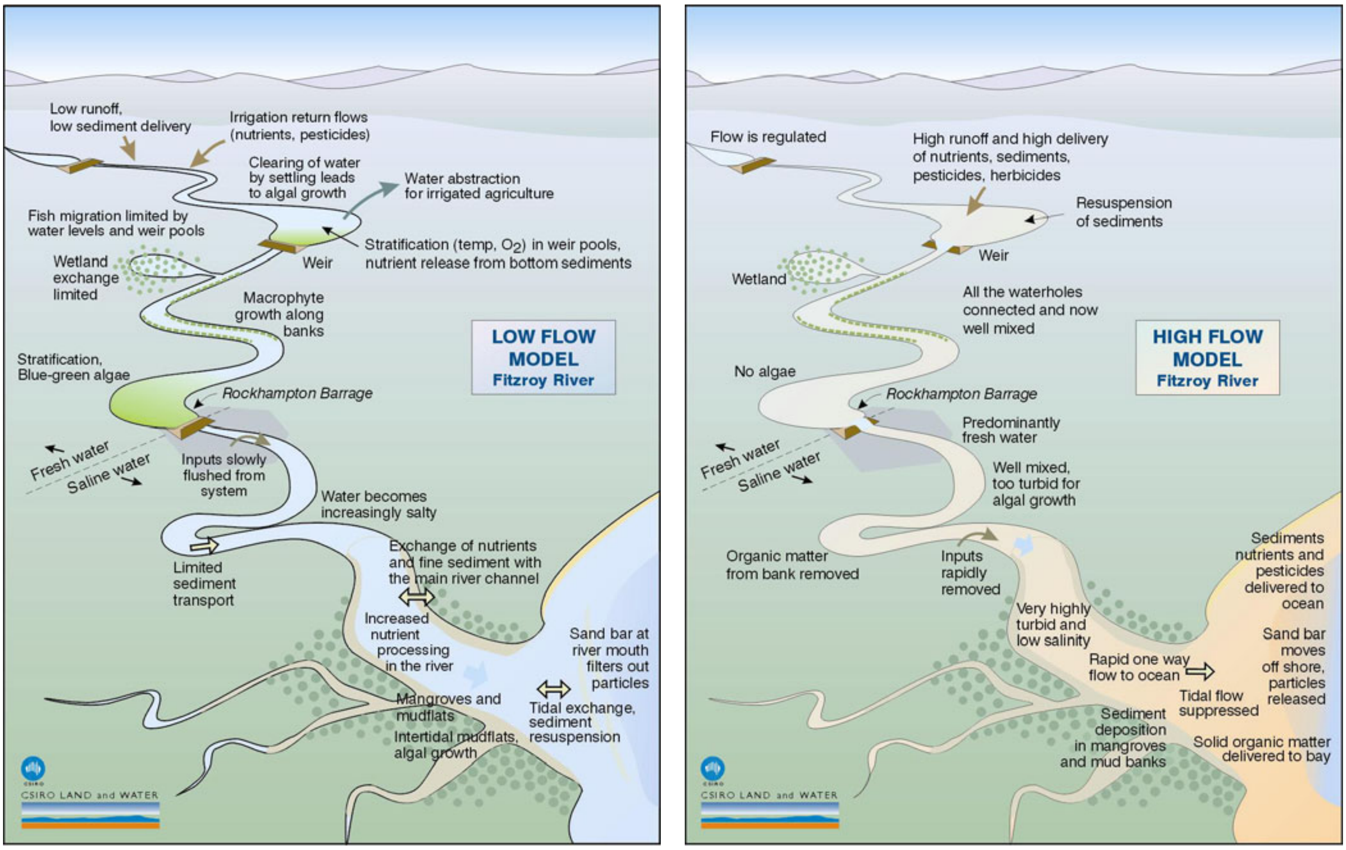

Figure 4: Low and high flow conceptual models for the Fitzroy River (Webster et al 2006)

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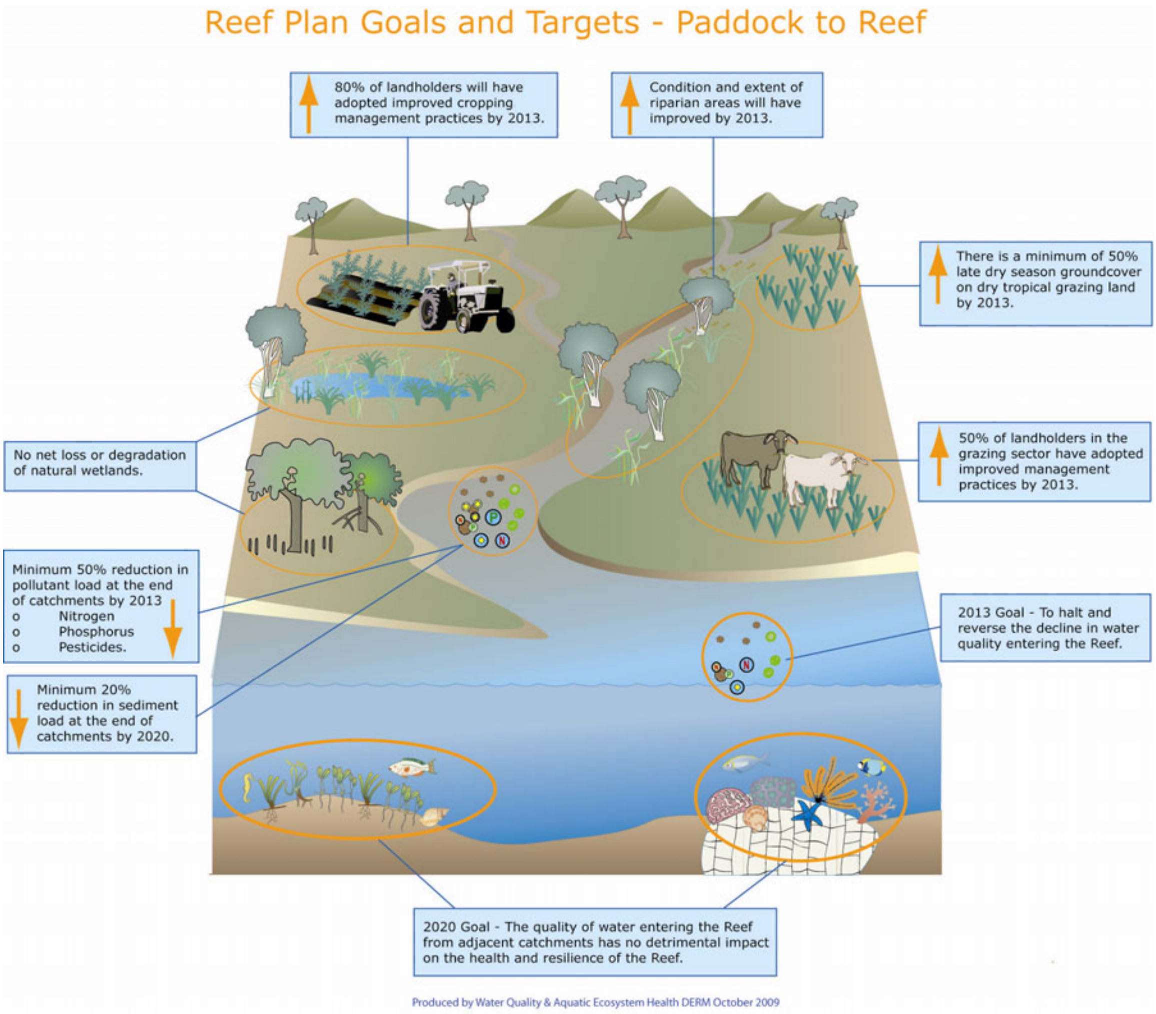
[6] Webster, I., Atkinson, I., Bostock, H., Brooke, B., Douglas, G., Ford, P., Hancock, G., Herzfeld, M., Leeming, R., Lemckert, C., Margvelashvili, N., Noble, B., Oubelkheir, K., Radke, L., Revill, L., Robson, B., Ryan, D., Schacht, C., Smith, C., Smith, J., Vicente-Beckett, V., and Wild-Allen, K. (2006). *The Fitzroy Contaminants project - A study of the nutrient and fine-sediment dynamics of the Fitzroy Estuary and Keppel Bay*. Cooperative Research Centre for Coastal Zone, Estuary & Waterway Management Technical Report no. 42 CRC for Coastal Zone, Estuary & Waterway Management. <www.clw.csiro.au>

Similarly, Figure 5 shows both a simple conceptual model and the reef plan goals and targets[7]. More detailed conceptual models for Grazing and Water Quality and Broadacre Cropping and Water Quality are in Appendix 1.



Produced by Water Quality & Aquatic Ecosystem Health DERM October 2009

Figure 5: Reef plan goals and targets (Queensland Government 2009)

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[7] Queensland Government (2009). Paddock to Reef Program——Integrated monitoring, modelling and reporting. Reef Water Quality Protection Plan. Program supported by the Australian and Queensland governments. November 2009.

3 Consultation process

As introduced in section 1.3, the EPP (Water) requires that the community (including industry and commerce sectors) are consulted in establishing EVs and WQOs. Hence, the department and the FBA developed the three stage consultation process outlined below and described in detail in FBA's consultation report (FBA 2010). It used FBA's existing community networks to support the consultation process.

3.1 Round 1—catchment champions workshop

On the 25 and 26 November 2009, a meeting was held in Rockhampton with a key representative from each of the ten Fitzroy Basin catchments (see Figures 1 and 6). These representatives were subsequently referred to as the 'champion' of their region. The aim of this initial consultation with champions was:

- to design the process and content for subsequent catchment workshops
- to use their local knowledge to draft 'straw-person' EVs tables as starting points for round 2 workshops.

3.2 Round 2—catchment workshops and meetings

Catchment workshops were then held around the Fitzroy Basin (4 February – 18 March 2010) to consult with stakeholders and community from each of the 10 catchment areas (workshop locations are shown in Figure 6). Workshops were a full day event and tools such as Geographic Information Systems (GIS) were used to support the sharing of stakeholder local knowledge and inform establishment of EVs of the waterways for each catchment.

Figure 6: Map of the Fitzroy Basin showing the division of catchments and the final workshop locations (blue stars)

Notes:

1. Details of the workshop locations, etc. are in FBA (2010).

2. The Isaac and Connors workshops were combined and held at the one location (Clarke Creek) following advice from catchment champions.

3. Due to flooding, the Comet workshop was held in conjunction with the Upper Nogoa workshop (Springsure).

3.2.1 Fitzroy Water Quality Advisory Group

The Fitzroy Water Quality Advisory Group (FWQAG) has been advised of the progress of this project at all of its meetings and teleconferences. The project was a key agenda item at its meeting on 15 February 2010. This included a presentation and detailed discussion on the project. Its members were invited to attend the basin-wide information day on 19 March 2010, as well as workshops in their catchment areas.

3.2.2 Traditional Owner workshop

Traditional Owners were invited to the catchment workshops, and an additional workshop for them was held on 15 March 2010 to discuss their inputs to all draft EVs and to capture knowledge about cultural and spiritual values attached to the Fitzroy Basin waterways.

3.2.3 Basin-wide information day

A basin-wide information day was held on 19 March 2010, immediately after the last round 2 workshop, to (i) provide feedback on the round 2 workshops and (ii) provide the context for the round 3 public review of the draft report. The day included presentations and discussion on:

- the WQ management process and the preliminary EVs from the catchment workshops (which were available for perusal)
- draft WQ guidelines and the process to develop WQOs (from EVs and WQ guidelines)
- management strategies for point and diffuse (urban and rural) sources
- tools/studies to assess social, economic and environmental impacts of management strategies
- monitoring and reporting strategies.

Interested attendees had the opportunity to ask questions about the project and related issues. The day was designed to bring together representatives from governments, primary industries, landholders, mining and other industries, conservation groups and various others with an interest in the process.

3.2.4 Improving workshop outputs (March–June 2010)

Round 2 workshops resulted in follow up actions to collect more detail on the draft EVs. These were progressed after the workshops.

The draft EVs tables for each workshop area were placed on the FBA website on 16 April 2010 to provide an opportunity for comment from interested people on the draft EVs (human uses and high value waterways). Workshop attendees were also emailed the information and asked to check that the draft EVs were correct. Follow up emails seeking attendees' comments were sent on 4 May 2010.

3.2.5 Round 3—public review of the draft reports (December 2010–February 2011)

This document containing draft EVs and WQOs forms the basis of the round 3 consultation. All people who attended (or expressed an interest in) any of the previous workshops and information day will receive a CD copy of this and the related reports. A public notice will be placed in the relevant newspapers to alert other interested parties. It will also be complemented with meeting(s) with groups such as the Fitzroy River Water Quality Advisory Group.

3.3 Information to support workshop consultations on environmental values

The main objective of the workshops was to discuss and record the community's collective knowledge of EVs (see Appendix 2) for the relevant waters. To support these workshops, the project team collated available information on uses and values that would assist the attendees. This information is discussed below and in Appendix 2. A Geographic Information System (GIS) was compiled with this information and was used as a discussion support tool. It allowed workshop attendees to 'zoom in' to local areas and see their waterways on the remote sensed images and other information layers outlined in Appendix 2.

3.3.1 Human uses and values

Appendix 2 details the EVs, process, tools and the sources of information used to assist identification of human uses and values for Fitzroy Basin.

3.3.2 Ecological values

High ecological value waterways offer a number of valuable ecosystem services (e.g. nursery area for aquatic life, seedstock sources for rivers downstream), as well as providing undisturbed benchmarks of local waterway health (which can be used to derive locally relevant WQ guidelines—see Appendix 5). Protection of high value waterways in the first place is a lot cheaper than having to repair them after they are disturbed. The NWQMS grades aquatic ecosystems using a hierarchical approach according to their condition or level of disturbance. The most pristine and healthy systems are considered to be of high ecological value (HEV). The aim for such waterways is to maintain their current, natural condition. Waterways which are slightly disturbed (SD) also have good water quality. The management goal for these waterways is to maintain or improve the health of the water and possibly restore them to high ecological value.

At the 'champions' workshop, feedback from attendees was that most of the Fitzroy Basin (and its waterways) has a moderate degree of disturbance due to historical development. Champions advised that the best candidate waterways for high value (HEV and SD) waterways were likely to be within national parks and other State lands (see Figure 7).

This helped guide discussion at catchment workshops where, during the afternoon session, stakeholders provided feedback on waterways in each of these areas in their catchment, their level of disturbance and whether they contain high ecological value or slightly disturbed waterways. While this feedback was based on their local knowledge of the level of disturbance, attendees suggested their feedback should be checked with local park and forest rangers for accuracy. The project team undertook additional consultations after the workshops.

The last catchment workshop exercise aimed to capture stakeholder information on specific waterway ecological characteristics for their waterways to help inform the water resource and water quality management plans for the Fitzroy Basin. This additional discussion was supported by departmental officers involved in each of these processes, as both planning processes aim to protect the same aquatic ecosystems.

Scientific assessment of aquatic ecosystem condition across the Fitzroy has not yet been completed (see section 12.2 for current and future directions).

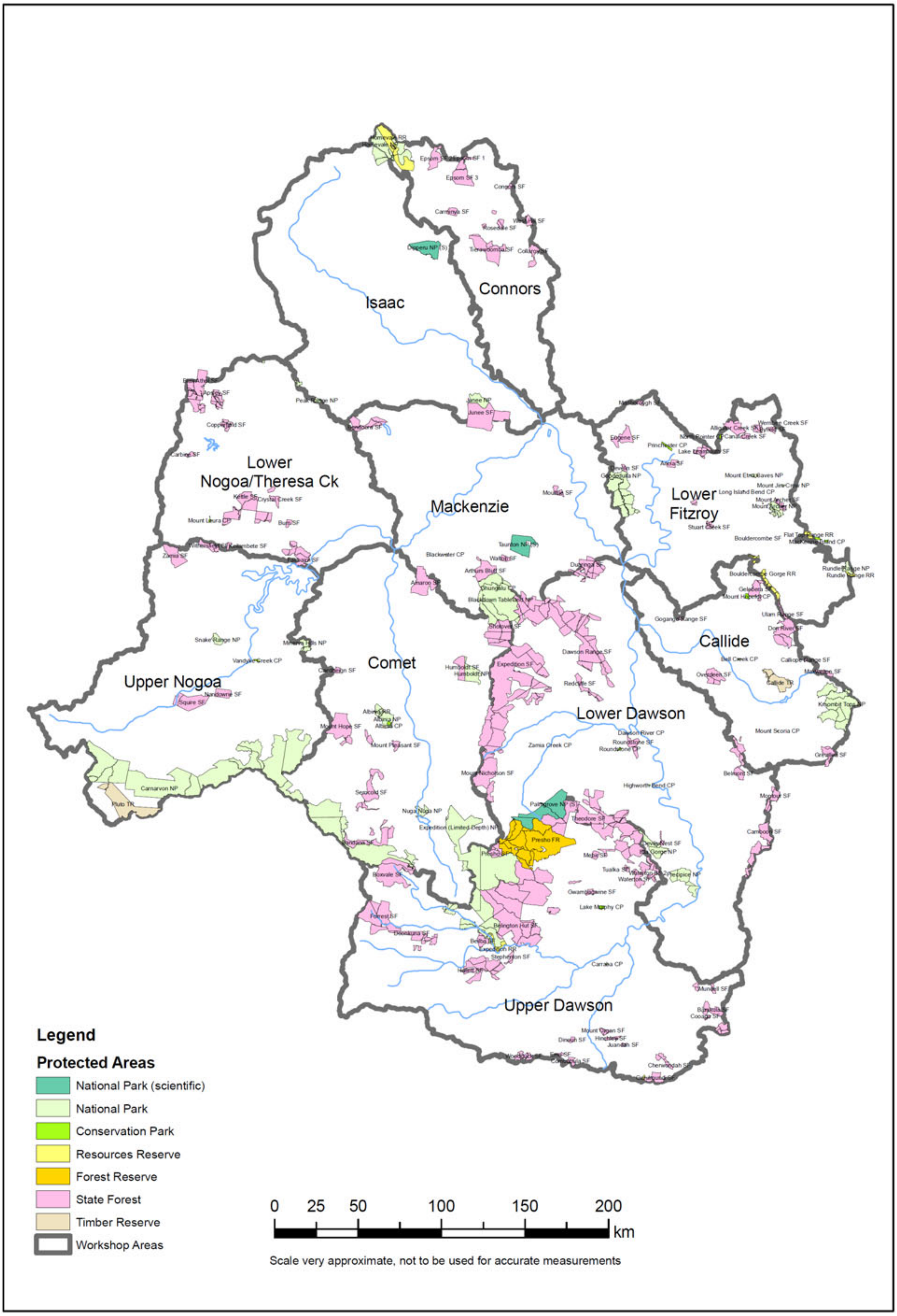


Figure 7: Map of protected areas (national parks and State lands)

3.4 Workshop process

The workshop agenda is included in FBA's community consultation report (FBA 2010). In summary, the order of proceedings at each workshop was:

- welcome and housekeeping
- introduction to the information kit
- FBA presentation on WQ management in the Fitzroy to date
- introductions and expectations from attendees
- departmental presentation on the WQ management process and examples of each component, as well as the implications of scheduling EVs and WQOs
- explanation of the first workshop session and the GIS and supporting information
- first ('human' use EVs) workshop session to facilitate discussion and record agreed EVs for each group of waterways, as well as EVs for ground waters in the area
- departmental presentations on the background to high value waterways and ecological characteristics
- explanation of the second workshop session and supporting information
- second (ecological values) workshop session to facilitate discussion and record attendees' information on high value (HEV and SD) waterways and ecological characteristics of waterways
- explanation of the project process after the workshop until finalisation
- attendees' feedback on what worked well and what could be improved
- checking attendees' expectations were met
- close of workshop.

An issues board was also kept at each workshop to record matters raised by attendees that were not the focus of the EVs workshop. Attendees were offered the opportunity to discuss these in more detail with the project team after the close of each workshop.

Input from attendees at catchment workshops resulted in follow up actions for the team and some attendees. These included providing further information towards draft EVs, and undertaking further consultations (e.g. with the park and forest rangers).

4 Commenting on environmental values

The main outputs of the catchment workshops are the draft EVs tables and the additional information on high value (HEV and SD) waterways.

4.1 Draft environmental values

Appendix 2 details the process and supporting information/GIS used in the first workshop session to progress through all EVs and all catchment waters and record the agreed EVs.

The draft report *Environmental Values for the Fitzroy: Community Consultation, Fitzroy Basin Association September 2010* contains the resulting detailed tables and maps of draft EVs for all groupings of waterways in all workshop areas across the Fitzroy Basin. A summary list of draft EVs is at Appendix 3. These are based on the groupings of waterways shown in Figure 8.

Comments are sought on these draft EVs.

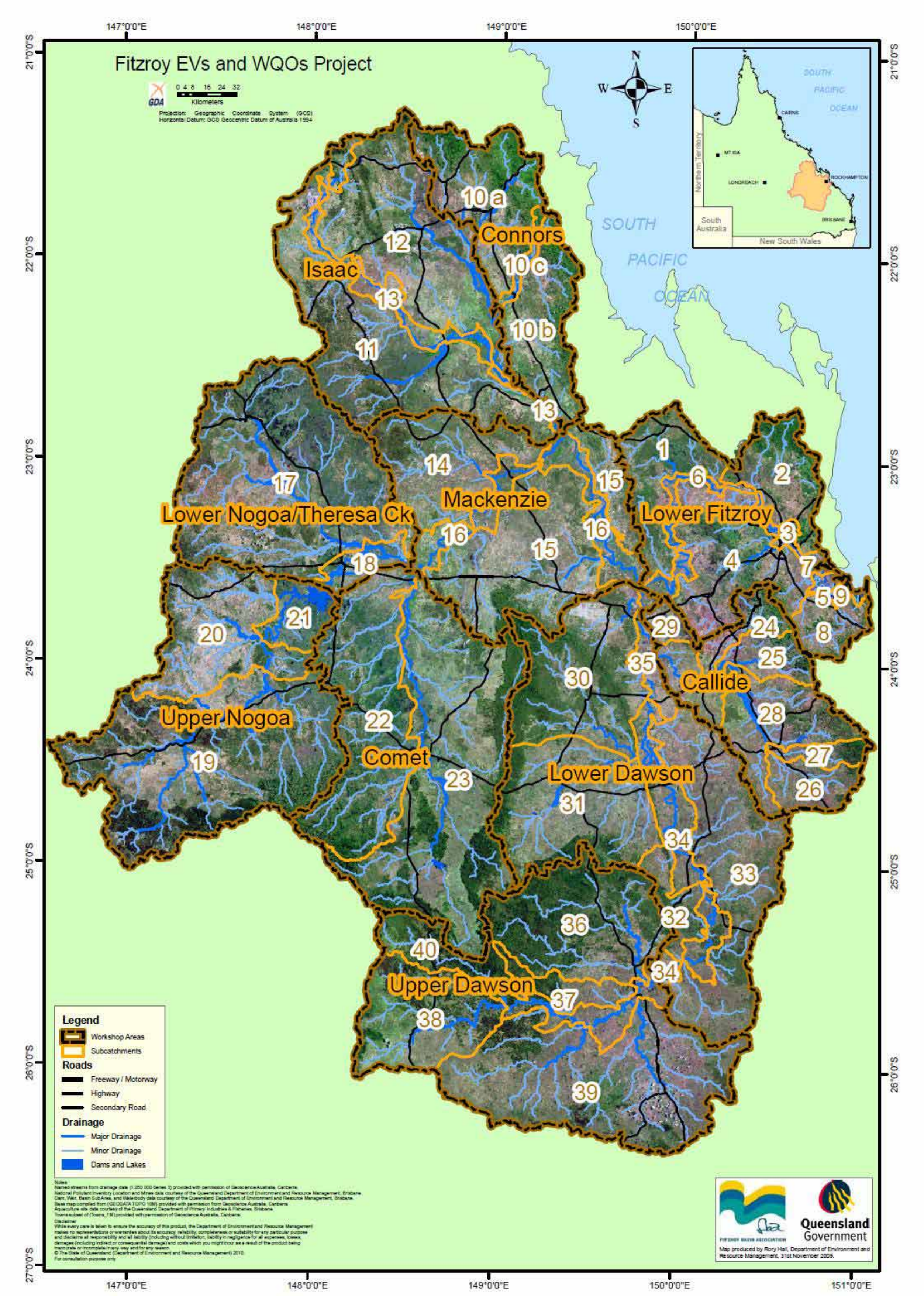


Figure 8: Groups of waterways for EVs tables

4.2 High value (High Ecological Value and Slightly Disturbed) waters

Section 3.3.2 details the process and supporting information/GIS used in the second workshop session of the catchment workshop to identify all potential high value (HEV and SD) waterways and record the draft results and follow up actions.

Appendix 4 provides the current high values waterways table with the following three columns:

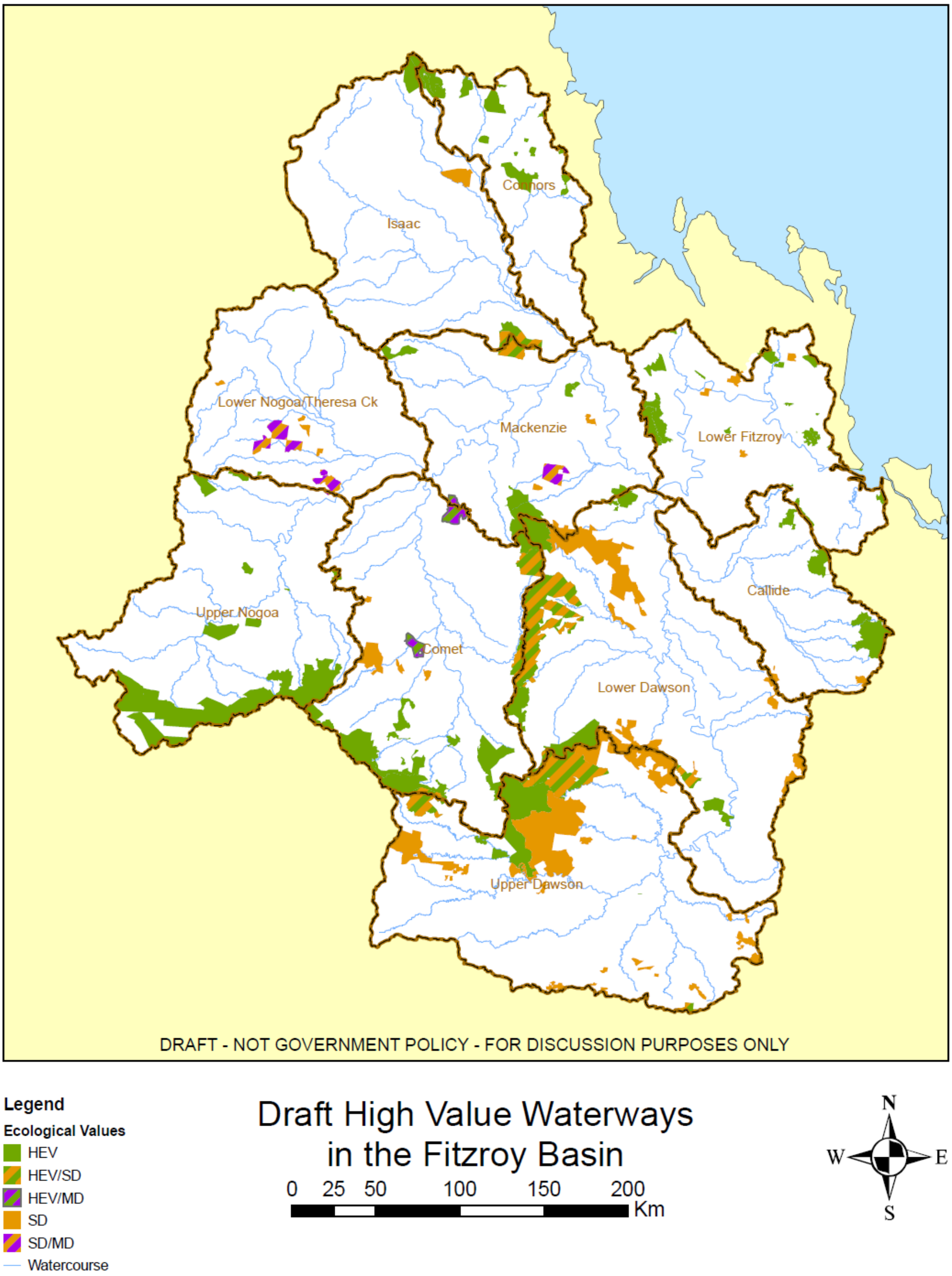
1. a list of areas containing potential high value waterways taken to the workshops
2. stakeholder views on the current aquatic ecosystem condition of the waterways based on their knowledge of the level of disturbance of the waterways
3. current draft aquatic ecosystem condition based on both the stakeholders' knowledge and the further information obtained from park/forest rangers. **Comments are being sought on this column.**

The feedback from stakeholders and rangers was that:

- some of these areas (as a whole) are reasonably undisturbed (and hence should be protected as HEV)
- some other areas (as a whole) have suffered some level of past disturbance and are only slightly disturbed (and hence should be SD with a management goal of maintaining or improving the health of the water and possibly restoring them to HEV)
- for some of these areas, parts of the whole area are reasonably undisturbed (and hence should be protected as HEV), while some other parts of the area have suffered some level of past disturbance and are only slightly disturbed (SD) i.e. the whole area is a mix of HEV and SD. Again, the management goal for the SD waters is to maintain or improve their health
- for some of these areas which are within national parks, parts of the whole area are reasonably undisturbed (and hence should be protected as HEV), while some other parts of the area have suffered significant level of past disturbance and are therefore moderately disturbed (MD), i.e. the whole area is a mix of HEV and MD. For these national parks, the stakeholders still felt that the management goal for the MD waters is to maintain or improve their health and possibly restore them to HEV.

Based on the stakeholder input to these high value waterways and subsequent input from park and forest rangers (as requested by stakeholders), **Figure 9 shows spatially the various combinations of current aquatic ecosystem conditions (i.e. HEV, SD and MD waterways as shown in column 3 in Appendix 4).**

The 'champions' workshop recommended that this project focus the discussion and decisions on high value waterways to national parks and State lands. DERM is currently undertaking more scientific assessments of conservation/ecological values of the Fitzroy Basin waterways, as well as collecting more data on reference sites (see section 12.4). The opportunity exists in the future to further refine high value waterways as this further technical information becomes available.



Notes:
HEV: High Ecological Value
SD: Slightly Disturbed
MD: Moderately Disturbed
Refer to EPP Water 2009 and accompanying report for further explanation of terms.

DISCLAIMER: © Fitzroy Basin Association Inc. [2004 - 2010]. In consideration of the Fitzroy Basin Association (FBA) permitting use of the licensed data, I acknowledge and agree the FBA gives no warranty in relation to the data (including accuracy, reliability, completeness or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data.
PROPERTY BOUNDARIES: The Property Boundary on this map is based on The Protected Areas of Queensland Data Base provided by the Department of Environment & Resource Management, ©DERM (2010). Consideration of the map scale is necessary when interpreting data at a scale less than 1:100,000.

Figure 9: Map of high value waterways (see Appendix 4 for details)

4.3 Specific waterway ecological characteristics

The outcome of the last workshop exercise, which aimed to capture any stakeholder information on the valued ecological characteristics for their waterways, resulted in both general feedback (e.g. protection of offstream wetlands, refugia waterholes) and some specific feedback for their waterways. The list below summarises the feedback received from stakeholders that will assist in current and future plans.

Further input/comment on these and other features can be provided during the public review of this draft report.

Lower Fitzroy

- freshwater wetland below barrage around Raglan/Alligator Creek.

Connors

- riparian vegetation (e.g. Isaac River/Grass Hut Gully)
- waterholes—providing water all year around, including two significant ox-bow lakes locally called Ungie Waterhole (Devlin Creek–Isaac confluence) and Eungy Waterhole (Clark Creek–Isaac confluence)
- Lake Plattaway, a large ox-bow lake between the Connors and Isaac rivers.

Isaac

- Pink Lily Lagoon (next to South Walker Mine)—Oxbow Lake of Bee Creek
- nature reserve adjacent to Peak Downs National Park
- Yatton Waterhole near Isaac River—healthy riparian zones, rocky outcrop, abundant with fish, eels and turtles and is a popular swimming hole.

Mackenzie

- Oxbow lakes, in particular 10 Mile Waterhole, and also Lake McDonald, and Lake Mary
- conservation area (Kaiuroo Reserve)
- land at Bluff on north side of road (near racecourse—unallocated State land).

Lower Nogoa

- riparian remnants, including areas in Crinum Creek
- waterholes, for example a) near Comet confluence with Mackenzie (just below lower Nogoa boundaries) containing very good saratoga habitat. Includes public reserve and recreation. b) Retreat Creek/Argyle Creek rock pools containing platypus and Yellowbelly habitat (three pools). c) Lilyvale waterhole area (historical interest as original supply for the town)
- Theresa Creek/Sandy Creek junction—area is one of the few creeks retaining water in dry times
- Sapphire Wetlands, unallocated State land north of racetrack containing wetland habitat that remains wet for months after filling.

Upper Nogoa

- Vandyke Creek—unusual given its high flow characteristics
- Bauhinia Waterhole (Nogoa River)
- Lake Salvador and Mitchell and Belinda springs.

Comet

- waterholes, including those in Meteor Creek (known as 20/22 Mile waterhole) and Freitag Creek
- offstream lakes/wetlands including Lake Nuga Nuga.

Callide

- Permanent waterholes along Dee River
- Lake Victoria (a natural billabong at the confluence of the Callide and Don River that supports a range of species)

- Callide Creek waterhole near Rainbow Creek (also has recreational values)
- important springs on Centre Creek
- top end of Callide Dam where Awoonga water is discharged (Stag Creek as conduit).

Lower Dawson

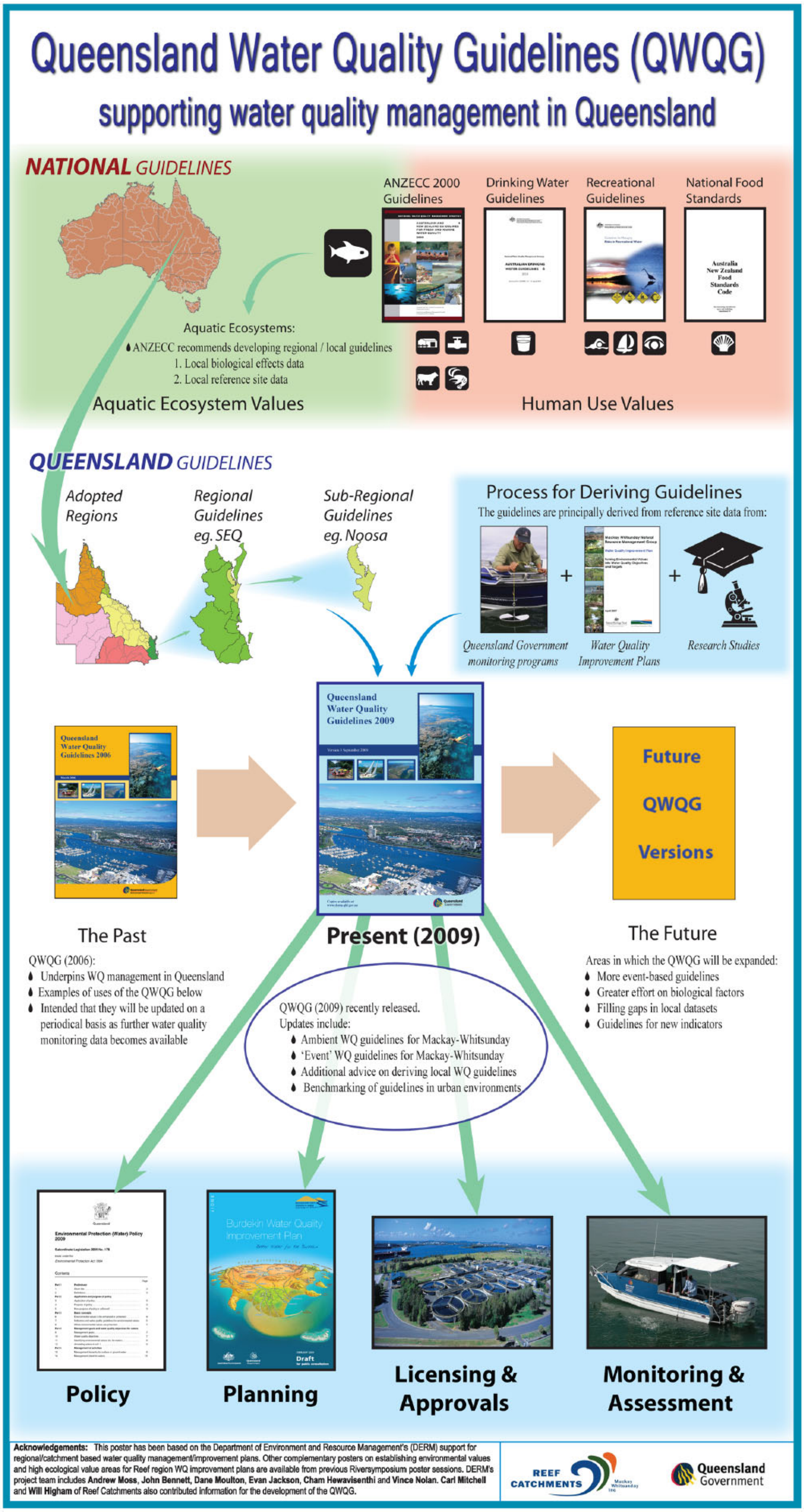
- waterholes, including at the junction of Precipice Creek and Dawson River
- platypus—various locations, e.g. Boyd Creek junction with Dawson and Dawson at Big Bend
- macroinvertebrates in Gap Creek—high diversity including sensitive aquatic organisms
- nature refuges (NRs), e.g. Willowa, Mimosa NRs
- Precipice Creek waterholes are spring fed
- Cracow creeks are spring-fed
- Robinson Creek, Cabbage Tree Creek, Melancholy Creek and Precipice National Park (no public access) are all excellent areas.

Upper Dawson

- platypus—all through the system
- riverine corridor upstream of Glebe Weir—good riparian area and junction with Palm Tree Creek, potentially impacted by future dams
- Boggomoss communities—groundwater–fed spring communities in various locations and listed on the national estate
- springs, e.g. around the Dawson–Hutton Creek junction important fish breeding area below the confluence
- native fish—general concern about effects of altered flows/barriers on breeding triggers and ability of native fish to move
- carp-free upper catchment waters: concern that carp from waters in Murray–Darling Basin could cross to the upper Dawson (understood to be free of carp) in times of flood, particularly in headwaters in the catchment (e.g. the upper areas known as the Melon Holes, around Guluguba at the headwaters of Dogwood and Downfall creeks).

5 Water quality guidelines

As introduced in section 1.2, this project has used the relevant National Water Quality Management Strategy (NWQMS) and NWQMS-recommended WQ guideline documents to develop WQOs for established EVs. Figure 10 shows the relevant WQ guideline documents (at the top) and their key uses (at the bottom), then focuses (in the centre) on the Queensland Water Quality Guidelines (QWQG) which use the NWQMS recommended process (refer Figure 3) for developing regional and sub-regional/local WQ guidelines for aquatic ecosystems. This process was used in this project to develop sub-regional WQ guidelines for lowland freshwater aquatic ecosystems, as detailed in Appendix 5 and discussed in the following sections.



Queensland Water Quality Guidelines (QWQG)

supporting water quality management in Queensland

NATIONAL GUIDELINES

Aquatic Ecosystems:
- ANZECC recommends developing regional / local guidelines
  1. Local biological effects data
  2. Local reference site data

QUEENSLAND GUIDELINES

Process for Deriving Guidelines

The guidelines are principally derived from reference site data from:

The Past

QWQG (2006):
- Underpins WQ management in Queensland
- Examples of uses of the QWQG below
- Intended that they will be updated on a periodical basis as further water quality monitoring data becomes available

Present (2009)

QWQG (2009) recently released.
Updates include:
- Ambient WQ guidelines for Mackay-Whitsunday
- 'Event' WQ guidelines for Mackay-Whitsunday
- Additional advice on deriving local WQ guidelines
- Benchmarking of guidelines in urban environments

The Future

Areas in which the QWQG will be expanded:
- More event-based guidelines
- Greater effort on biological factors
- Filling gaps in local datasets
- Guidelines for new indicators

Acknowledgements: This poster has been based on the Department of Environment and Resource Management's (DERM) support for regional/catchment based water quality management/improvement plans. Other complementary posters on establishing environmental values and high ecological value areas for Reef region WQ improvement plans are available from previous Riversymposium poster sessions. DERM's project team includes **Andrew Moss**, **John Bennett**, **Dane Moulton**, **Evan Jackson**, **Cham Hewavisenthi** and **Vince Nolan**. **Carl Mitchell** and **Will Higham** of Reef Catchments also contributed information for the development of the QWQG.

Figure 10: Water quality guidelines – documents, derivation and use

5.1 Water quality guidelines for protection of aquatic ecosystems—context and summary table

The management goal for aquatic ecosystems relates to retaining the structure and function of these systems. The development of WQOs for the protection of aquatic ecosystems is considered at two levels of protection/significance:

1. high ecological value waterways
2. other waterways.

For high ecological value waterways, the WQOs are to maintain current condition. For waterways identified as slightly disturbed[8], the intent is to improve these towards HEV WQ condition (i.e. WQOs). **For other waterways, the WQOs are based on the established EVs and the relevant WQ guidelines.** Note: ANZECC and ARMCANZ (2000) includes the overriding principle of continual improvement in water quality management at all times[9].

In deriving WQ guidelines ('trigger values') for the protection of aquatic ecosystems, the NWQMS recommends a preferred hierarchy as shown in Figure 3. The most preferred approach is based on local biological effects data. For the Fitzroy Basin, there is little local biological effects data and therefore this most preferred approach is not applicable.

The second-most preferred approach is to identify local reference (i.e. least impacted) sites, and establish sub-regional guidelines for relevant parameters based on water quality at these sites, using protocols outlined in the NWQMS. The derivation of sub-regional guidelines means that these can be used rather than defaulting back to the relevant state or national guidelines. As part of the Fitzroy EVs process, a study was undertaken leading to the development of draft (first phase) water quality guidelines for selected parameters in lowland fresh waters across most Fitzroy catchments. Lowland freshwaters include the majority of rivers in the basin. Appendix 5 documents the methods used and the first phase results from this study.

Table 1 summarises the results from the study and contains the draft sub-regional WQ guidelines for the lowland freshwater reaches of the Fitzroy Basin. For some areas/parameters, there was insufficient information to derive sub-regional guidelines. In this situation the relevant regional WQ guidelines in the Queensland Water Quality Guidelines (QWQG, DERM 2009) have been used. Table 1 therefore also includes default regional guidelines for some parameters, where there was insufficient data to derive a sub-regional guideline.

Tables 2 (physico-chemical guidelines) and 3 (pesticide guidelines) provide further information on regional/national WQ guidelines for additional parameters that relate to the key water quality issues in the Fitzroy Basin. As listed in section 5.2, relevant water quality indicators/parameters for protection of aquatic ecosystem typically include:

- salinity (electrical conductivity (EC) is a measure of salinity)
- nutrients (nitrogen, phosphorus)
- dissolved oxygen
- turbidity/suspended sediments
- pH
- toxicants
- other indicators relevant to the WQ issues identified.

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[8] For some national parks identified as containing some moderately disturbed waters, the stakeholders also included a management goal that such waters be restored back to HEV.

[9] 'An overriding principle that should guide management should be *continual improvement*. This is more obvious where water or sediment quality does not match the WQOs. In badly polluted waters it might even be necessary to set intermediate levels of water quality to be achieved in well defined stages, each subsequent target closer to the required water quality objective, until it is finally met. However, in waters that are of better quality than that set by the WQOs, some emphasis could still be given to reducing the level of contamination from all sources, particularly for highly modified water resources. Wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the WQOs.' (ANZECC and ARMCANZ 2000, p. 2–16).

'Note that even though a system is assigned a certain level of protection, it does not have to remain 'locked' at that level in perpetuity. The EVs and management goals (including level of protection) for a particular system should normally be reviewed after a defined period of time, and stakeholders may agree to assign it a different level of protection at that time. However, the concept of continual improvement should be promoted always, to ensure that future options for a water resource are maximised and that highly disturbed systems are not regarded as 'pollution havens'.' (ANZECC and ARMCANZ 2000, p. 3.1–12).

Table 1: Draft sub-regional water quality guidelines for protection of aquatic ecosystems

Catchment	**Sub-regional WQ guidelines for protecting aquatic ecosystems in Fitzroy Basin lowland freshwaters** [1]						
	TSS	EC	SO_4	Total N	Total P	pH	pH
	mg/L	µS/cm	mg/L	µg/L	µg/L	Low	High
Callide	25	1220	20	500[2]	50[2]	6.5	8.5
Upper Dawson	25	360	5	350	70	6.5	8.5
Lower Dawson	10[2]	340[2]	ID[3]	500[2]	50[2]	6.5	8.5
Comet	25	338	5	500[2]	50[2]	6.5	8.5
Upper Nogoa	155	275	15	1000	350	6.5	8.5
Lower Nogoa/Theresa Creek	10[2]	340/720[2, 4]	ID[3]	500[2]	50[2]	6.5	8.5
Isaac	55	835	25	500[2]	50[2]	6.5	8.5
Lower Isaac	20	400	5	450	70	6.5	8.5
Connors	15	465	10	500	75	6.5	8.5
Mackenzie	90	330	10	750	130	6.5	8.5
Fitzroy	60	445	15	500[2]	50[2]	6.5	8.5

Notes:
1. All values shown are sub-regional guideline values unless otherwise stated (refer notes below). These guidelines are for low flow regimes (see Appendix 5).
2. There is insufficient data to derive a sub-regional guideline for these parameters. QWQG regional guidelines apply until sub-regional guidelines are developed. For parameters other than electrical conductivity (EC), these are QWQG Central Coast regional guidelines. For EC these are based on salinity guidelines in Appendix G of the QWQG. Refer to Section 5.2 for further information on regional guidelines.
3. ID = Insufficient data to derive a sub-regional guideline. Currently, no regional guidelines apply.
4. There are two guidelines specified in this cell because the lower Nogoa/Theresa Creek catchment traverses the boundaries of two different salinity zones (refer QWQG, Appendix G and Figure G3 for zone boundaries).

5.2 Water quality guidelines for protection of aquatic ecosystems—additional tables

Table 2: Central Coast regional water quality guidelines for physico-chemical indicators for protection of aquatic ecosystems[10]

Environmental values		Regional water quality guidelines for protection of aquatic ecosystems												
		Water type*	Indicator											
			Nutrients								Micro-algal growth	Water clarity		
			Inorganic N		Organic N	Total N	Particulate N	FRP	Total P	Particulate P	Chl-a	Turbidity	Secchi	TSS
			NH3-N	NOx-N										
			µg/L									NTU	m	mg/L
Aquatic ecosystems	High ecological value (HEV) and slightly disturbed (SD) systems	Freshwater and estuarine	Assess existing conditions in individual rivers or reaches. WQOs for both HEV and SD waters are the same. For HEV waters, the WQOs are intended to reflect no change from existing values: i.e. no change in median and no change in outlying upper and lower percentiles (refer to QWQG for more details). For waters identified as slightly disturbed, the intent is to improve their condition towards the HEV WQOs.											
	Moderately disturbed systems	Upland freshwater	10[1]	15[1]	225[1]	250[1]	ng	15[1]	30[1]	ng	n/a[1]	25[1]	ng	ng
		Lowland freshwater[A]	20[1]	60[1]	420[1]	500[1]	ng	20[1]	50[1]	ng	5.0[1]	50[1]	ng	10[1]
		Lakes	10[1]	10[1]	330[1]	350[1]	ng	5[1]	10[1]	ng	5.0[1]	1–20[1]	ng	ng
		Wetlands	ng[1]	ng[1]	ng[1]	ng[1]	ng	ng[1]	ng[1]	ng	ng[1]	ng[1]	ng	ng

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[10] Data from the Queensland Water Quality Guidelines (QWQG) Section 3.2 (Central Coast region).

Environmental values		Regional water quality guidelines for protection of aquatic ecosystems												
		Water type*	Indicator											
			Nutrients								Micro-algal growth	Water clarity		
			Inorganic N		Organic N	Total N	Particulate N	FRP	Total P	Particulate P	Chl-a	Turbidity	Secchi	TSS
			NH3-N	NOx-N										
			µg/L									NTU	m	mg/L
		Upper estuary	30[1]	15[1]	400[1]	450[1]	ng	10[1]	40[1]	ng	10.0[1]	25[1]	0.4[1]	25[1]
		Mid-estuary	10[1]	10[1]	260[1]	300[1]	ng	8[1]	25[1]	ng	4.0[1]	8[1]	1.0[1]	20[1]
		Enclosed coastal/lower estuary	8[1]	3[1]	180[1]	200[1]	ng	6[1]	20[1]	ng	2[1]	6[1]	1.5[2]	15[2]
	GBR Marine Park	Coastal	2[1]	2[1]	ng	140[1]	20[2]	3[1]	20[1]	2.8[2]	0.45[2]	1[1]	10[2]	2[2]
		Inshore	2[1]	2[1]	ng	140[1]	20[2]	3[1]	20[1]	2.8[2]	0.45[2]	ng	10[2]	2[2]
		Offshore	2[1]	2[1]	ng	120[1]	17[2]	3[1]	12[1]	1.9[2]	0.4[2]	ng	17[2]	0.7[2]

Notes:

Salinity (electrical conductivity - EC) guidelines are not shown in this table. Refer to EC guidelines in Table 1. For more details on salinity refer to Appendix G of the QWQG (DERM 2009).

* See Appendix 5 and QWQG Appendix B (DERM 2009) for definitions of water types.

ng = no guideline available (Guidelines for particulate nitrogen and phosphorus are not available for all water types.); n/a not applicable

[1.] Source: Queensland Water Quality Guidelines. (DERM 2009)

[2.] Source: Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2008)

[A] Sub-regional WQ guidelines in Table 1 supersede these values where they are available.

Table 3: Water quality guidelines for pesticide indicators for protection of aquatic ecosystems

Environmental values		Water quality guidelines for pesticide indicators for aquatic ecosystems											
		Water type*	Indicator										
			Diuron	Atrazine	Chlorpyrifos	Endosulfan	Ametryn	Simazine	Hexazinone	2,4-D	Tebuthiuron	MEMC	Diazinon
			µg/L										
Aquatic ecosystems	High ecological value (and slightly disturbed[1]) systems	Freshwater (99% species prot^{n} level)	0.2[3]	0.7[3]	0.00004[3]	0.03[3]	ng	0.2[3]	75[3]	140[3]	0.02[3]	ng	0.00003[3]
	High ecological value (and slightly disturbed[1]) systems	Estuary/Marine (99% species prot^{n} level)	1.8[4]	0.7[4]	0.0005	0.005	ng	0.2[4]	75[4]	140[4]	0.02[4]	ng	0.00003[4]
	Moderately disturbed systems	Upland freshwater	0.2[3]	13[3]	0.01[3]	0.2[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
		Lowland freshwater	0.2[3]	13[3]	0.01[3]	0.2[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
		Lakes	0.2[3]	13[3]	0.01[3]	0.2[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
		Wetlands	0.2[3]	13[3]	0.01[3]	0.2[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
		Upper estuary	1.8[3]	13[3]	0.009[3]	0.01[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
		Mid-estuary	1.8[3]	13[3]	0.009[3]	0.01[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]

Environmental values		Water quality guidelines for pesticide indicators for aquatic ecosystems											
		Water type*	Indicator										
			Diuron	Atrazine	Chlorpyrifos	Endosulfan	Ametryn	Simazine	Hexazinone	2,4-D	Tebuthiuron	MEMC	Diazinon
			µg/L										
		Enclosed coastal/lower estuary	1.8[3]	13[3]	0.009[3]	0.01[3]	ng	3.2[3]	75[3]	280[3]	2.2[3]	ng	0.01[3]
	GBR Marine Park	Coastal	0.9[2]	0.4[2]	0.005[2]	0.005[2]	0.5[2]	3.2[3]	75[2]	0.8[2]	2[2]	0.002[2]	0.01[2]
		Inshore	0.9[2]	0.4[2]	0.005[2]	0.005[2]	0.5[2]	3.2[3]	75[2]	0.8[2]	2[2]	0.002[2]	0.01[2]
		Offshore	0.9[2]	0.4[2]	0.005[2]	0.005[2]	0.5[2]	0.2[3]	75[2]	0.8[2]	0.02[2]	0.002[2]	0.00003[2]

Notes:

* See Appendix 5 and DERM (2009), Appendix B, for definitions of water types.

ng = no guideline available

[1] For waters identified as slightly disturbed, the intent is to improve their condition towards the HEV WQOs.

[2] Source: Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2008)

[3] Source: Australian and New Zealand Guidelines for Fresh and Marine Waters (ANZECC &ARMCANZ 2000)

[4] For these parameters the Australian and New Zealand Guidelines for Fresh and Marine Waters (ANZECC &ARMCANZ 2000) do not specify guideline values for 99% species protection in estuarine/marine waters. These values are therefore based on the corresponding ANZECC/ARMCANZ freshwater values for 99% species protection.

5.3 Water quality guidelines for human uses and values

The water quality guideline documents for ‘human’ uses and values are shown in the pink shaded section of Figure 10. Sections 5.3.1–5.3.8 below discuss the management goal for each EV, the relevant WQ guideline document and the relevant water quality indicators/parameters. Appendix 6 provides the relevant WQ guidelines for ‘human’ use and value EVs.

5.3.1 Irrigation and farm use

The management goal for this EV is to maintain water quality at a level suitable for a range of crops typically grown in the Fitzroy Basin and associated farm equipment.

The relevant WQ guidelines are in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000)[11].

Relevant water quality indicators/parameters include salinity (impact on crop), toxicants (impact on crop), sodicity (impact on soil structure) and pH, hardness (corrosion and fouling of equipment).

5.3.2 Stock watering

The management goal for this EV is to maintain water quality at a level suitable for successful livestock production for the range of animal species typically drinking water from waterways in the Fitzroy Basin.

The relevant WQ guidelines are in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000).

Relevant water quality indicators/parameters include salinity, blue-green algae, pathogens, toxicants and parasites (impact on animal health).

5.3.3 Aquaculture

The management goal for this EV is to maintain water quality at a level to support viable aquaculture operations with water taken from the waterways of the Fitzroy Basin.

The relevant WQ guidelines are the QWQG (DERM 2009)[12] and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000).

Relevant water quality indicators/parameters include physical, chemical and biological contaminants (impact on animal health and productivity) and tainting substances (impact on palatability).

5.3.4 Human consumption of aquatic foods

The management goal for this EV is to protect the health of humans from water quality threats posed by consuming aquatic foods (e.g. fish, shellfish) taken from the waterways of the Fitzroy Basin.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) refer to the Australian and New Zealand Food Standard Code (ANZFSC 2007)[13] for standards for chemical contaminants in food for the protection of human consumers of aquatic foods. These standards are statutory. For each chemical, standards are set for one or more food items.

Chemical contaminants are therefore the relevant indicator/parameter.

5.3.5 Recreation and aesthetics

The management goal for the primary and secondary contact recreation EVs is to protect the health of humans from water quality threats posed during recreational use of the waterways of the Fitzroy Basin.

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[11] ANZECC and ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Document 4, National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand. 2000.

[12] DERM (2009) Queensland Water Quality Guidelines, Version 3. ISBN 978-0-9806986-0-2. Department of Environment and Resource Management. September 2009.

[13] ANZFSC (2007). Australian and New Zealand Food Standard Code. 2007

The relevant WQ guidelines are in the Guidelines for Managing Risks in Recreational Water (NHMRC 2008)[14].

Relevant water quality indicators/parameters include:

- microbial quality
- algal toxins.

The management goal for the visual appreciation EV is to support aesthetically valuable flora and fauna and to be visually pleasing from the perspective of aquatic scenery and hence free from objectionable matter.

The relevant WQ guidelines are in the Guidelines for Managing Risks in Recreational Water (NHMRC 2008).

Relevant water quality indicators/parameters include:

- transparency and colour
- oil, grease and detergents
- litter
- odour.

5.3.6 Drinking water

The management goal for this EV is firstly health-related—to ensure that the quality of water supplied for treatment for human consumption does not result in adverse human health effects—and secondly, aesthetic value-related—to maintain the palatability and to ensure that the odour of drinking water is not offensive to most consumers.

The relevant WQ guidelines are in the Australian Drinking Water Guidelines. (NHMRC and NRMMC 2004)[15]. The guidelines apply to the quality of water at the point of use (e.g. kitchen or bathroom tap). They apply to reticulated water at the consumer's tap, rainwater for drinking, and source water if it is to be used without prior treatment.

Relevant water quality indicators/parameters include:

- blue-green algal toxins
- major odour compounds
- total dissolved solids
- sodium
- chloride
- pesticides (where a risk can be demonstrated).

5.3.7 Industrial uses

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) state that there are no WQ guidelines provided for industrial water. Typically, industries would pre-treat water to the standard they need for their industrial processes.

5.3.8 Cultural and spiritual values

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) state that there are no WQ guidelines provided for cultural and spiritual values. The following extract from the guidelines discusses the cultural importance of water in Australia and New Zealand:

> "Water resources have important cultural and spiritual values, particularly for indigenous peoples of New Zealand and Australia.

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[14] NHMRC (2008), Guidelines for managing risks in recreational water. Australian Government, Canberra.

[15] NHMRC and NRMMC (2004), Australian Drinking Water Guidelines. Document 6, National Water Quality Management Strategy. National Health and Medical Research Council & Natural Resource Management Ministerial Council. 2004

In Australia, indigenous cultural and spiritual values may relate to a range of uses and issues including spiritual relationships, sacred sites, customary use, the plants and animals associated with water, drinking water or recreational activities. Native title legislation, and Commonwealth and state cultural heritage legislation provide for recognition and management of indigenous interests in water.

At this stage no WQ guidelines have been developed for the protection of cultural and spiritual values in either New Zealand or Australia. Because of the lack of such guidelines, in the water management framework, cultural values can be taken into account through the process of establishing the specific WQOs for a particular water resource (similar to the process in Figure 2 in this report).

Until further work is undertaken to better define cultural and spiritual value for users in both Australia and New Zealand, managers in both countries, in full consultation and co-operation with indigenous peoples, will need to decide how best to account for cultural values within their own management frameworks. They will need to take account of existing legislation, regulations and guidelines."

5.4 Water quality guidelines for human uses and values—summary tables

Appendix 6, Tables A4 and A5 provide examples of WQ guidelines for ‘human’ uses and values for a selection of the following parameters relating to the key water quality issues in the Fitzroy Basin:

- water clarity/sediment related parameters
    - total suspended solids (TSS)
    - turbidity
    - secchi disc depth
- salinity/salts
    - electrical conductivity (a measure of salinity)
    - sulphate (SO4)
- nutrients
    - inorganic nitrogen (Ammonia-N (NH_3-N), Nitrite-N (NO_2-N), Nitrate-N (NO_3-N), NO_X=NO_2+NO_3)
    - organic nitrogen
    - particulate nitrogen
    - total nitrogen (TN)
    - filterable reactive phosphorus (FRP)
    - particulate phosphorus
    - total phosphorus (TP)
- pesticides
    - diuron
    - atrazine
    - chlorpyrifos
    - endosulfan
    - ametryn
    - simazine
    - hexazinone
    - 2,4-D
    - Tebuthiuron
    - MEMC
    - diazinon

6 Developing water quality objectives from EVs and water quality guidelines

WQOs represent the quality of water required to sustain all EVs for any particular group of waterways. WQOs are based on EVs that stakeholders and the community have identified along with the most stringent WQ guideline values (for relevant indicators/parameters) for all selected EVs. An example for the Upper Nogoa main channel is detailed below to show the process to establish WQOs (using Table 4 below to show how the EVs and WQ guidelines are combined to get the most stringent WQ guidelines for each parameter i.e. the WQOs).

Step 1: The draft EVs for the Upper Nogoa main channel (shown in Appendix 2, Table A1, third last row) are reproduced in the second column in Table 4.

Step 2: The sub-regional WQ guidelines for protection of aquatic ecosystem in the Upper Nogoa (from Table 1) are reproduced in the ‘aquatic ecosystem’ row.

Step 3: The WQ guidelines for the relevant human uses and values are taken from Appendix 6, Table A4 and reproduced in the relevant row.

Step 4: Then the most stringent WQ guideline for each indicator/parameter is highlighted in the shaded cells in Table 4. These highlighted numbers are then the WQOs (for these indicators / parameters) as they will protect all EVs for this group of waterways.

Current water quality can then be checked to see if it meets the specific WQO that has been set for each particular group of waterways in the catchment. WQOs are then used in waterway management e.g. planning, approvals and checking monitoring results (as shown at the bottom of Figure 10).

Table 4: Example of draft WQOs for the Upper Nogoa catchment

	Draft EVs	TSS	EC	SO_4	Total N	Total P	pH	pH
		mg/L	µS/cm	mg/L	µg/L	µg/L		
Upper Nogoa (main channel)	Aquatic ecosystems[1]	155	275	15	1000	350	6.5	8.5
	Irrigation[2]	ng	600-4200	ng	5000	50	6	8.5
	Farm use[2]	ng	ng	ng	ng	ng	6	8.5
	Stock water[2]	ng	0-7500	1000	ng	ng	ng	ng
	Human consumption[2]	ndr	ndr	ndr	ndr	ndr	ndr	ndr
	Primary recreation[2]	ng	ng	ng	ng	ng	6.5	8.5
	Secondary recreation[2]	ng	ng	ng	ng	ng	ng	ng
	Visual appreciation[2]	ng	ng	ng	ng	ng	ng	ng
	Drinking water[2, 3]	ng	ng	ng	ng	ng	ng	ng
	Industrial use[2]	ng	ng	ng	ng	ng	ng	ng
	Cultural and spiritual values[2]	ng	ng	ng	ng	ng	ng	ng

Notes: Draft WQOs for each parameter (i.e. the most stringent WQ guideline for each parameter) are shown in shaded cells.

[1.] Aquatic ecosystem guidelines for all catchments are shown in tables 1, 2 and 3.

[2.] 'Human use' guidelines are sourced from Appendix 6 (Table A4).

[3.] Drinking water guidelines in this table relate to WQ at consumer's tap.

ng = no guideline; ndr = nil detected residues.

6.1 WQOs for high value (HEV and SD) waterways

As outlined in section 3.3.2, an ecosystem can be graded for its water quality using a hierarchical approach according to its condition or level of disturbance. The most pristine and healthy systems are considered to be of high ecological value. The WQO for such a waterway is designed to maintain this current, natural condition. Waterways which are slightly disturbed also have water quality which is typically better than the WQOs described above. The management goals for these waterways are to maintain or improve the health of the waterway and, where possible, restore it to high ecological value.

7 Current water quality

Current water quality varies throughout the Fitzroy Basin from excellent WQ in undisturbed national parks at the top of some catchments through to impacted WQ in more downstream areas where development occurs. WQ also varies over time with rainfall and run-off causing pollutants to be washed off the various catchment land uses and routed through waterways. WQ monitoring[16] occurs at a number of sites throughout the basin by a number of organisations and for a number of different objectives. FBA and DERM are working collaboratively on a project aiming to better coordinate relevant monitoring programs and this is discussed further in section 11.

Water quality monitoring results for sites in both freshwaters and the Fitzroy estuary are provided in Appendix 7 that compare the results of current monitoring with the WQ guidelines.

The first examples provided in Figures A11–A16 are for the key freshwater WQ parameter i.e. electrical conductivity (EC) (microsiemens/centimetre) and include a comparison with the relevant sub-regional WQ guideline value for the protection of aquatic ecosystems from Table 1. These plots are for the following sampling stations:

- Coolmaringa (Mackenzie River)
- Yatton (Isaac River)
- Comet River at the Weir
- Craigmore (Nogoa River)
- Taroom (Dawson River)
- Eden Bann (Fitzroy River).

Locations of these sites are shown on Figure A6 in Appendix 5.

These examples show the WQ statistics for all the low flow data between 1 September 2007 and 1 October 2009. ‘Box and whisker’ plots are used and they show (as indicated in the legend) the following statistics from all the low flow data over this period at each sampling station:

- the minimum value from all the data

at that sampling station

- the 25th percentile from all the data

(i.e. a quarter of the values are below this level)

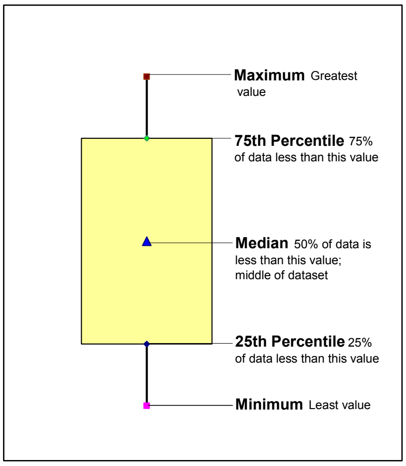
- the median from all the data

(i.e. half the values are below this level)

- the 75th percentile from all the data

(i.e. three quarters of the values are below this level)

- the maximum value from all the data.



The final piece of information on each graph is the relevant draft WQ guideline from Table 1 (shown as the extended red horizontal line). For a general comparison of current water quality (for non-toxic parameters) with the WQ guidelines, the national WQ guidelines recommend using the ‘median’.

In summary, the median values for all the six freshwater examples meet the WQ guideline value relevant to their catchment.

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[16] Region map for the Fitzroy, Pioneer, Plane, Waterpark areas on the DERM website at: <www.derm.qld.gov.au>.

Regional Water Quality Monitoring and Reporting on the FBA website at: <www.fba.org.au>.

Water quality information on the Fitzroy River website: <www.fitzroyriver.qld.gov.au>

The second sets of plots in Appendix 7, Figures A17-A21, are for an upper estuary site (57.3 km from the mouth – about 2.5km downstream of the barrage at Rockhampton) and a mid-estuary site (20km from the mouth).

The plots are for the following key estuarine WQ parameters of chlorophyll a, total nitrogen, total phosphorus, turbidity and dissolved oxygen (respectively). These plots show the median values for all the data between 1 October 2007 and 30 September 2009, together with the relevant WQ guideline values.

The total nitrogen and phosphorus data show elevated levels due to the point source discharges around Rockhampton (e.g. treated sewage plant effluent) to these upstream reaches. However, because of the light limitations (see turbidity levels), these nutrient levels do not result in major growth of algae (as would be evidenced by elevated levels of chlorophyll a). In low flow situations, these estuarine stores of nutrients are gradually dispersed downstream in the estuary, then in high flows, are flushed out of the estuary and into Keppel Bay. The dissolved oxygen levels at the upstream site show some high values due to the algal growth that is able to occur in the upper layers where light is available. The mid-estuary turbidity levels reflect the higher tidal velocities in this area which resuspend the fine sediment that has been deposited.

8 Links to water planning and management

Figure 2 shows the process recommended in the NWQMS to develop catchment based WQ management plans. To comply with the NWQMS, this same process is used in the Queensland Government's *Environmental Protection (Water) Policy 2009*—the EPP (Water)—which calls these plans healthy waters management plans (section 24). In this context, this project has used the process in the EPP (Water) to establish EVs and WQOs and hence completed important components of a healthy waters management plan (HWMP) for the Fitzroy Basin.

Numerous other activities have progressed other components of a HWMP as discussed in this report. This section provides an overview of links to water planning and management that will assist in achieving the WQOs and hence protecting the EVs. FBA intends to lead a project to update the WQ management component of CQSS2 and develop a HWMP in CQSS3 in the 2010–11 financial year. That HWMP will update and consolidate planning and management actions towards achieving WQOs, as well as the monitoring, evaluation and reporting process to measure progress (and if necessary, continue to adaptively manage these actions).

The basin-wide information day for this project[17] (19 March 2010) was structured to provide detail in line with this framework and included presentations on relevant activities for all components of the framework. The planning and management component (i.e. the combinations of 'alternative management strategies' referred to in Figure 2) and the associated impact assessments and tools are discussed in sections 8-10 to provide context for these activities and how they relate to EVs and WQOs.

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[17] Consultation workshops and basin-wide information day details are on the FBA website: <www.fba.org.au>.

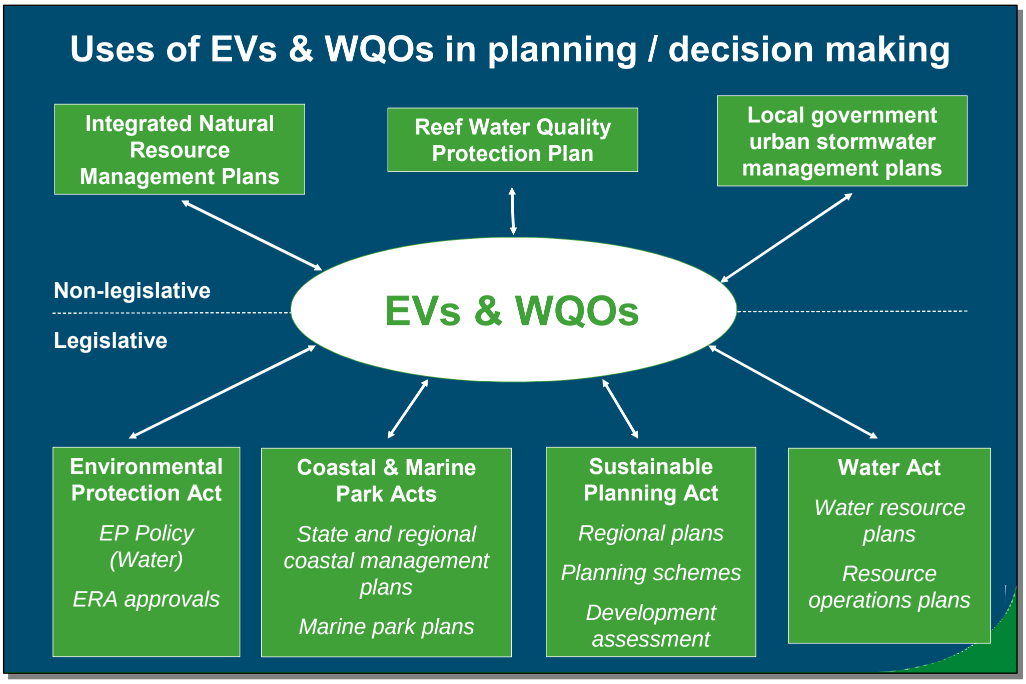

Figure 11: Planning and decision making processes relevant to achieving WQOs

Figure 11 shows the key planning and management processes relevant to achieving WQOs and hence protecting the EVs, including:

- Environmental Protection Act and EPP (Water)—set up the WQ management process (and HWMPs) and a key operational function is determining environmental authorities for environmentally relevant activities (ERAs) e.g. point source discharges from sewage treatments plants and industry (e.g. mining, aquaculture) operations
- Coastal and Marine Parks Acts—planning and management of activities in coastal zones and marine parks
- Sustainable Planning Act (SPA) and state planning policies—regional and local government planning and development assessment for future urban development. Larger local governments have developed or are developing their own urban stormwater management plans to manage urban stormwater pollution. These are a requirement under the EPP (Water) as part of total water cycle management plans and will be required by the forthcoming state planning policy for healthy waters to be considered when developing a local and regional planning instrument under the SPA
- Water Act—planning and management of water flow regimes
- integrated natural resource management plans (such as CQSS2)—a key component of these plans is assessing, prioritising and identifying responsible implementers and managing funding support for management actions to improve water quality (typically focusing on pollution from rural diffuse sources)
- Reef Water Quality Protection Plan—aims to reduce the load of key pollutants (sediments, nutrients and pesticides) entering the Great Barrier Reef, as well as protecting natural functioning of wetlands and flood plains that improves water quality
- Local government urban stormwater plans – refer to comments in Sustainable Planning Act above

The key mechanisms for managing pollution from point sources, urban and rural diffuse sources, and the role of EVs and WQOs, are discussed below.

8.1 Point sources

EVs and WQOs are one of a number of criteria specified in the *Environmental Protection Act 1994* used in considering environmental applications such as licensing approvals (i.e. environmental authorities for ERAs).

The numbers contained in a WQO can be the same as or different from those specified in an environmental approval under the Environmental Protection Act, depending on individual circumstances. The potential for variation is because WQOs apply to the receiving water while the environmental approval relates to the discharge quality from a particular activity. Furthermore, the context of the discharge is relevant in determining what type of WQO or guideline is important. For example, a continuous discharge from a sewage treatment plant is much more likely to affect 'ambient' conditions of a waterway compared to an infrequent event-based release from a mine. In addition, the type of contaminants in the discharge will determine the mechanism of impact and the type of WQO/WQ guideline that is important. For event-based releases of toxicants, biological effect guidelines and potential toxic mixing zones may be the key consideration in terms of determining appropriate discharge criteria and conditions. For continuous release of nutrients, reference-based guidelines and consideration of sustainable loads to achieve WQOs are more likely to be important for determining suitable discharge criteria and conditions.

As mentioned, EVs and WQOs are only one of a number of criteria to be considered when assessing environmental applications. Others include best practice environmental management, the public interest and the resilience of the receiving environment. For information on the process of assessing point source discharges under the *Environmental Protection Act*, refer to the department's operational policy (2008)[18].

Following the floods in early 2008 and the subsequent discharges of water from flooded mine operations, DERM has worked with all the mining operators and, using a standardised approach, has reviewed and revised the conditions of all their environmental authorities. This has also resulted in the mining operations designing and implementing receiving environment monitoring programs that they are required to report to DERM on by October 2011.

The WQOs are also used to assess the results from receiving environment monitoring programs to check if regulation of such discharges is having the desired result.

8.2 Rural diffuse sources

Typically, catchment-based WQ management plans (i.e. HWMPs) provide the mechanism to formulate, assess and prioritise rural diffuse source management actions. For example, the management actions to address reductions in sediment loads in CQSS2 and the Fitzroy Water Quality Improvement Report are the result of such planning. For HWMPs, WQOs become the receiving water 'target' that allows catchment and receiving water modelling to assess alternative combinations of management strategies/actions and prioritise these on the basis of the WQ improvement they achieve (For cases where WQ needs improving towards the WQO, the aim is to achieve the 'sustainable' load which will result in achieving the WQO).

8.3 Urban diffuse sources

With future urban development, the hierarchy for best achieving WQOs is firstly in configuring the 'urban footprint' under regional plans and local government planning schemes, then in assessing, conditioning and approving development proposals. The WQOs can be used, in regional and local government planning, the same way as for catchment-based WQ management plans (i.e. HWMPs). At both planning levels, alternative patterns of development (i.e. the future options for urban footprints) can be modelled to check the best compatibility with achieving the WQOs.

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[18] DERM (2008). Operational Policy—Waste water discharge to Queensland waters. Queensland Department of Environment and Resource Management. 2008. <www.derm.qld.gov.au>.

9 Considering economic and social impacts of protecting environmental values

The EPP (Water) requires consideration of the economic and social impacts of protecting the EVs for the waters, as part of the statutory process to include the environmental values and water quality objectives in Schedule 1.

DERM commissioned Marsden Jacob Associates (MJA) Pty Ltd to undertake a desktop study to consider the economic and social impacts. The report[19] is included in the public consultation documents and the executive summary is reproduced below.

This project's assessment of the economic and social impacts is informed by the complementary study of protecting the environmental values for the Great Barrier Reef waters, also completed by Marsden Jacob and Associates (2010)[20] .

Both of the above mentioned reports are published on the department's website at <www.derm.qld.gov.au>.

The FBA's current WQ management plan for the Fitzroy Basin is being updated this financial year. It provides the opportunity to establish, in more detail, the agreed priority combination of management strategies for point sources, urban and rural diffuse sources to achieve the WQOs, as well as a monitoring and evaluation program to track progress.

9.1 Overview of findings of Marsden Jacob Associates report—The economic and social impacts of protecting the environmental values of the Fitzroy Basin waters.

9.1.1 Background and study purpose

Under the Queensland Government's *Environmental Protection (Water) Policy 2009*, environmental values (EVs) and water quality objectives (WQOs) are being established for the Fitzroy Basin. EVs relate to the values or uses that are reliant on water quality, while the WQOs represent the measured quality of water required to sustain all values and uses for that waterway (e.g., salinity or sediment concentrations etc). EVs, management goals and WQOs are key parts of the framework for managing Queensland's water environment.

Marsden Jacob Associates (MJA) has been engaged by the Department of Environment and Resource Management (DERM) to undertake a desktop study to identify and scope the economic and social implications of protecting the EVs by achieving WQOs in the Fitzroy Basin. All rural diffuse, urban diffuse and point sources of pollutants are within scope of this report.

9.1.2 Key findings

Management of pollution loads into waterways provides a wide range of benefits both within those waterways, but also in the marine environment adjacent to the catchments in the Fitzroy Basin (part of the Great Barrier Reef (GBR)). The key socio-economic benefits of achieving the WQOs are derived from managing pollution loads and avoiding the costs to businesses and the community (including environmental costs) that would accrue from a further decline in water quality. The key socio-economic costs are the monetary costs of management actions to maintain or improve receiving water quality.

At a basin-wide scale, the dominant source of sediment and nutrient loads are from rural land use, particularly grazing. However, our analysis also demonstrates that a major source of water quality degradation risk in the Fitzroy Basin stems from *point sources* in the mining and energy sectors, and the associated flow-on economic activity. In the case of coal mines, the conditions of environmental authorities under the *Environmental Protection Act 1994* were amended in 2009[21] to further address contaminated stormwater discharge to receiving waters, and this is reflected in the business-as-usual case of this report.

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[19] MJA (2010) The economic and social impacts of protecting the environmental values of the Fitzroy Basin waters. Report prepared by Marsden Jacobs Associates. October 2010. <www.derm.qld.gov.au>.

[20] MJA (2010) The economic and social impacts of protecting the environmental values in Great Barrier Reef catchment waterways and the reef lagoon. Report prepared by Marsden Jacobs Associates. March 2010. <www.derm.qld.gov.au>.

[21] Final Model Water Conditions for Coal Mines in the Fitzroy Basin, Department of Environment and Resource Management, August 2009, Pers. Comm.

Key benefits of meeting water quality objectives

Key socio-economic benefits (avoided costs) in the inland and the GBR areas of the Fitzroy Basin from achieving the WQOs relate to:

- **Human health.** Ensuring human health is maintained through reducing risks to water supplies and waters where human contact is likely.
- **Ecosystem function and services.** Provision of ecosystem function and services, most of which relates to the unpriced social values of protecting biodiversity and ecosystem function. Previous studies suggest that even a 1% change in the condition of inland waters health has a social value of around $11.6 million to the local community. Furthermore, benefits attributable to enhancing marine ecosystem function and services could be significantly higher, particularly if sediment reduction targets are met.
- **Primary industries,** as a water dependent sector. Primary industries with a gross value of production of approximately $1.2 billion per annum could be adversely impacted by declining water quality, particularly where salinity levels and drought affect irrigation crops and impact on cattle production.
- **Industrial users.** Many industrial uses of water are reliant on specific water quality. Poor water quality can considerably increase the costs of some industrial processes.
- **Water treatment.** As water quality declines, potable water treatment costs increase. Increased salinity could trigger significant water treatment costs (potentially increasing costs to $1,600 to $3,000 / ML of potable water supply). A 10% increase in the turbidity of source water for Fitzroy River Water could increase their treatment costs by as much as $120,000 per annum.
- **Tourism.** Turnover in the tourism sector in the Fitzroy Basin (both inland and in the GBR) is estimated to be worth in excess of $700 million per annum and much of the sector is strongly reliant on enjoyment and use of the region’s natural resources.
- **Commercial fishing.** Commercial fishing is also partially reliant on water quality to maintain and enhance stocks. The benefits of enhanced water quality will primarily accrue to owners of the commercial fishing fleet. Across the GBR catchments, the commercial fishing sector is worth in excess of $100 million per annum (primarily in the northern GBR catchments).
- **Recreational fishing.** Recreational fishing is a major recreational pastime in the Fitzroy, enjoyed by residents and visitors alike. It is estimated that annual expenditure is approximately $35 million.
- **Visual and aesthetic amenity.** Visual and aesthetic amenity is related to maintaining waterway health, which can have an impact on property prices.
- **Cultural and spiritual values.** Such values could be negatively impacted by declines in water quality, particularly those relating to significant sites and the connections of Indigenous communities to land and waters.

Managing diffuse loads

Diffuse loads are already a major focus of planning, management and investment in the Fitzroy, particularly in relation to:

- Rural diffuse loads. A series of actions and investment to reduce erosion from agricultural activities are already underway (particularly increasing ground cover). The cost of reducing sediment loads by 750,000 tonnes over 10 years (the target) has previously been estimated at between $36 and $51 million in present value terms. There is some data available to suggest that landholders are already investing around 2% of their income in enhanced natural resource management, in addition to funding via government programs; and
- Urban diffuse loads. Under the Queensland Development Code (under the *Building Act 1975*) and the State Planning Policy for Healthy Waters, there are requirements for enhanced stormwater management in urban areas, including via water sensitive urban design (WSUD) in greenfield developments. The cost of achieving this policy has previously been estimated at around $54-80 million over the next 10 years (based on anticipated dwelling growth rates). This equates to an extra 1-2% of the cost of establishing a new home.

Managing point sources

For point source loads, the benefits of meeting WQOs are often relatively modest under pollution concentrations typically experienced in recent years. This is because the impacts of cumulative discharges can often be within the assimilative capacities of the receiving waters (that is, the WQOs are not exceeded). The substantial socio-economic benefits of achieving the WQOs from managing point source loads relate to:

- Mitigating the more extreme and infrequent high rainfall situations when the release of contaminated stormwater can result in high salinity concentrations in receiving waters, with potentially significant environmental and socio-economic risks.
- Reducing the risks (frequency and magnitude) attributable to cumulative discharges expected under growth scenarios for the mining and energy sectors.
- Managing the nutrient emissions from wastewater treatment plants.

The issue mentioned under the first dot point above has been addressed in amended environmental authority conditions for all coal mines. Under the amended environmental authority conditions implemented in 2009, contaminated stormwater discharges from coal mines must maintain in-stream EC levels (a measure of salinity) of below 1000 uS/cm, or below 750 uS/cm depending on location. This is specifically designed to avoid potential impact on any drinking water reservoirs immediately downstream of the discharge.

Future policy and management challenges

The key emerging challenges for water quality management in the Fitzroy are twofold:

- For diffuse loads, the challenge will be to reduce existing loads at the lowest cost to the community, via targeted actions and investments.
- For point source loads, the key challenge will be to manage the downside environmental and socio-economic risks associated with current and future economic activity, without imposing excessive compliance costs on regulated emitters and unnecessarily constraining economic growth.

Careful and robust analysis is required to ensure that the amended environmental authorities for coal mines are effective in mitigating material risks and remain economically efficient. Cumulative impact modelling of contaminated stormwater discharges by coal mines and future coal seam gas wastewater discharges will refine the approaches to managing these risks to water quality.

All rural and urban diffuse and point source emitters have a major vested interest in ensuring risks to vital natural assets that underpin regional economic activity and enhance community values are managed and these assets maintained.

10 Considering environmental impacts of protecting environmental values

In developing Healthy Waters Management Plans (HWMP), catchment and receiving water quality models are used to assess the impacts of combinations of alternative management strategies. The catchment models simulate the run-off of pollutants from all the catchment sources and result in loads of pollutants delivered to the receiving waters. Then the receiving water model simulates the movement and transformations of these pollutants through the receiving waters, predicting concentrations of the pollutants. These concentrations can be compared to the achievement of the WQOs (and hence protection of EVs). The simulation of various strategies then assists in choosing the best management strategy to be implemented.

The Fitzroy Basin Water Quality Improvement Report (FBA 2008) included this type of assessment for sediments and nutrients (shown graphically in Figure 12) and will be a key resource in developing the Fitzroy Basin HWMP in CQSS3. Another project currently underway is the development of a receiving WQ model for the freshwater reaches of the Fitzroy Basin. This will allow prediction of the salinity levels in these reaches and assessment of relevant management strategies. This will also assist in developing the HWMP.

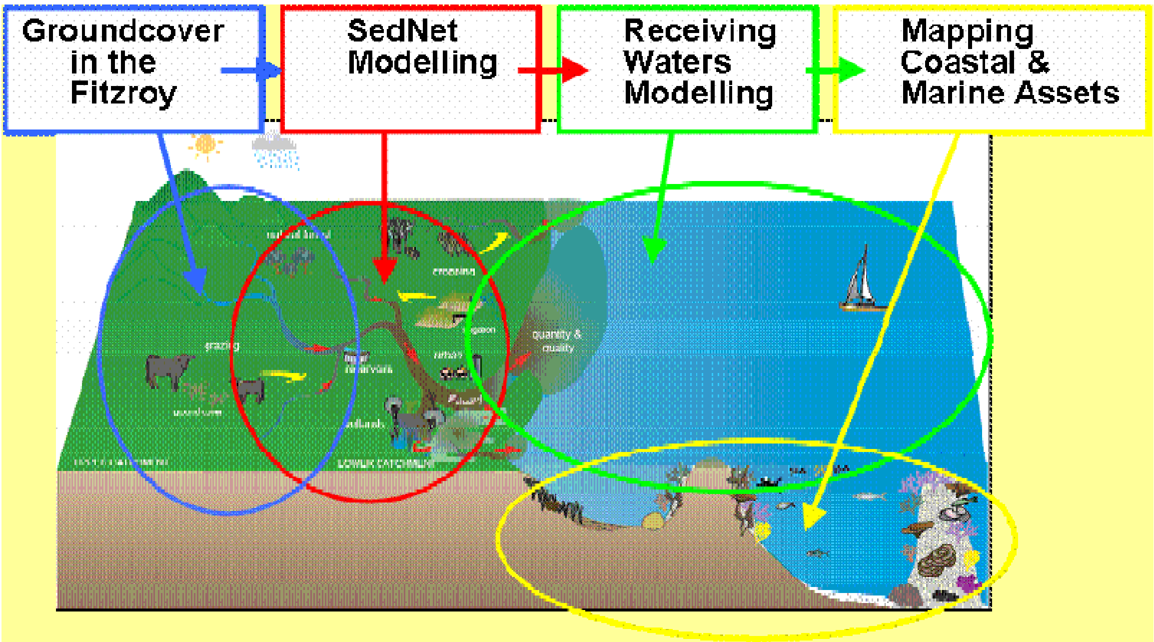


Figure 12: Modelling and studies for the Fitzroy Water Quality Improvement Report (FBA 2008)

11 Monitoring, evaluation and reporting

The NWQMS provides for monitoring, evaluation and reporting activities within the above WQ management framework. A key objective of monitoring activities aligned to this framework is tracking of waterway condition and trend according to the WQOs set through this EVs and WQOs process for the Fitzroy Basin. Other monitoring program objectives aligned to the above framework components include: monitoring of reference sites to allow for refinement of WQ guidelines; monitoring of management actions being implemented to assist in evaluating water quality progress towards defined WQOs; monitoring the effectiveness of management actions to help plan the most effective management actions to implement; and collection of calibration and validation data for the mathematical models used to assess alternative management strategies.

Waterway monitoring in the Fitzroy Basin spans over 30 years with an initial focus on water quantity monitoring undertaken by the Queensland Government. Subsequent monitoring was implemented through the now Central Queensland University, the Downstream Effects of Land Use study, the Great Barrier Reef Marine Park Authority, Waterwatch and Sedimentwatch programs. Queensland Government monitoring continued to expand with addition of Water Resource Plan, Estuarine and State of the Rivers monitoring. The formation of the Coastal CRC (1999–2006) resulted in coordinated cross-disciplinary monitoring programs during this period. The Coastal CRC programs were followed by monitoring associated with the National Action Plan for Salinity and Water Quality and the Reef Water Quality Protection Plan 2003. Under the *Environmental Protection Act*, holders of environmental authorities are required to monitor both the WQ of their point source discharges and the impacted receiving environment.

Despite this long monitoring history, recent evaluations for this project have confirmed there are limitations on data for WQ at reference sites suitable for informing the setting of local WQ guidelines. Appendix 5 reports on the evaluation of available data, as well as the current departmental program to fill some of these gaps and identify further program needs.

In recent times, the responsibility of waterway monitoring, evaluation and reporting in the Fitzroy has fallen to an increasing range of parties. This has resulted in greater complexity and an increased difficulty in coordinating the evaluation and reporting of monitoring data. A partnership approach has been identified in the statewide monitoring framework report as a suitable model to meet the need for an integrated monitoring and reporting approach.

The Fitzroy Partnership for River Health is being established to involve all parties in coordinating collective monitoring, evaluation and reporting effort across the Fitzroy Basin. Once established, this partnership aims to have the role of caretaker of waterway monitoring and reporting for the relevant programs across the Fitzroy Basin.

There are several concurrent monitoring initiatives being implemented at a spatial scale relevant to the Fitzroy Basin. To ensure partnership success, coordination/integration and enhancement of these initiatives rather than re-invention is paramount. Major current initiatives include:

- Reef Water Quality Protection Plan monitoring, modelling, evaluation and reporting relevant to the agricultural industry impacts on Reef health which is being implemented across the GBR catchments including the Fitzroy Basin
- Fitzroy Basin Water Resource Plan monitoring, evaluation and reporting associated with the capture and supply of bulk water
- monitoring programs for point source discharges from mining and industry operations within the Fitzroy Basin relevant to the Queensland *Environmental Protection Act*
- water management plan monitoring, evaluation and reporting associated with domestic water suppliers in the Fitzroy Basin relevant to the Queensland *Water Supply Act*.

Coordination, integration and enhancement of relevant monitoring initiatives will allow for delivery of a common monitoring, evaluation and reporting framework that meets the needs of partners while adding value to the knowledge base and providing a more efficient and effective long term solution for the Fitzroy Basin to deliver on a wider range of monitoring program objectives. The Fitzroy Partnership for River Health’s Strategic Working Group is currently considering a range of monitoring and reporting objectives including a basin-wide river health report and those relevant to the NWQMS and other monitoring initiatives outlined above.

12 Future directions

As discussed throughout this report, the EVs and WQOs provide the basis for water quality planning and decision making and hence this report, when finalised, will be used for these activities. As well, this report has identified areas where further information is required. Future programs will assist with refining the EVs and WQOs. This section provides an overview of key future directions in using and improving the EVs and WQOs.

12.1 Scheduling EVs and WQOs

As identified in the project plan and discussed at relevant sections in this report, the department will undertake a subsequent process to schedule these EVs and WQOs under the EPP (Water) 2009. The process for doing this is set out in section 12 of the EPPW and DERM will aim to complete this process by early 2011.

12.2 High value waterways

The 'champions' workshop recommended that this project focus the discussion and decisions on high value waterways to national parks and State lands. DERM is currently undertaking more scientific assessments of conservation/ecological values of the Fitzroy Basin waterways, as well as collecting more data on reference sites (see section 12.4). The opportunity exists in the future to further refine high value waterways as this further technical information becomes available.

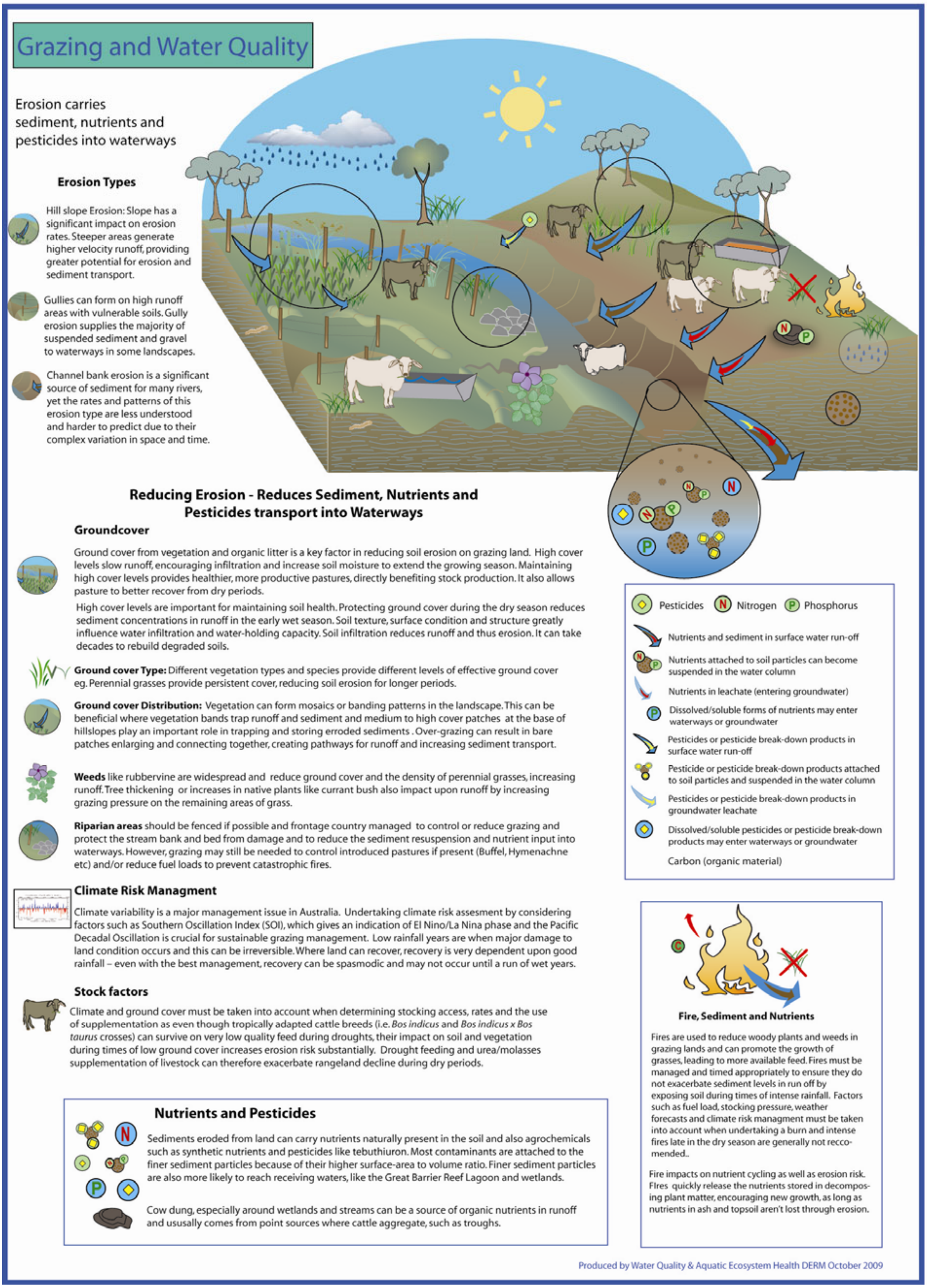
12.3 Fitzroy Healthy Waters Management Plan

FBA have received Q2 Coasts and Country funding for 2010–11 financial year to update CQSS2 to CQSS3 and include a Healthy Waters Management Plan (HWMP) as the water quality management component of CQSS3. The department will assist in this process to ensure the HWMP is compatible with section 24 of the EPP (Water). As indicated, this task will bring together all the recent work, since CQSS2, and synthesise it into the plan for priority water quality management actions to achieve the WQOs over the next five to seven years.

12.4 Water quality guidelines

This project included development of WQ guidelines for protection of lowland freshwater aquatic ecosystems based on local reference site data (Appendix 5). Where the currently available data was sufficient, it was used to derive WQ guidelines for low flow conditions. However, as reported in Appendix 5, there were insufficient data for a number of parameters, for other water types and for high flow conditions. Therefore, when sufficient data is available, these guidelines will need to be updated. A project is currently underway to collect some of this data and to set priorities for future data collection.

Appendix 1: Conceptual models



Grazing and Water Quality

Erosion carries sediment, nutrients and pesticides into waterways

Erosion Types

Hill slope Erosion: Slope has a significant impact on erosion rates. Steeper areas generate higher velocity runoff, providing greater potential for erosion and sediment transport.

Gullies can form on high runoff areas with vulnerable soils. Gully erosion supplies the majority of suspended sediment and gravel to waterways in some landscapes.

Channel bank erosion is a significant source of sediment for many rivers, yet the rates and patterns of this erosion type are less understood and harder to predict due to their complex variation in space and time.

Reducing Erosion - Reduces Sediment, Nutrients and Pesticides transport into Waterways

Groundcover

Ground cover from vegetation and organic litter is a key factor in reducing soil erosion on grazing land. High cover levels slow runoff, encouraging infiltration and increase soil moisture to extend the growing season. Maintaining high cover levels provides healthier, more productive pastures, directly benefiting stock production. It also allows pasture to better recover from dry periods.

High cover levels are important for maintaining soil health. Protecting ground cover during the dry season reduces sediment concentrations in runoff in the early wet season. Soil texture, surface condition and structure greatly influence water infiltration and water-holding capacity. Soil infiltration reduces runoff and thus erosion. It can take decades to rebuild degraded soils.

Ground cover Type: Different vegetation types and species provide different levels of effective ground cover eg. Perennial grasses provide persistent cover, reducing soil erosion for longer periods.

Ground cover Distribution: Vegetation can form mosaics or banding patterns in the landscape. This can be beneficial where vegetation bands trap runoff and sediment and medium to high cover patches at the base of hillslopes play an important role in trapping and storing eroded sediments. Over-grazing can result in bare patches enlarging and connecting together, creating pathways for runoff and increasing sediment transport.

Weeds like rubbervine are widespread and reduce ground cover and the density of perennial grasses, increasing runoff. Tree thickening or increases in native plants like currant bush also impact upon runoff by increasing grazing pressure on the remaining areas of grass.

Riparian areas should be fenced if possible and frontage country managed to control or reduce grazing and protect the stream bank and bed from damage and to reduce the sediment resuspension and nutrient input into waterways. However, grazing may still be needed to control introduced pastures if present (Buffel, Hymenachne etc) and/or reduce fuel loads to prevent catastrophic fires.

Climate Risk Managment

Climate variability is a major management issue in Australia. Undertaking climate risk assesment by considering factors such as Southern Oscillation Index (SOI), which gives an indication of El Nino/La Nina phase and the Pacific Decadal Oscillation is crucial for sustainable grazing management. Low rainfall years are when major damage to land condition occurs and this can be irreversible. Where land can recover, recovery is very dependent upon good rainfall – even with the best management, recovery can be spasmodic and may not occur until a run of wet years.

Stock factors

Climate and ground cover must be taken into account when determining stocking access, rates and the use of supplementation as even though tropically adapted cattle breeds (i.e. *Bos indicus* and *Bos indicus x Bos taurus* crosses) can survive on very low quality feed during droughts, their impact on soil and vegetation during times of low ground cover increases erosion risk substantially. Drought feeding and urea/molasses supplementation of livestock can therefore exacerbate rangeland decline during dry periods.

Nutrients and Pesticides

Sediments eroded from land can carry nutrients naturally present in the soil and also agrochemicals such as synthetic nutrients and pesticides like tebuthiuron. Most contaminants are attached to the finer sediment particles because of their higher surface-area to volume ratio. Finer sediment particles are also more likely to reach receiving waters, like the Great Barrier Reef Lagoon and wetlands.

Cow dung, especially around wetlands and streams can be a source of organic nutrients in runoff and ususally comes from point sources where cattle aggregate, such as troughs.

◇ Pesticides N Nitrogen P Phosphorus

- Nutrients and sediment in surface water run-off
- N P Nutrients attached to soil particles can become suspended in the water column
- Nutrients in leachate (entering groundwater)
- P Dissolved/soluble forms of nutrients may enter waterways or groundwater
- Pesticides or pesticide break-down products in surface water run-off
- Pesticide or pesticide break-down products attached to soil particles and suspended in the water column
- Pesticides or pesticide break-down products in groundwater leachate
- ◇ Dissolved/soluble pesticides or pesticide break-down products may enter waterways or groundwater
- Carbon (organic material)

Fire, Sediment and Nutrients

Fires are used to reduce woody plants and weeds in grazing lands and can promote the growth of grasses, leading to more available feed. Fires must be managed and timed appropriately to ensure they do not exacerbate sediment levels in run off by exposing soil during times of intense rainfall. Factors such as fuel load, stocking pressure, weather forecasts and climate risk managment must be taken into account when undertaking a burn and intense fires late in the dry season are generally not reccomended..

Fire impacts on nutrient cycling as well as erosion risk. FIres quickly release the nutrients stored in decomposing plant matter, encouraging new growth, as long as nutrients in ash and topsoil aren't lost through erosion.

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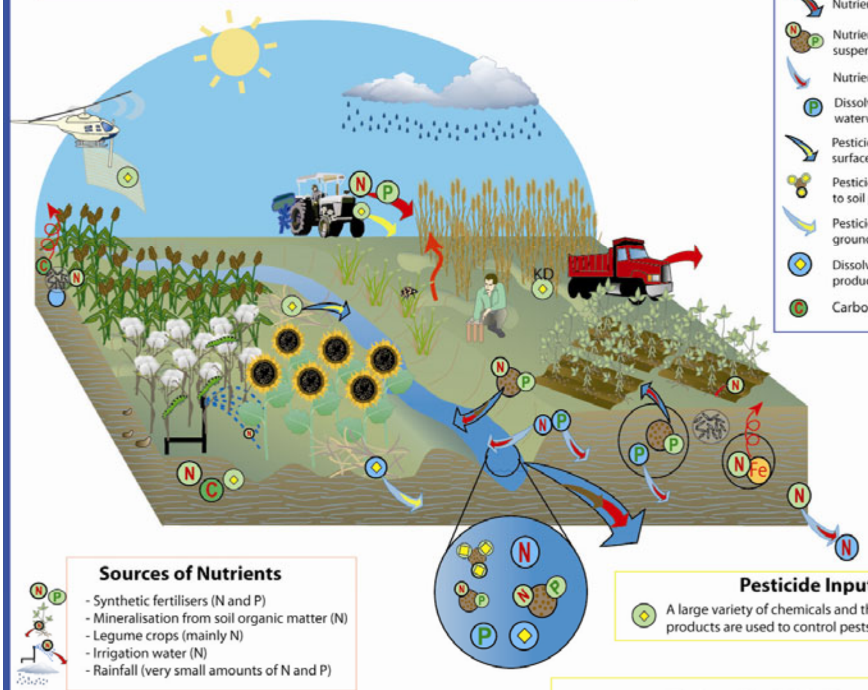
Broadacre Cropping and Water Quality



◇ Pesticides N Nitrogen P Phosphorus

- Nutrients and sediment in surface water run-off
- Nutrients attached to soil particles can become suspended in the water column
- Nutrients in leachate (entering groundwater)
- Dissolved/soluble forms of nutrients may enter waterways or groundwater
- Pesticides or pesticide break-down products in surface water run-off
- Pesticide or pesticide break-down products attached to soil particles and suspended in the water column
- Pesticides or pesticide break-down products in groundwater leachate
- Dissolved/soluble pesticides or pesticide break-down products may enter waterways or groundwater
- Carbon (organic material)

Sources of Nutrients

- Synthetic fertilisers (N and P)
- Mineralisation from soil organic matter (N)
- Legume crops (mainly N)
- Irrigation water (N)
- Rainfall (very small amounts of N and P)

Reduce Nutrient Requirements

Use a legume break crop to input organic nitrogen into the soil

Soil testing and crop mapping allow for fine tuning of nutrient input, to ensure no more than optimal quanitites are used

Reduce soil disturbance through controlled traffic farming and retaining the trash blanket. This increases soil reserves of organic matter, which plays an important role in the retention and cycling of soil nutrients, particularly N

Manage Nutrient Application

To reduce risk of waterway contamination ensure fertilisers are applied at:

- the right rate and frequency,
- the right timing in relation to rainfall, irrigation, fertigation, soil moisture and crop stage,
- the right place (generally as close to the root zone as possible).
- with application equipment that is calibrated, maintained and checked for accuracy of distribution

Nutrient Loss Pathways

-Run-off (N and P in soluble and particulate forms and attached to sediment particles)

-Denitrification and volatilisation (N)

-Crop growth and removal of harvested product (N and P)

-Leaching into the groundwater system (soluble forms of N and P)

-Chemo-denitrification in the groundwater (where nitrate is reduced to nitrogenous gases) (N)

Reducing Run off - Reduces Sediment, Nutrients and Pesticides transport into Waterways

Use contour drains to minimise run-off.

Maintain vegetation cover during typically rainy periods to minimise run-off and leaching.

Minimum tillage and retaining crop residues improves soil structure and health, reducing erosion, and improves soil moisture retention, reducing irrigation requirements.

Farm designed with water return systems to re-use water and capture "first flush" storm run off

Pesticide Inputs

A large variety of chemicals and their associated breakdown products are used to control pests (including insects and weeds).

Reduce Pesticide Requirements

The best way to reduce pesticide impacts on water quality is to use less and and to only use knockdown chemicals with no residual effects. Combined with a farming system that interrupts early phases of pest lifecycles, an integrated pest management (IPM) program will control pests over the whole crop cycle with residual chemicals only used strategically in fallow and plant crops and not at all in ratoon crops. Regional climate effects the ability to implement such a program

Reduce pesticide requirments: varietal selection for 'inbuilt' insect resistance

Crop rotations break disease and pest cycles

Preserve native vegetation along rivers and creeks. This can provide a natural breeding ground for beneficial insects that prey on pests and help protect waterways from run-off

Increasing the soil's organic carbon content, through practices such as applying manure, retaining crop residues and/or incorporating cover crops into the soil, increases the efficiency of water and pesticide use. While maintaining good soil health in general, with diverse and active soil biology promotes healthy crops that are more resistant to pests and diseases .

Only using pesticides if pest numbers exceed threshold levels and limit blanket sprays in favour of spot applications

Use "trap" crops to isolate pest species and reduce the areas requiring pesticides

Pupae busting to 'mechanically' remove pests before they become a problem

Manage Pesticide Application

Managing application timing in relation to rainfall, crop stage, pest lifecycle stage, irrigation and weather conditions is crucial in ensuring effective treatment, reducing run-off, reducing leachate into groundwater and non-target contamination.

Where possible select environmentally friendly pesticides, such as oils, soaps and biological control agents, and narrow-spectrum pesticides instead of broad-spectrum pesticides.

Application Method Ensuring correct nozzle use, boom height and spray amount and pressure, or the use of interrow directed sprays or tractor mounted shielded spray units minimises the risk of contamination to non-target areas.

Pesticide Loss Pathways

-Erosion and run-off of treated soils either attached to soil and organic matter or dissovled in surface water

-Leaching into the groundwater

-Run-off from residues of decaying material from treated crops

-Breakdown through biotic processes (aerobic and anaerobic) in soil and water

-Chemical break down and exposure to sunlight, both potentially resulting in a suite of break down products. However break down in water by sunlight can only occur when turbidity is low.

-To a lesser extent: volatilisation; transport with dust particles; groundwater discharge and from direct application (spray drift - if application is not managed correctly).

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Appendix 2: Environmental values and sources of information used to assist identification of human uses/values for the Fitzroy Basin

Environmental values

Environmental value	Supporting details		Questions
Human uses/values			
Primary industries		Irrigating crops such as cotton, citrus, grapes, hay	Where is water used for irrigation? What crops are irrigated?
		Water for farm use such as milking sheds, vehicle wash-down, piggeries, feedlots	Where is the water used around farms for washing down areas or fruit packing?
		Stock watering	Where is the water used for watering stock? What type of stock?
		Water for aquaculture such as prawns, barramundi	Where is the water used in aquaculture operations and what species are cultivated?
		Human consumption of wild or stocked fish or crustaceans	Where is there consumption of wild or stocked fish or crustaceans
Recreation and aesthetics		Primary recreation with direct contact with water, e.g. swimming, snorkelling, skiing	Are there any recreational activities where people are fully immersed in the water? If so, where?
		Secondary recreation with indirect contact with water, e.g. sailing, canoeing, boating, rafting, wading	Are there any recreational activities where people are possibly splashed with water e.g. fishing, boating, sailing? If so, where?
		Visual appreciation—no contact with water e.g. bushwalking, picnicking, sightseeing	What areas of waterways are regularly used by people who enjoy looking at and being near the waterway?
Drinking water		Raw drinking water supplies	Where do people or local governments take water from the river for water supplies?
Industrial uses		Water for industrial use, e.g. power generation, manufacturing plants	What are the industries that take water from the river for their operations and where does this occur?
Cultural and spiritual		Cultural and spiritual values	What are the cultural and spiritual values associated with these waterways?

Aquatic ecosystems			
Aquatic ecosystems	🐟	Pristine or modified aquatic ecosystems—three possible 'levels of protection' apply (see Level 1—HEV systems below)	
High conservation/ecological value systems (HEV)		Systems are largely unmodified. Often found in national parks, conservation reserves or inaccessible locations. Targets aim to maintain no discernable change from this natural condition (i.e. no physical, chemical and biological change)	Are waterways largely unmodified or changed very little? Where are they?
Environmental management goals for all aquatic ecosystems		Estuarine	What components of these ecosystems do you want to protect e.g. seagrasses, mangroves, turtles, fish, shellfish?
		Freshwater	What components of these ecosystems do you want to protect e.g. turtles, fish, macroinvertebrates, riparian vegetation, in-stream habitats, flows?

Process and tools used to assist identification of human uses/values for Fitzroy Basin

The main objective of the workshops was to discuss and record the community's collective knowledge of EVs for the relevant waters. To support these workshops, the project team collated available information on uses and values that would assist the attendees. This information is detailed below. A Geographic Information System (GIS) was compiled with this information and was used as a discussion support tool. It allowed workshop attendees to 'zoom in' to local areas and see their waterways on the remote sensed images and other information layers outlined below.

For most workshops, examples of the most commonly used information layers were the 'licensed aquaculture' layer for the 'aquaculture' EV; and the 'grazing' and 'cropping' land use layers for the 'stock water' and 'irrigation' EVs respectively.

The project team developed a 'land use' map and a 'satellite image' map for each of the ten catchment areas (Figures A1 and A2 are examples of these maps for the Upper Nogoa catchment). The GIS operator was then able to use the corresponding information layers in the workshop (as layers could be turned on/off or 'zoomed to' as needed).

The Fitzroy Basin waters (Figure 8) were subdivided into groups with similar EVs (examples at Figures A1 and A2). These groupings formed the basis of the workshop tables (example at Appendix 2, Table A1) that collected the attendees' knowledge on the EVs for these groups of waterways (or sub-groups if needed).

The workshops EVs tables were designed to be flexible in recording the attendees' inputs at the workshops. This included a number of options. Firstly, two of the project team recorded the agreed EVs (and additional information) on blank tables at the workshop. This was done by recording the agreed EVs as either present or absent (with ticks and crosses), with the option for an indication of the level of a particular use (high, medium, low) if the attendees desired. The recorders' tables had additional rows (for cases where the EVs for some tributaries were different to the others in the main grouping) and spaces for capturing the supporting information. Secondly, the order of completing the rows was agreed with the attendees. Typically, this resulted in completing the EVs for the 'developed' groups of waterways first, then the ground water EVs. Finally, the EVs for waterways in the 'undeveloped' areas (described as the areas largely covered with natural vegetation) were completed to see if they had different EVs. For example these areas would typically not have irrigation, aquaculture and mining uses. This row was mainly captured as an additional piece of information, which may assist managers in the future.

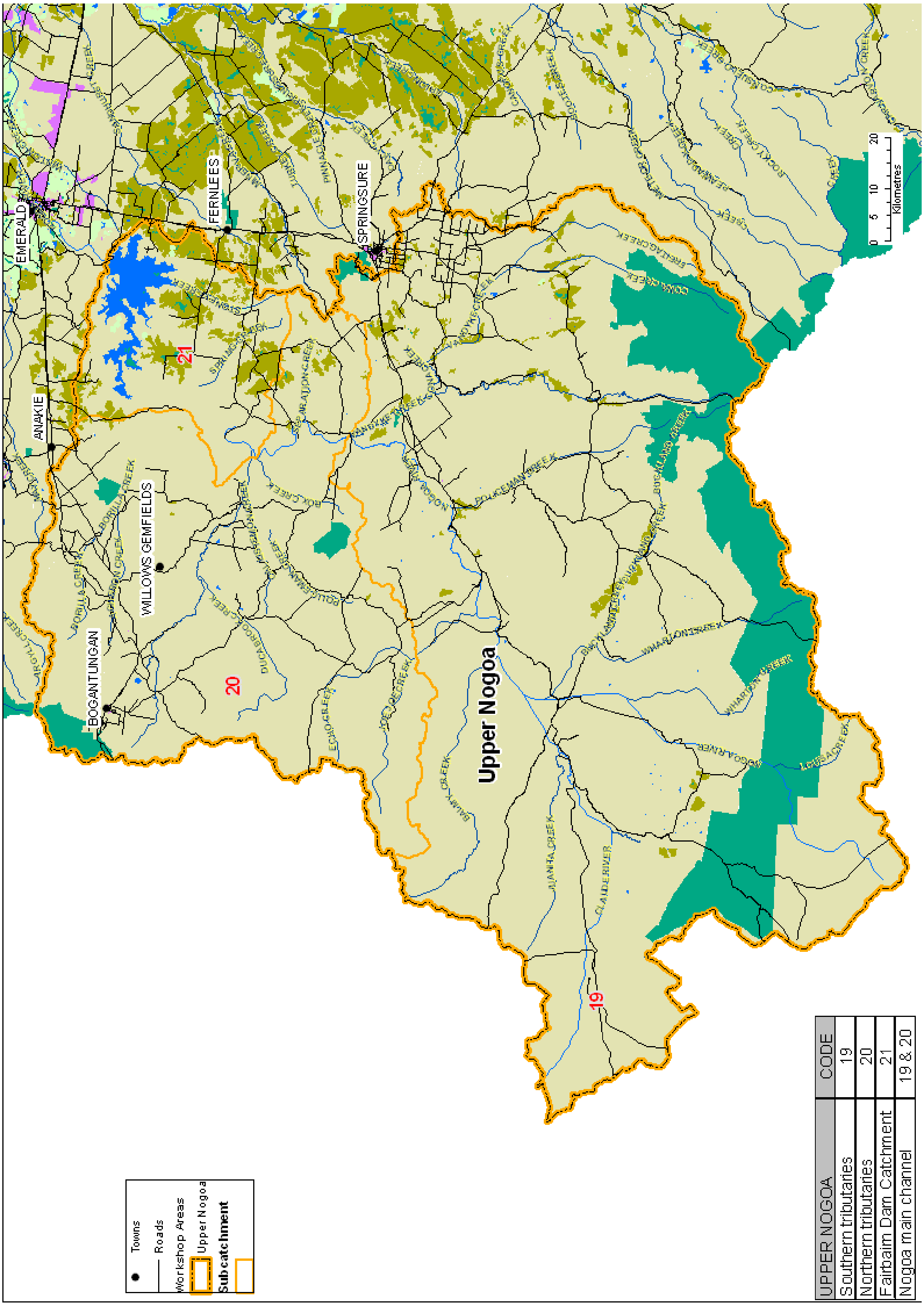
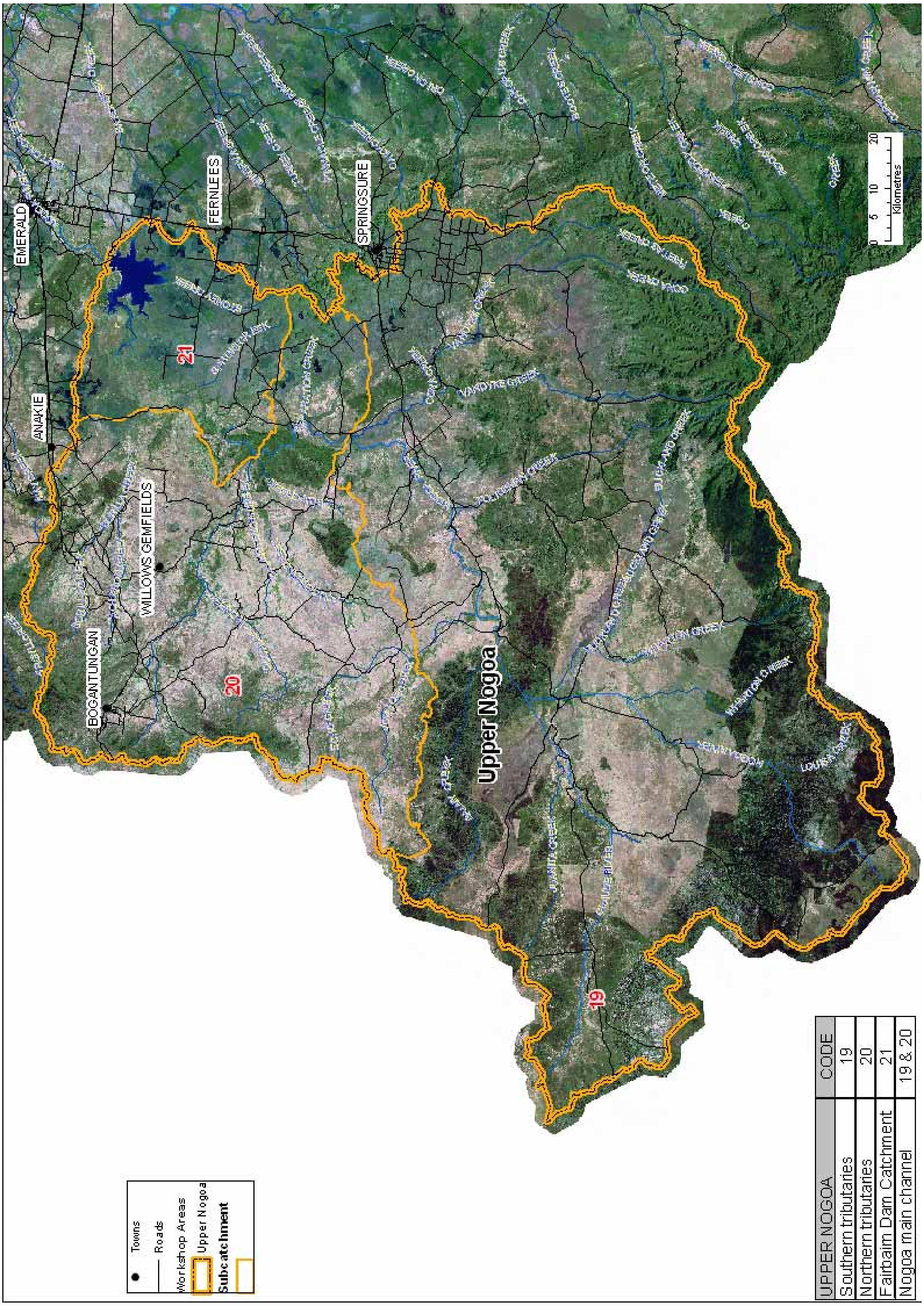


Figure A1: Upper Nogoa land use map



UPPER NOGOA	CODE
Southern tributaries	19
Northern tributaries	20
Fairbairn Dam Catchment	21
Nogoa main channel	19 & 20

Figure A2: Upper Nogoa satellite image map

	Human uses/values for Fitzroy Basin waterways (✓= present × = absent) H = High M = Medium L = Low											
Waterway	**Irrigation** (e.g. cotton irrigation)	**Farm supply** (e.g. fruit packing, milking sheds)	**Stock watering** (e.g. cattle)	**Aquaculture** (e.g. barramundi, red claw farm)	**Human consumer** (e.g. of wild or stocked fish, shellfish)	**Primary recreation** (fully immersed in water e.g. swimming, snorkelling)	**Secondary recreation** (possibly splashed with water, e.g. sailing, fishing)	**Visual appreciation** (no contact with water, e.g. picnic, bush walking)	**Drinking water** (raw water supplies taken from river for drinking)	**Industrial use** (e.g. power generation, manufacturing)	**Cultural and spiritual values**	**Aquatic ecosystems** (i.e. protect current condition)
	Now / future	**Now / future**	**Now / future**	**Now / future**	**Now / future**	**Now / future**	**Now / future**	**Now / future**	**Now / future**	**Now /future**	**Now / future**	
UPPER NOGOA - undeveloped	×/	×/	✓/	×/	×/	✓/	✓/	✓/	✓/	×/	✓/	✓
UPPER NOGOA - developed	See sub-catchment rows below											
19 – Southern tributaries (incl. Acheron, Balmy, Box, Buckland, Cona, Dry, Ducabrook, Echo, Frietag, Juanita, Police, Policeman, Reedy, Sandy, Vandyke, Wharton Cks and Claude River).	×/	✓/	✓/	×/	✓/	✓/	✓/	✓/	×/	✓/	✓/	✓
20 – Northern tributaries (incl Acheron, Back, Borilla, Branch, Ducabrook, Echo, Gum, Joe Joe, Jumbuck, Policeman, Borilla, Sandy, Separation, Spring, Box, Medway, North, Rocky Cks) – excl. Fairbairn Dam.	×/	✓/	✓/	×/	✓/	✓/	✓/	✓/	✓/	✓/	✓/	✓
21 – Fairbairn Dam Catchment (incl. Gindy, Stoney, Spring Cks)	✓/	✓/	✓/	×/	✓/	✓/	✓/	✓/	✓/	✓×?/	✓/	✓
Check dams/weirs: Fairbairn Dam	/	/	/	/	/	/	/	/	/	/	/	✓
19 & 20 - Nogoa main channel (adopted same as 21)	✓/	✓/	✓/	×/	✓/	✓/	✓/	✓/	✓/	✓?/	✓/	✓
Local variations	/	/	/	/	/	/	/	/	/	/	/	✓
Groundwater	/	/	/	/	/	/	/	/	/	/	/	✓

Note: This table focused on the human uses/values. Protection of aquatic ecosystems applied to all waters. Cells highlighted in yellow were identified by stakeholders as warranting further review. This has been undertaken, and revised EVs are provided for comment in Appendix 3.

Table A1: Example EVs workshop table—Upper Nogoa

Sources of information used to assist identification of human uses/values for Fitzroy Basin

Irrigation

Uses of storage water in water supply schemes (Sunwater and Rockhampton Regional Council)—irrigation.

Queensland Land Use Mapping Project (QLUMP; Dept of Environment and Resource Management)—irrigated land use.

Fitzroy Basin Resource Operation Plan supplemented and unsupplemented take of water (DERM).

Farm use

QLUMP (DERM)—intensive animal produce, dairies, irrigated tree fruit, irrigated vine fruit and tree fruit areas (use of water for washing down equipment, sheds and produce).

National Pollutant Inventory (DERM)—Piggeries and Poultry (water to wash down equipment and sheds).

Stock watering

QLUMP (DERM)—livestock grazing and intensive animal production areas.

National Pollutant Inventory (DERM)—Piggeries and Poultry.

Aquaculture

Aquaculture site data for Queensland (Queensland Primary Industries & Fisheries (QPIF)) collected as part of the authorisation of commercial aquaculture required under the *Fisheries Act 1994*.

Human consumption of fish/crustaceans

Fishing information from State of the Rivers (SoR) database for sub-catchments of the Fitzroy Basin (DERM) includes sites suitable for shore fishing, small boat fishing, large boat fishing.

Dams/weirs and usage information from Sunwater.

Fishing information (Infofish).

Primary recreation

Primary recreation from SoR database for sub-catchments of the Fitzroy Basin (DERM) including sites suitable for water skiing, swimming.

Secondary recreation

Secondary recreation from SoR database for catchments of the Fitzroy Basin (DERM), including sites suitable for canoes, rowing, sailing, shore fishing.

Dams/weir usage information (Sunwater)—boating.

Queensland public boat ramps data (QPIF).

Fishing information (Infofish).

Visual appreciation

Visual appreciation from SoR database for sub-catchments of the Fitzroy Basin (DERM) including sites suitable for picnics, bush camping, day visits, car camping, photography, nature appreciation, and natural beauty, physical beauty, scenic rural, scenic urban or artistic values.

National Parks, Forests and Reserves (DERM).

Dams/weir usage information (Sunwater)—picnic tables.

Drinking water

Queensland towns data (DERM).

Local government allocations for water from Central Queensland Regional Water Supply Strategy (DERM).

Industrial use

Uses of storage water in water supply schemes (Sunwater)—industry.

National Pollutant Inventory (DERM)—power stations.

Operating coal mines in Queensland 2008 sourced from the GRDB (Department of Mines and Energy (DME)).

Location of Port Alma salt works (DERM).

Locations of gem-fields (DME).

Cultural and spiritual values

Covers entire region as all rivers have value.

Appendix 3 Draft Environmental Values for the waters of the Fitzroy Basin

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
Lower Fitzroy— developed	See sub-catchment rows below											
1. Fitzroy western tributaries—excl. main Fitzroy channel.	✓	×	✓	✓	×	✓	✓	✓	✓	✓ L	×	✓
2. Fitzroy eastern tributaries—excl. main Fitzroy channel, urban stretches and tidal areas.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
3. Urban creeks—excl. tidal areas.	✓	✓ L	×	✓	×	✓	✓	✓	✓	×	✓	✓
4. Fitzroy south/central tributaries—excl. main channel and tidal areas.	✓	✓	✓	✓	✓ L	✓	✓	✓	✓	✓ L	✓	✓

	Human uses/values for Fitzroy Basin waterways[1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
5. Fitzroy lower estuarine creeks	✓	×	×	× (dry times) ✓ (flood events)	×	✓	✓	✓	✓	×	✓	✓
6. Fitzroy main channel—above barrage (up to top of catchment)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓ H	✓H	✓
7. Fitzroy main channel—below barrage, i.e. estuarine (incl. tidal areas of tributaries)	✓	×	×	× (dry times) ✓ (flood events)	✓	✓	×	✓	✓	×	×	✓
8. Raglan Creek and tributaries—excl. tidal areas.	✓	✓	✓	✓	✓L	✓	✓	✓	✓	×	✓	✓
9. Raglan estuarine area	✓	×	×	×	✓ L	✓	×	✓	✓	×	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🪣	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
(includes all tidal areas)												
Groundwaters	✓	✓	✓	✓	×	×	✓L	×	×	✓	×	✓
Lower Fitzroy—undeveloped	✓	×	✓	✓ L	×	✓ L	✓	✓	✓	✓ L	×	✓
Connors—developed	See sub-catchment rows below											
10a. Northern Connors Range tributaries	✓	✓	✓ H	✓H	✓ L	✓	✓	✓	✓	✓	✓	✓
10b. Eastern tributaries	✓	✓ L	✓ L	✓ H	×	✓	✓	✓	✓	✓	×	✓
10c. Connors main channel	✓	✓	✓	✓ H	×	✓	✓	✓	✓	✓	×	✓
10d. New western extension of unit 10	✓	✓	✓	✓ H	×	✓	✓	✓	✓	✓	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🪣	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
Groundwaters	✓	✓	✓	✓	×	×	✓	×	×	✓	✓	✓
Connors—undeveloped	✓	×	×	✓	×	✓	✓	✓	✓	✓	×	✓
Isaac—developed	See sub-catchment rows below											
11. Isaac western uplands	✓	✓ L	✓	✓ H	✓	✓	✓	✓	✓	✓	✓	✓
12a. Isaac north/central floodplain tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
13. Isaac River main channel	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Burton Gorge Dam	✓	×	×	✓	×	×	✓ L	✓ L	✓ L	✓ L	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
Groundwaters	✓	✓	✓	✓	×	×	✓	×	×	✓	×	✓
Isaac—undeveloped	✓	×	×	✓	×	✓	✓	✓	✓	✓	×	✓
Mackenzie—developed	See sub-catchment rows below											
14. North-western tributaries—excluding any dam/weir pools	✓	×	×	✓ H	×	✓	✓	✓	✓	✓	✓	✓
15. Southern and eastern tributaries												
15a. eastern edge Rookwood Range	✓	×	×?	✓	×	✓	✓	✓	✓	×	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
15b. Duaringa, Blackwater	✓	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
16. Mackenzie main channel, incl lakes, dams, weirs, supplemented reaches	✓	✓ H	✓ H	✓	✓	✓	✓	✓	✓	✓	✓	✓
Groundwaters	✓	✓	✓	✓	×	×	×	×	×	✓ L	✓ L	✓
Mackenzie—undeveloped	✓	×	×	✓L	×	✓	✓	✓	✓	✓	×	✓
Lower Nogoa/Theresa Creek—developed	See sub-catchment rows below											
17. Theresa Creek, tributaries	✓	✓L	✓ L	✓ H	×	✓	✓	✓	✓	✓ H	✓ L	✓
17a. Theresa Creek main	✓	✓	×	✓	✓ L	✓	✓	✓	✓	✓ M	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
channel (including Theresa Creek Dam)						(dam = H)	(dam = H)	(dam = H)				
18. Nogoa main channel (from junction with Comet River to Fairbairn Dam)	✓	✓ H	✓ H	✓H	✓ H	✓	✓	✓	✓	✓ H	✓	✓
Fairbairn Dam	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓ L	✓
Groundwater	✓	✓	✓ H	✓ H	×	×	✓	×	×	✓	✓	✓
Lower Nogoa/Theresa Creek—undeveloped	✓	×	×	✓ L	×	✓	✓	✓	✓	✓ L	×	✓
Upper Nogoa— developed	See sub-catchment rows below											
19. Southern tributaries	✓	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
20. Northern tributaries—excl. Fairbairn Dam.	✓	×	✓	✓	×	✓	✓	✓	✓	✓ L	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🪣	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
21. Fairbairn Dam catchment	✓	×	✓	✓	×	✓	✓	✓	✓	✓ L	×	✓
Fairbairn Dam (storage only)	✓	✓ H	✓	✓	×	✓	✓	✓	✓	✓ L	✓ L	✓
19 & 20—Nogoa main channel	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓ L	✓
Groundwaters	✓	✓	✓	✓	×	×	✓ L	×	×	✓	✓	✓
Upper Nogoa—undeveloped	✓	×	×	✓L-M	×	✓	✓	✓	✓	✓	×	✓
Comet—developed	See sub-catchment rows below											
22. Western tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
23. Eastern tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
22 & 23—Comet main channel (including Comet weir waters)	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Groundwaters	✓	✓	✓	✓	×	×	✓	×	×	✓	✓	✓
Comet—undeveloped	✓	×	✓	✓	×	✓	✓	✓	✓	✓	×	✓
Callide—developed	See sub-catchment rows below											
24. Dee River and tributaries	✓	✓H	✓	✓H	×	✓	✓	✓	✓	✓	✓	✓
25. Don River and tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓L	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**										
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
26. Kariboe/Scoria creeks and tributaries	✓	✓	✓	✓	×	×	✓L	✓L	✓L	×	×	✓
27. Kroombit Creek and tributaries	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
28. Callide Creek and tributaries	✓	✓	✓	✓	×	✓	✓ H	✓ H	✓ H	✓	✓	✓
29. Northern creeks	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓
Groundwaters	✓	✓	✓	✓	×	×	✓	×	×	✓	✓	✓
Callide—undeveloped	✓	×	×	✓ L	×	✓ L	✓	✓	✓	✓	×	✓
Lower Dawson— developed	See sub-catchment rows below											
30. North upland tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
31. South upland tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓
32. Western tributaries	✓	✓	✓	✓	×	✓	✓	✓	✓	✓L	×	✓
33. Eastern tributaries	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
34. Lower Dawson main channel - regulated	✓	✓H	✓H	✓	✓	✓	✓H	✓H	✓H	✓H	✓H	✓
35. Lower Dawson main channel—unregulated	✓	✓	✓	✓	×	✓	✓ H	✓ H	✓H	✓	✓	✓
29. Callide northern creeks	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓
Groundwaters	✓	✓	✓	✓	✓L	×	✓	×	×	✓	×	✓
Lower Dawson— undeveloped	✓	×	×	✓L	×	✓	✓	✓	✓	✓L	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
Upper Dawson— developed	See sub-catchment rows below											
36. Northern upland tributaries (Taroom workshop)	✓	✓	✓	✓ H	×	✓	✓	✓ L	✓	✓	×	✓
37. Central tributaries (Taroom workshop)	✓	×	✓	✓	×	✓ L	✓ L	✓ L	✓	✓ L (mainly bores)	×	✓
38. Upper tributaries (Injune workshop)	✓	×	×	✓ L	×	✓	✓	✓	✓	✓ L	×	✓
39. Southern tributaries (Taroom workshop)	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
40. Upper Dawson main channel/immediate tributaries (Injune workshop)	✓	×	×	✓	×	✓ L	✓L	✓L	✓L	✓ L	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] **(✓= present × = absent) H = High M = Medium L = Low)**											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
	🐟	🚰	🏠	🐄	🦐	🐚	🏊	⛵	👁	🥛	🏭	👣
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
40. Upper Dawson main channel/immediate tributaries (Taroom workshop) (map: extend sub-catchment downstream to Nathan Dam site)	✓	✓	✓	✓	×	✓	✓(Glebe Weir:H)	✓(Glebe Weir:H)	✓(Glebe Weir:H)	✓ L	✓ L	✓
Local variations (Taroom) 39. Southern tribs: (map: downstream extension into unit 33 around Nathan Dam area)	✓	✓	✓	✓	×	✓	✓	✓	✓	✓ L	✓ L	✓
Groundwaters												
Injune catchment groundwater												
- shallow (windmill bores)	✓	✓ L	✓ L	✓	×	×	×	×	×	✓ L	×	✓

	Human uses/values for Fitzroy Basin waterways [1-9] (✓= present × = absent) H = High M = Medium L = Low)											
	Aquatic Ecosystem	**Irrigation**	**Farm use**	**Stock watering**	**Aquaculture**	**Human consumer**	**Primary recreation**	**Secondary recreation**	**Visual appreciation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Groupings of waterway		(e.g. cotton irrigation)	(e.g. fruit packing, milking sheds)	(e.g. cattle)	(e.g. barramundi, red claw farm)	(e.g. of wild or stocked fish, shellfish)	(fully immersed in water e.g. swimming, snorkelling)	(possibly splashed with water, e.g. sailing, fishing)	(no contact with water, e.g. picnic, bush walking)	(raw water supplies taken from river for drinking)	(e.g. power generation, manufacturing)	(e.g. traditional lore and customs)
		(lawns) × (crops)										
- precipice sandstone	✓	✓ L	✓ L	✓ H	✓	✓	✓ L	×	×	✓	×	✓
- coal seam gas layer	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓
- Hutton sandstone (Injune town)	✓	×	✓ L	✓	×	×	✓	×	×	✓	×	✓
Taroom catchment groundwater	✓	✓ L	✓ H	✓	×	×	✓	×	✓	✓	✓	✓
Upper Dawson—undeveloped (Taroom)	✓	×	✓ L	✓ L	×	✓	✓	✓	✓	✓	✓ L	✓
Upper Dawson—undeveloped (Injune)	✓	×	×	✓ L	×	✓L	✓	×	✓	✓ L	×	✓

Notes:

1. This draft table is an updated summary of more detailed EVs tables prepared to record attendee's inputs at each of the catchment stakeholder workshops throughout the Fitzroy Basin in February and March 2010. The detailed draft EVs tables were provided on the FBA website for consultation and include greater detail on the creeks within each unit, and additional notes and comments on particular EVs. The FBA report: Community consultation to establish Environmental Values for the Fitzroy Basin waterways (FBA 2010) also provides more details on the processes used to derive draft EVs, workshop attendees, etc.
2. EVs identified are for current waterway uses/values. During workshops, stakeholders were also invited to comment on known future waterway uses/values (e.g. already approved) that might change from current status. Any such future uses are identified in the relevant cells.
3. EVs are provided for surface and ground waters.
4. The aquatic ecosystem EV is selected for all waters. In principle, the aim for aquatic ecosystems is to maintain (and where possible improve) current condition. A separate table (Appendix 4) has been prepared to identify the high ecological value and slightly disturbed waterways in the Fitzroy Basin, using available information and stakeholder input.
5. For the ‘domestic’ component of a ‘stock and domestic’ water licence, a number of EVs may be relevant depending on the use e.g. ‘irrigation’ if used to water lawns, etc; ‘farm use’ if used to wash down sheds, fruit, etc.; ‘drinking water’ if used for drinking; ‘primary recreation’ if used for showers (with a similar risk of ingestion of water).
6. Stock watering is typically the ‘stock’ component of a ‘stock and domestic’ licence.
7. Where groundwaters are used as a source for filling swimming pools, this is captured under primary recreation.
8. Tourism water uses/values are captured under relevant EVs, e.g. sightseeing (visual recreation), sailing (secondary recreation), swimming (primary recreation), etc.
9. For industrial uses, the main intent was to identify specific industrial uses of water direct from waterways (rather than from town water supplies). Road works may also source water from waterways as required (e.g. dust suppression).

Appendix 4: High ecological value waters

Potential high ecological value (HEV) and slightly disturbed (SD) waters in the Fitzroy Basin, (catchments listed in alphabetical order)

HEV = high ecological value waters; SD = slightly disturbed waters; MD = moderately disturbed waters

NP = national park; SF = state forest; CP = conservation park; RR = resources reserve

Areas containing potential HEV/SD waters [1]	**Stakeholder views on current ecosystem condition (from catchment workshops)** [2]	**Current ecosystem condition as mapped (following additional QPWS officer input)** [3]
Callide—Jambin, 17 March 2010		
Kroombit Tops NP	HEV	HEV
Don River SF	Limited local knowledge [2]	HEV
Ulam Range SF	Limited local knowledge [2]	HEV
Gelobera SF	HEV?	HEV
Bouldercombe Gorge Resources Reserve	HEV	HEV
Mt Hopeful CP	Limited local knowledge [2]	HEV
Belmont SF	Limited local knowledge [2]	SD
Grevillea SF	Limited local knowledge [2]	SD
Maxwelton SF	Limited local knowledge [2]	HEV (outside study area)
Gogango Range SF	SD	SD
Mt Scoria CP	SD	SD
Headwaters of Don River	HEV	Not yet mapped
Headwaters of Dee River	HEV	Not yet mapped
Bell Creek CP, Ovendeen SF, Callide TR	MD	MD—not shown on map
Comet—Springsure, 11 February 2010		
Carnarvon NP	HEV	Majority HEV
Expedition NP	HEV	HEV
Blackdown Tablelands NP	HEV	HEV
Minerva Hills NP	HEV	HEV
Albinia NP	East side: HEV? West side: MD/worse.	East side: HEV, West side: MD (mapped as HEV/MD)
Lake Nuga Nuga NP	SD	HEV

Areas containing potential HEV/SD waters [1]	**Stakeholder views on current ecosystem condition (from catchment workshops)** [2]	**Current ecosystem condition as mapped (following additional QPWS officer input)** [3]
Mt Pleasant SF	Limited local knowledge [2]	SD
Boxvale SF	HEV	HEV/SD
Bandana SF	HEV	HEV
Sercold SF	HEV	HEV
Cairdbeign SF	SD	SD
Shotover SF	Limited local knowledge [2]	HEV/SD
Mt Nicholson SF	HEV	HEV
Amaroo SF	HEV (upland), SD (lower lands)	HEV (Mackenzie)/MD (Comet) (mapped as HEV/MD)
Presho SF	HEV/SD	HEV/SD
Mt Hope SF	SD–HEV	SD
Humbolt NP and SF, Albinia CP	Not HEV	MD?—not shown on map
Connors—Clarke Creek, 3 March 2010		
Homevale NP	HEV	HEV
Homevale Resources Reserve	HEV	HEV
Epsom SF	HEV	HEV
Tierawoomba SF	HEV	HEV
Carminya SF	HEV	HEV
Connors SF	HEV	HEV
West Hill SF	HEV	HEV
Collaroy SF	HEV	HEV
Rosedale SF	HEV	HEV
Isaac—Clarke Creek, 3 March 2010		
Dipperu NP Scientific	Limited local knowledge [2]	SD
Junee NP	HEV	HEV/SD
Peak Range NP	HEV	HEV
Homevale NP	HEV	HEV

Areas containing potential HEV/SD waters [1]	Stakeholder views on current ecosystem condition (from catchment workshops) [2]	Current ecosystem condition as mapped (following additional QPWS officer input) [3]
Junee SF	HEV	HEV/SD
Bundoora SF	HEV	HEV
Homevale Resources Reserve	HEV	HEV
Lower Dawson—Theodore, 18 March 2010		
Palmgrove NP (S)	SD	HEV
Isla Gorge NP	HEV	HEV/SD
Precipice NP	HEV	HEV
Blackdown Tableland NP	SD?	HEV
Devils Nest SF	Limited local knowledge [2]	SD
Theodore SF	SD?	SD
Mt Nicholson SF	Limited local knowledge [2]	HEV (90% HEV)
Expedition SF	Limited local knowledge [2]	HEV/SD (75% HEV)
Shotover SF	Defer to Comet	HEV/SD
Dawson Range SF	Limited local knowledge [2]	SD
Redcliffe SF	Limited local knowledge [2]	SD
Duaringa SF	Limited local knowledge [2]	HEV
Belmont SF	SD?	SD
Montour SF	Limited local knowledge [2]	SD
Camboon SF	Limited local knowledge [2]	SD
Dawson River CP	Limited local knowledge [2]	?—not mapped
Zamia Creek CP, Roundstone Creek SF, Roundstone Creek CP	Disturbed, ??, disturbed	MD—not mapped
Upper Dawson—Taroom, 16 February 2010, and Injune, 18 February 2010		
Carnarvon NP	HEV over 90%	Majority HEV
Expedition NP	SD/HEV	HEV
Palmgrove NP Scientific	SD/HEV	HEV
Isla Gorge NP	SD/any HEV?	HEV/SD

Areas containing potential HEV/SD waters [1]	Stakeholder views on current ecosystem condition (from catchment workshops) [2]	Current ecosystem condition as mapped (following additional QPWS officer input) [3]
Boxvale SF	SD/HEV	HEV/SD
Forrest SF	HEV?	SD
Doonkuna SF	SD	SD
Presho FR	SD?	HEV/SD
Presho SF	HEV/SD	HEV/SD
Belington Hut SF	SD	SD
Expedition Resources Reserve	SD	SD
Beilba SF	HEV	SD
Theodore SF	Unsure – SD?	SD
Stephenton SF	SD	SD
Woodduck SF	SD	SD
Combabula SF	SD?	SD
Emu SF	Limited local knowledge [2]	SD
Gurulmundi SF	MD?, SD – HEV?	HEV/SD
Cherwondah SF	MD-SD	SD
Barakula SF	North = SD, South = SD	SD
Cooaga SF	SD	SD
Mundell SF	MD in west?	SD
Dinoun SF	Limited local knowledge [2]	SD
Mt Organ SF	HEV	SD
Hinchley SF	HEV	SD
Juandah SF	SD	SD
Lake Murphy CP	SD?	SD (based on stakeholder input)
Carraba CP	HEV	HEV (based on stakeholder input)
Hallett SF	SD	MD – not shown on map
Lower Fitzroy—Rockhampton, 4 February 2010		
Rundle Range NP	HEV	HEV
Goodedulla NP	SD-HEV?	HEV

Areas containing potential HEV/SD waters [1]	**Stakeholder views on current ecosystem condition (from catchment workshops)** [2]	**Current ecosystem condition as mapped (following additional QPWS officer input)** [3]
Mt Etna Caves NP	MD-SD-HEV	HEV
Mt Jim Crow NP	MD-SD-HEV	HEV
Mt Archer NP	HEV	HEV
Don River SF	HEV?	HEV
Ulam Range SF	Limited local knowledge [2]	HEV
Bouldercombe Gorge Resources Reserve	HEV?	HEV
Develin SF	SD?	HEV
Eugene SF	Limited local knowledge [2]	HEV
Malborough SF	HEV	HEV
Bukkulla CP	Limited local knowledge [2]	Not in Fitzroy Basin
Lake Learmouth SF	Limited local knowledge [2]	SD
Aricia SF	Limited local knowledge [2]	SD
Princhester CP	Limited local knowledge [2]	HEV
Canal Creek SF	Limited local knowledge [2]	HEV
Alligator Creek SF	Limited local knowledge [2]	HEV
Werribee Creek SF	Limited local knowledge [2]	SD
Byfield SF	HEV	HEV
North Pointer CP	HEV	HEV
Mt Archer SF	SD-HEV?	HEV
Flat Top Range Resources Res	Probably HEV	HEV
Mackenzie Isld CP	Probably HEV	HEV
Rundle Range Resources Reserve	SD-HEV?	HEV
Mt Larcom SF	SD-HEV?	Not in Fitzroy Basin
Stuart Creek SF	Limited local knowledge [2]	SD
Morinish SF	Limited local knowledge [2]	HEV
Limestone Creek CP	Limited local knowledge [2]	HEV
Fitzroy River Fish Habitat Area (A)—estuarine	Raglan Creek (SW) = HEV Others = MD–SD–MD	Raglan Creek section: HEV
Long Isld Bend CP	Limited local knowledge [2]	Not HEV—not shown on map

Areas containing potential HEV/SD waters [1]	**Stakeholder views on current ecosystem condition (from catchment workshops)** [2]	**Current ecosystem condition as mapped (following additional QPWS officer input)** [3]
Mackenzie—Dingo, 4 March 2010		
Taunton NP Scientific	MD–SD	SD/MD
Blackdown Tableland NP	HEV	HEV
Ghungalu CP (within Blackdown Tableland NP)	HEV	HEV
Goodedulla NP	SD–HEV	HEV
Dawson Range SF	SD	SD
Arthurs Bluff SF	HEV	HEV
Walton SF	MD	SD
Amaroo SF	HEV/SD	HEV (Mackenzie)/MD (Comet) (mapped as HEV/MD)
Bundoora SF	SD–HEV	HEV
Junee SF	SD–HEV	HEV/SD
Duaringa SF	SD	HEV
Moultrie SF	SD	SD
Kaiuroo Reserve (in ‘other lands’ in GIS layer)	Raised for consideration	HEV
Lower Nogoa—Emerald, 9 February 2010		
Peak Range NP	HEV? (limited local knowledge [2])	HEV
Zamia SF	HEV	HEV
Withersfield SF	HEV	HEV
Keilambete SF	SD	HEV
Fairbairn SF	MD with poss SD in north	SD/MD
Kettle SF	MD–SD	MD/SD
Crystal Creek SF	SD	SD
Llandillo SF	SD	SD
Burn SF	SD? (quarry)	SD
Carbine SF	SD–HEV	SD
Zig Zag Range	SD–HEV?	HEV (not yet mapped)

Areas containing potential HEV/SD waters [1]	**Stakeholder views on current ecosystem condition (from catchment workshops) [2]**	**Current ecosystem condition as mapped (following additional QPWS officer input) [3]**
Blair Athol, Aspley, Copperfield SFs	MD?, MD?, SD?	MD—not shown on map
Mt Leura CP	Limited local knowledge [2]	??—not shown on map
Upper Nogoa—Springsure, 11 February 2010		
Carnarvon NP	HEV	Majority HEV
Snake Range NP	HEV	HEV
Minerva Hills NP	HEV	HEV
Pluto Timber Reserve	SD–HEV?	HEV
Squire SF	HEV	HEV
Nandowrie SF	HEV	HEV
Zamia SF	HEV	HEV
Withersfield SF	HEV	HEV
Keilambete SF (e.g. May Creek)	SD	HEV
Fairbairn SF	MD with poss SD in north	SD/MD
Mt Hope SF	HEV	SD
Cairdbeign SF (far east)	HEV	SD
Vandyke Creek CP	HEV	HEV (based on stakeholder input)

Notes:

[1] This draft table is an updated version of ecological value tables provided for consultation on the FBA web site from April–June 2010 following catchment stakeholder workshops in February–March 2010. The terms used in this table relate to the EPP (Water). The principal intent of the table is to identify essentially unmodified (HEV) or slightly disturbed (SD) waterways whose values could be maintained at, or improved to, HEV status. Of the listings in this table, only those areas identified as having waterways with HEV or SD condition have been included in the accompanying map (Figure 9 of the main report). The first column of the table lists the main areas whose waterways' ecosystem conditions were discussed in stakeholder workshops and in subsequent meetings with QPWS officers. The majority of these waterways occur within national parks, state forests, conservation parks, and resources reserves. All waters discussed were freshwaters aside from estuarine reaches in the lower Fitzroy River.

[2] This column summarises stakeholder comments received in catchment workshops held across the Fitzroy Basin in February–March 2010. These catchment workshops followed an earlier 'champions' workshop in late 2009. Where a park straddled catchment boundaries, stakeholder input was obtained at both catchment workshops and is reported in each catchment area. Local stakeholders provided comments on waterways where they had knowledge; however for a number of areas they had limited/no information (shown by 'limited local knowledge' in the table). Consequently they recommended further local input from QPWS staff and further review of water quality information to improve understanding about the condition of waterways under their management. This was undertaken and is ongoing. (Where stakeholder comments are used as the basis for mapped areas, this is identified in the next column.)

[3] This column summarises waterway ecosystem condition following inputs from both stakeholders and QPWS staff about waterways condition, and any further information obtained subsequent to catchment workshops. The condition in this column corresponds to condition shown in the accompanying map (Figure 9 of this report). Where further inputs are received or additional information is obtained, these ratings may be revised/updated in the final report.

Scientific assessment of aquatic ecosystem condition across the Fitzroy has not yet been completed (see section 12.2 for current and future directions).

Appendix 5: Developing WQ guidelines for the protection of aquatic ecosystems in the Fitzroy Basin: Phase 1

Mary-Anne Jones and Andrew Moss, Department of Environment and Resource Management

Background

In 2009, the Queensland Government made a key commitment to improve water quality management within the Fitzroy Basin. This followed concerns about mining impacts on water quality after Ensham Resources Pty Ltd discharged water from its coal mine near Emerald in January 2008. Because of inundation after unprecedented rainfall, the mine had released 138 gigalitres of mine-affected water into the Fitzroy River system between February and September 2008. Downstream users, including townships of Blackwater, Bluff and Rockhampton raised concerns about the impacts of this water on human health and the environment. In response, Premier Anna Bligh commissioned Professor Barry Hart to examine the management of water quality in the Fitzroy Basin. The Queensland government also investigated the cumulative impacts of mining releases on the Fitzroy River system. Based on results and recommendations of these studies, the Queensland government has initiated several projects; one being the development of local WQ guidelines for protecting aquatic ecosystems of the Fitzroy Basin.

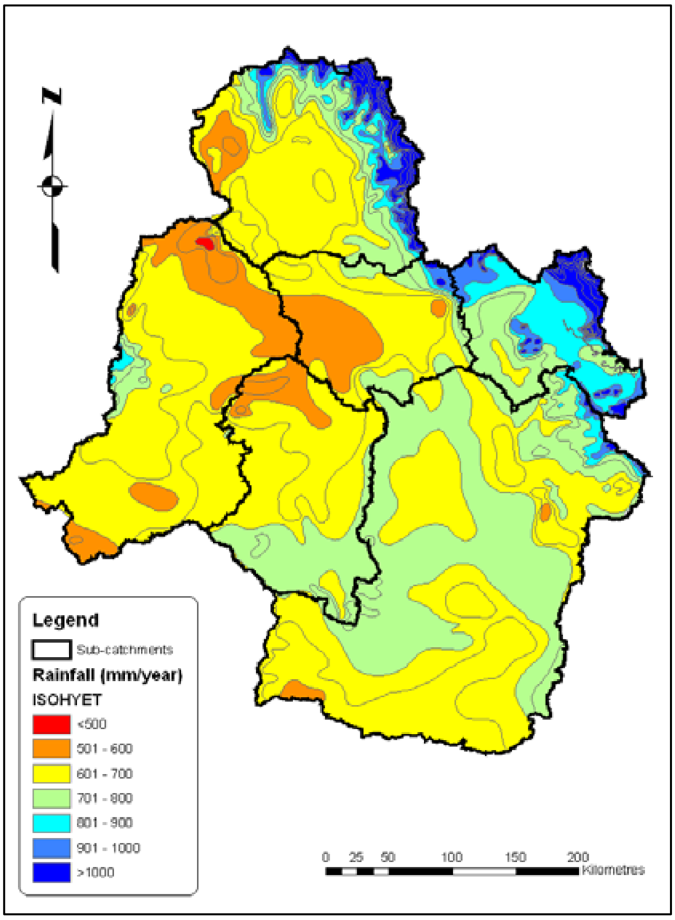


Figure A3: Spatial variation in mean annual rainfall for the Fitzroy Basin. (Source: Negus (2007) Water Quality Information for the Fitzroy Region, DERM Indooroopilly)

The Fitzroy is a very large and complex system. It has a catchment area of approximately 142 000 km^2 (twice the size of Tasmania) and comprises numerous rivers, streams, waterholes and impoundments. Its major tributaries are the Dawson Comet, Nogoa, Mackenzie, Isaac, and Connors rivers. Flows in this system are largely from run-off during rainfall, which is summer-dominant. Some flows, however, originate from springs, as in the case of the upper Dawson and Nogoa rivers, and Carnarvon and Mimosa creeks. Others emanate from alluvial reserves. In sections of the Nogoa, Mackenzie, Dawson and Fitzroy rivers, flows are regulated by infrastructure, which in unison captures up to 1500 gigalitres of water for industry and town supply (Department of Natural Resources and Mines 2004). This is equivalent to three times the volume of Sydney Harbour.

Because of the size and topography of the Fitzroy Basin, climate varies from one area of the catchment to another. For example, mean annual rainfall decreases from about 1200 mm in the Connors Range to around 800 mm near Emerald in the west of the basin (Figure A3). A strong temporal variation in rainfall is also evident in association with the El niño southern oscillation. Since climate determines flow patterns, stream flows in the Fitzroy Basin vary considerably between catchments, seasons, years and even decades. The last decade, for instance, was dominated by El niño and this resulted in below average annual discharges from the Fitzroy River for all years, except 2008. This compares to that found in the 1970s, when higher than average annual discharges occurred except in 1972 (record 1965–2009; Figure A4). Subsequently, water quality within the Fitzroy River is highly variable given the unpredictability of flow and run-off from rainfall (Rustomji et al. 2009).

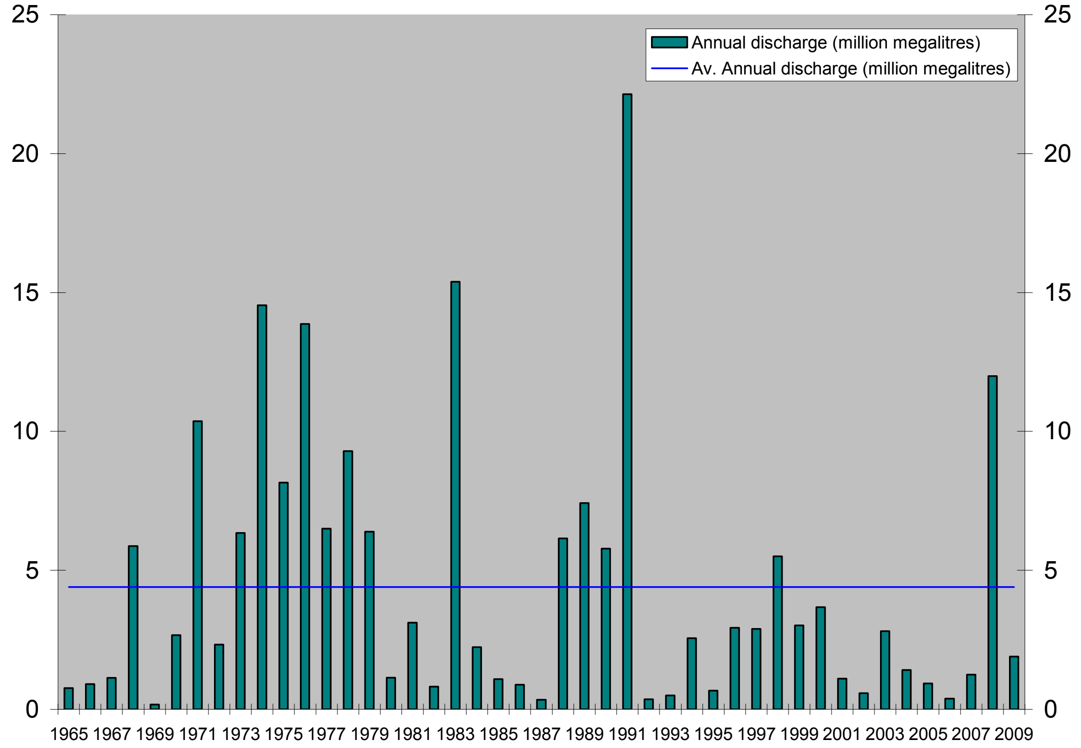


Figure A4: Annual discharge from the Fitzroy River from 1965 to 2009

Geology also affects run-off from rainfall and influences flows from springs and alluvial reserves. It too varies across the Fitzroy Basin. For example, basalt is prominent in the Nogoa catchment, whereas siliciclastic rock formations are characteristic of the Upper Dawson (Douglas et al. 2006). While climate and geology are two natural forces affecting water quality, human activities are potentially more important as drivers of stream condition within the Fitzroy Basin. This is especially so concerning major land uses of mining, coal seam gas extraction and agriculture. Large reserves of coal and coal seam gas take in a considerable portion of the Fitzroy Basin and hence mining and extraction are growing industries of the region. Meanwhile, agriculture has historically been important and remains a major industry throughout the basin. Given their extent, without proper management, these industries have the potential to impair water quality of the Fitzroy Basin and beyond.

Purpose of this report

This report describes methods used in Phase 1 of developing WQ guidelines for aquatic ecosystem protection within the Fitzroy Basin. This phase uses existing data to derive guidelines for protection of aquatic ecosystems in lowland freshwaters of the Fitzroy Basin based on the referential approach recommended in the national WQ guidelines (ANZECC & ARMCANZ 2000a).

Derivation of local/sub-regional water quality guidelines

In accordance with the national WQ guidelines' preferred hierarchy for deriving WQ guidelines (see Figure 3 of main report), the EPP (Water) states that accredited local information takes precedence over state and national WQ guidelines. Where little or no local or state information exists, then the national guidelines apply (ANZECC & ARMCANZ 2000a). The current ANZECC 2000 national guidelines relate to four regions of Australia and the Fitzroy Basin straddles two of these, namely tropical and south-east regions (see Figure A5). Consequently, the use of these least preferred national guidelines in the Fitzroy is confounding, and in any case the national guidelines for either of these regions are largely inappropriate for the freshwaters of the Fitzroy Basin. The main aim of this project was therefore to derive more appropriate guidelines based on local reference site data (see Figure 3 of the main report). Once these guidelines are agreed, they will be incorporated into the Queensland WQ guidelines (DERM 2009a).

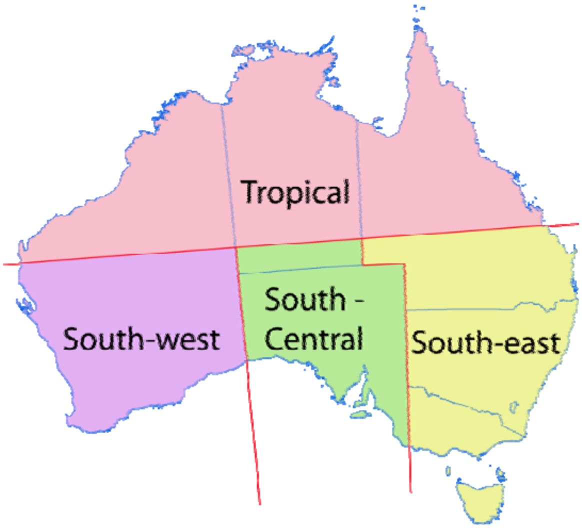


Figure A5: The four regions of the national aquatic ecosystems guidelines

The referential approach to developing guidelines uses limits based on percentiles of data from least-impacted sites (reference sites). Usually these limits are the 20th and/or 80th percentiles; the 80th percentile being the upper limit, and the 20th percentile the lower. The lower limit is important for parameters such as pH and dissolved oxygen that are harmful for aquatic organisms at levels both above and below a certain range. The choice of percentiles is arbitrary and Hart (2001) acknowledges there is no agreement on the best way to deal with the effect of water quality variations on aquatic ecosystems. Another percentile that is commonly used as an upper limit is the 75th percentile. This has been used by the Victorian Environmental Protection Agency (EPA Vic 2003) and the US EPA (2000), and by the Queensland Government as an upper limit for salinity in freshwaters of Queensland (DERM, 2009a). Much lower percentiles are also practised as upper limits. The US EPA, for instance, uses a 25th percentile of data from sites in developed (i.e. impacted) areas where no reference conditions exist and a 5th percentile where systems are highly degraded (US EPA 2000).

The approach used to derive Fitzroy sub-regional guidelines

Base data

Water quality and flow time-series data were extracted from the department’s Hydstra database. This dataset covers several decades of stream monitoring at many sites within the Fitzroy Basin. Water quality data were also obtained from the event monitoring program of the FBA and departmental studies of run-off impacts, which include the Brigalow research study and the neighbourhood catchment scale study of Spottswood (Dawson) and Gordonstone (Nogoa) catchments. The department is also seeking suitable reference site data from industry or other parties and any such data will be used to update the guidelines in the next phase.

Defining sub-regions

Because the Fitzroy is such a large catchment, it was initially divided into major sub-regional catchment areas. These are similar to divisions used for defining EVs of the Fitzroy Basin (refer to main report) and include:

- Callide
- Upper Dawson (catchments of the Dawson that are upstream of Taroom)
- Lower Dawson (Dawson catchments below Taroom)
- Comet
- Upper Nogoa (catchments of the Nogoa that are upstream of the Fairbairn Dam)
- Lower Nogoa/Theresa Creek (catchments of the Nogoa that are downstream of the Fairbairn Dam)
- Isaac
- Connors.

Since the Dawson catchment is very large (50 800 km^2), the lower catchments were treated separately using the Dawson River at Taroom as the dividing point. Similarly, the Nogoa catchment, although smaller at 28 000 km^2, was separated into two areas, using the Fairbairn Dam as a divide. The Mackenzie and Fitzroy catchments were not included in this initial list because sites with available data in these areas are downstream of impacted catchments. Their inclusion is discussed below.

Establishing reference sites

A total of 39 existing water monitoring sites were selected from the department's monitoring network based on expert opinion in regard to their suitability as reference sites and availability of data. These sites were rated against reference site criteria listed in the QWQGs (Attachment 1; from DERM 2009a), using the best available spatial information and local on-ground knowledge.

Twenty-two of the 39 sites met the criteria (yellow markers in Figure A6). Seven of these were excluded because of too few data. Meanwhile, three sites were added to allow derivation of guidelines in catchment areas where there were no sites that fully met the reference criteria. Firstly, for the Mackenzie and Lower Fitzroy catchments, sites at Coolmaringa and Riverslea, respectively, were included within the reference site group as these were 'least impacted' and had sufficient data to develop guidelines for these catchments. Similarly, another site, Yatton, was included to represent the Lower Isaac, a section of the Isaac downstream of its confluence with the Connors. It was decided to distinguish this section from the remainder of the Isaac sub-region because of the influence of the Connors and results of data analyses, which showed different water quality in this region. In total, 18 sites were used in the development of the guidelines (Appendix 5, Table A2). Examples of sites used in this project are presented in the photos in Appendix 5, Figure A7.

Sites of the event monitoring programs managed by the FBA and the department were examined in a similar way, but after due assessment, sites meeting the criteria were found to have too few data to establish reliable guideline values to suit event (high flow) conditions. The reasons for this are discussed later in this report.

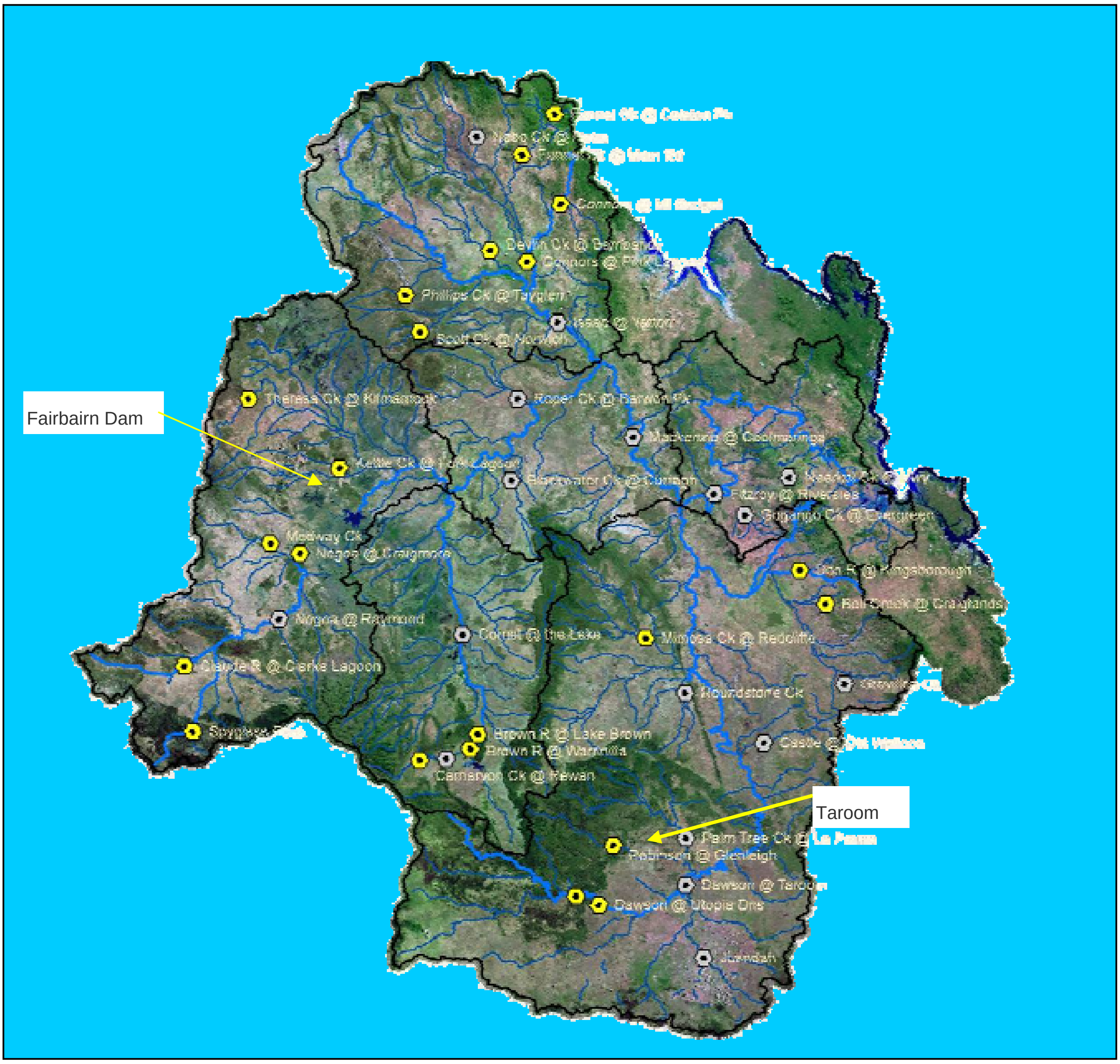


Figure A6: Total sites assessed as reference sites. Yellow markers show those that met the reference site criteria

Key water types

The ANZECC 2000 guidelines suggest that for freshwater, separate guidelines should be developed for lowland and upland water types. They indicate an elevation greater than 150 m defines upland streams (ANZECC & ARMCANZ 2000a). This may be appropriate for southern waterways, but the sheer size of the Fitzroy basin makes this definition invalid. The Comet River, for example, starts at an elevation of 237 m AHD and extends to 144 m AHD after meandering 294 km. Likewise, the Nogoa River begins at 501 m AHD and ends at 140 m AHD after travelling a vast 569 km.

Steep gradients are the main contributors to characteristics of upland streams, namely cool, clear and fast flowing with rocky substrates. These compare to lowland streams, which are characteristically slow flowing and turbid. For most of the Fitzroy Basin, gradients are gentle and only mountain ranges in the outer extremes have steep gradients.

Table A2: List of sites that were used to develop Phase 1 of the water quality guidelines for the protection of freshwater aquatic ecosystems in the Fitzroy Basin

Catchment	Site
Callide	Don River at Kingsborough
	Bell Creek at Craiglands
Upper Dawson	Dawson River at Utopia Downs
	Robinson at Glenleigh
Comet	Brown River at Warrinilla
	Carnarvon Creek at Rewan
Upper Nogoa	Nogoa River at Craigmore
	Medway Creek
Isaac	Devlin Creek at Bombandy
	Scott Creek at Norwich
	Phillips Creek at Tayglen
Lower Isaac	Yatton
Connors	Connors River at Mt Bridget
	Connors River at Pink Lagoon
	Funnel Creek at Main Road
	Funnel Creek at Colston Park
Mackenzie	Coolmaringa
Fitzroy	Riverslea

Therefore, it was initially assumed that most of the available water quality data pertained to lowland waters. This was tested by categorising the initial 39 sites as either upland or lowland. If sites were close to mountain ranges, they were classed as upland. Position and topography were determined using satellite imagery and contour maps. This resulted in five sites being categorised as upland. A principal component analysis (PCA) examined variation among the 39 sites in terms of water quality. Data comprised values of electrical conductivity (EC), total suspended solids (TSS), sulphate, hardness and total alkalinity collected for low flow conditions. These were square-root transformed and normalised before analysis.

The first two axes of the PCA accounted for 85 per cent of variation among sites (Axes 1: eigenvalue of 3.25; Axis 2: eigenvalue of 1.02). Figure A8 (a) shows there was no clear separation among sites because of upland/lowland definition, but sites did cluster in relation to sub-regions/catchments (Figure A8 (b)). Most variation along the first axis related to EC, hardness and total alkalinity, while TSS accounted for most along the second axis. In this respect Callide and Isaac catchments related to comparatively high values of EC, sulphate hardness and total alkalinity, while the Nogoa was associated with high TSS.

These results validated using the chosen sites to derive guidelines for one water type, i.e. lowland. They also justified breaking the Fitzroy Basin into catchment/sub-regions as the catchments/subregions used in the analyses showed a reasonable amount of separation among them, although there were some overlaps.

Figure A7: Examples of sites used as reference locations for developing water quality guidelines for the protection of freshwater aquatic ecosystems in the Fitzroy Basin: Phase 1

Defining indicators of interest

Water quality variables were chosen based on land use activities in the Fitzroy Basin (Rowland et al. 2006). The indicators selected were:

- electrical conductivity (EC = measure of salinity)
- turbidity
- total suspended solids (TSS)
- pH
- sulphate (SO4)
- nutrients (e.g. total nitrogen [TN], nitrogen oxides, ammonia, total phosphorus [TP] and filterable reactive phosphorus)
- metals
- pesticides
- chlorophyll a.

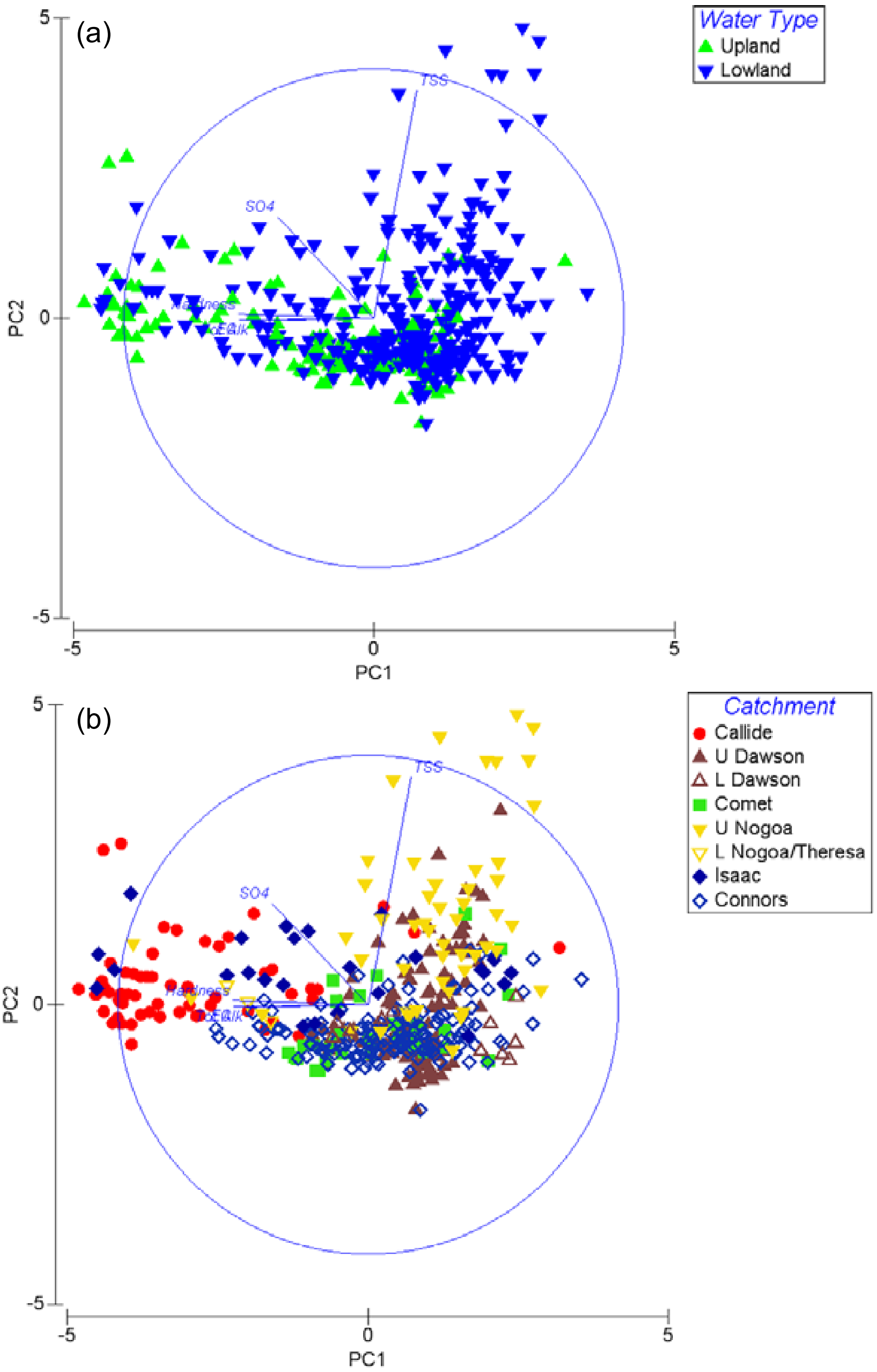


Figure A8: PCA plots show no clear separation in terms of water quality between water types (a), but differences occur between sub-regions/catchments (b). Higher values of electrical conductivity (EC), sulphate, hardness and total alkalinity distinguish the Callide and Isaac catchments, while elevated total suspended solids (TSS) concentrations separate the Nogoa from the rest, The first axis (PC1) accounts for 65 per cent and the second axis (PC2) 20 per cent of the variation in the data.

Data requirements

The quality of sampling protocols and laboratory methods used to derive water quality data were interrogated and compared with current valid procedures (DERM 2009b, ANZECC & ARMCANZ 2000b). The quantity of data required for each parameter was based on methods for deriving guidelines in the QWQGs (DERM 2009a).

Flow regimes

It is known that the values of some indicators (e.g. turbidity, salinity) are strongly related to flow. The possibility of determining separate guidelines for high flow and low flow conditions was therefore investigated. In order to do this, a method of stratifying flows into ‘high flow’ and ‘low flow’ was required. Instead of using a standard percentile (i.e. top 10th or 20th percentile) based on a flow duration curve at a site (i.e. flow values over time at a site) to separate the data in terms of flow, this project used a more site-specific approach. This was deemed necessary because flow duration among the sites varied considerably owing to differences in catchment size, stream order and hydrodynamics. For example, one site may flow 100 per cent of the time, whereas another only 5 per cent of the time, and so a universal percentile was not applicable.

The approach taken in this project involved three main steps. Firstly, a plot of EC concentrations against flow rate (cumecs) at a site was used to establish a flow rate that logically separated the data into low and high flow data. Typically, EC is lower at high flow because salts are diluted by rainfall. So, in plotting EC against flow, an obvious change in EC values with flow was expected. Figure A9 illustrates such a conceptual model between EC and flow. Theoretically then, plots could be used to visualise a point in the flow that separated the data into low and high flow datasets. A plot of actual values is shown in Figure A10 with a vertical line depicting the point along the flow axis that separated the data into ‘low’ and ‘high’ flow datasets for this site. A similar approach was used to stratify data for all sites.

The second stage involved refining the flow-separated datasets by examining inconsistencies. Values were moved from one dataset to another when further evidence suggested a different flow regime dominated the result. Time-series flow data were obtained from the department for this purpose. As an example, if an EC value in a ‘low’ flow data set was obviously lower than the rest, the time-series flow record was investigated for the influence of a rising or falling flow at the time the sample was taken. If such influence was evident, the value was moved to the ‘high’ flow set. Rainfall records of a nearby weather station were used to strengthen evidence when needed. Data associated with zero flow were removed from the low flow dataset at this stage because during nil flow periods water quality in individual water holes becomes highly variable and these data would bias results.

Finally, for each site, values of all parameters were separated ‘low’ and ‘high’ flow datasets to coincide with the separated EC datasets of ‘low’ and ‘high’ flow.

Calculating guideline values

The derivation of guidelines based on the 20th and 80th percentile values of reference site(s) data is an approach proposed in the ANZECC 2000 guidelines. Where there were sufficient data, both the 20th and 80th and also the 25th and 75th percentiles were calculated for each parameter at each reference site. Where there were two or more reference sites for a region, percentiles of all the sites were averaged.

Following examination of the data, it was decided to use the 75th percentile rather than the 80th percentile to derive upper limit guideline values. This was done because the high variability of the data meant that using the 80th percentile would have set guidelines at values that would allow too great a degree of change from reference. The 75th percentile has been used as an upper limit previously (e.g. DERM 2009a, EPA Vic 2003, US EPA 2000). Use of the 75th percentile was also regarded as more appropriate than the 80th percentile because many of the reference sites were subject to some level of upstream disturbance.

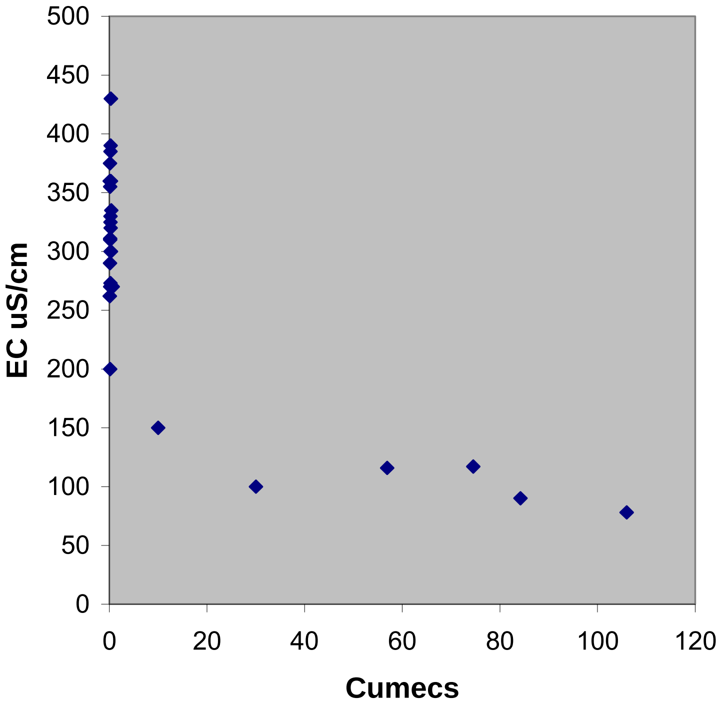


Figure A9: A conceptual relationship between electrical conductivity (EC) and flow (cumecs) where EC decreases with high flow

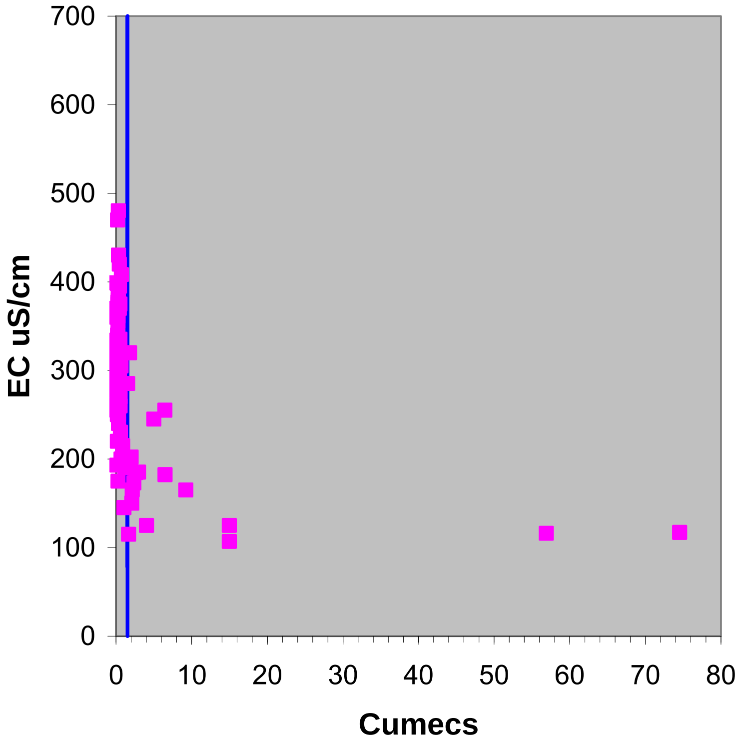


Figure A10: An actual plot of electrical conductivity (EC) against flow (cumecs) at Utopia Downs in the Upper Dawson catchment. Vertical line on plot shows where data were initially separated into high and low flow conditions

For similar reasons, in cases where indicators (e.g. dissolved oxygen) require a lower limit guideline, it was considered appropriate to use the 25th rather than the 20th percentile. The only indicator considered here that required a lower limit guideline was pH. However given the wide diel variation that can occur with this indicator, a blanket guideline range of 6.5 to 8.5 was seen as a more practical approach than using calculated percentiles from reference data collected mainly in the middle of the day.

Results and discussion

This Phase 1 project derived guidelines for protection of aquatic ecosystems for TSS, EC, SO4, TN, TP and pH under low-flow conditions in lowland streams of sub-regions of the Fitzroy Basin. These are presented in Table A3 below.

Table A3: Phase 1 sub-regional water quality guidelines for protecting freshwater aquatic ecosystems for catchments of the Fitzroy Basin. All values shown are sub-regional guideline values, unless otherwise stated (refer notes below). These guidelines are for low flow regimes.

	TSS	EC	SO_4	TN	TP	pH	
	mg/L	µS/cm	mg/L	µg/L	µg/L	Low	High
QWQG 2009*	***10***	***340/720/760[1]***	**-**	***500***	***50***	***6.5***	***8.0***
Callide	25	1220	20	500[2]	50[2]	6.5	8.5
Upper Dawson	25	360	5	350	70	6.5	8.5
Lower Dawson	10[2]	340[2]	ID[3]	500[2]	50[2]	6.5	8.5
Comet	25	338	5	500[2]	50[2]	6.5	8.5
Upper Nogoa	155	275	15	1000	350	6.5	8.5
Lower Nogoa/Theresa Ck	10[2]	340/720[2,4]	ID[3]	500[2]	50[2]	6.5	8.5
Isaac	55	835	25	500[2]	50[2]	6.5	8.5
Lower Isaac	20	400	5	450	70	6.5	8.5
Connors	15	465	10	500	75	6.5	8.5
Mackenzie	90	330	10	750	130	6.5	8.5
Fitzroy	60	445	15	500[2]	50[2]	6.5	8.5

Notes:
* QWQG regional water quality guidelines for lowland streams of Central Coast Queensland. Refer to section 5 of main report for more details on these regional guidelines. (Regional values have been used where it was not possible to derive sub-regional guideline values.)
1. These are based on the 75th EC percentiles for Queensland salinity zones listed in Appendix G of the QWQG, i.e. 340 for Fitzroy Central, 720 for Fitzroy North and 760 for Callide. They have been used where it was not possible to derive sub-regional guideline values.
2. There is insufficient data to derive a sub-regional guideline for these parameters. QWQG regional guidelines apply until sub-regional guidelines are developed. For parameters other than EC, these are QWQG Central Coast regional guidelines. For EC these are based on salinity guidelines in Appendix G of the QWQG.
3. ID = Insufficient data to derive a sub-regional guideline. Currently, no regional guidelines apply.
4. There are two guidelines specified in this cell because the lower Nogoa/Theresa Creek catchment traverses the boundaries of two different salinity zones (refer QWQG, Appendix G and Figure G3 for zone boundaries).

There were insufficient data to develop guidelines for Theresa Creek/Lower Nogoa and Lower Dawson catchments. As well, there were not enough data to derive TN and TP guidelines for Lower Fitzroy, Isaac, Comet and Callide or dissolved nutrients (e.g. nitrates) for any region. The already-limited nutrient dataset for the Fitzroy was further reduced after several early recordings were eliminated because of inadequate sampling and storage techniques. For turbidity, there were not enough field data and that obtained from laboratory analyses was limited by inadequate upper-reporting levels. There were also very little or no data to derive guidelines for metals, pesticides and chlorophyll a.

This phase did not develop guidelines to suit high flow conditions. In most cases, this was owing to insufficient data. The parameters of TSS, TN and TP, for example, vary over the hydrograph with their concentrations depending on whether the flow is rising, peak or falling. This variability and the realisation that there were too few samplings of event situations restricted the development of high-flow guidelines for these parameters. This was based on assessments of data from event monitoring programs of both FBA and the department. It is anticipated that future monitoring and supporting modelling projects will support the development of high-flow guidelines concerning these. Meanwhile, the most adequate data set for developing high flow guidelines is for EC, and these are proposed for Phase 2 of the development of WQ guidelines for the Fitzroy Basin.

These guidelines were based on existing data at the best available (i.e. least impacted) reference sites within the Fitzroy Basin. Because of the complexity and size of this system and the limitations of past efforts in water quality monitoring, not all desired outcomes were achieved in this phase. In order to increase the available database for deriving guidelines, an initial exercise of monitoring at 50 reference sites within the Fitzroy Basin will be carried out in May and August 2010. The data from this will assist in validating the applicability of the first phase guidelines, support further development of guidelines to cover all desired indicators and regions, and will identify areas for future data collection.

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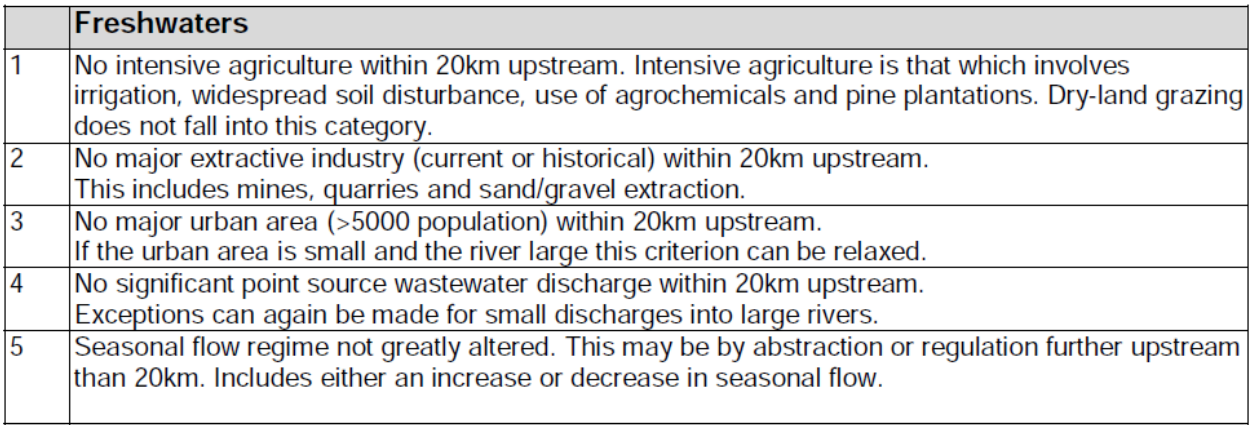
Attachment 1: Criteria for selection of reference sites for developing water quality guidelines (DERM 2009a)



	Freshwaters
1	No intensive agriculture within 20km upstream. Intensive agriculture is that which involves irrigation, widespread soil disturbance, use of agrochemicals and pine plantations. Dry-land grazing does not fall into this category.
2	No major extractive industry (current or historical) within 20km upstream. This includes mines, quarries and sand/gravel extraction.
3	No major urban area (>5000 population) within 20km upstream. If the urban area is small and the river large this criterion can be relaxed.
4	No significant point source wastewater discharge within 20km upstream. Exceptions can again be made for small discharges into large rivers.
5	Seasonal flow regime not greatly altered. This may be by abstraction or regulation further upstream than 20km. Includes either an increase or decrease in seasonal flow.

Appendix 6: Water quality guidelines for ‘human use’ environmental values

Table A4: Water quality guidelines for physico-chemical indicators for each ‘human use’ environmental value

Environmental values		Water type*	Guidelines for physico-chemical indicators for each EV							
			TSS	EC	SO_4	Total N	Total P	pH	pH	NO_3
			mg/L	µS/cm	mg/L	µg/L	µg/L	Low	High	mg/L(NO_3)
Primary industries	Irrigation		ng	600–4200[3]	ng	5000[3]	50[3]	6[3]	8.5[3]	ng
	Farm use		ng	ng	ng	ng	ng	6[3]	8.5[3]	400[3]
	Stock water		ng	0–7500[3]	1000[3]	ng	ng	ng	ng	4003
	Aquaculture	Freshwater	40[3]	4480[3]	ng	ng	ng	5.0[3]	9.0[3]	100[1]
		Saltwater	10[3]	49250–55250[3]	ng	ng	ng	6.0[3]	9.0[3]	1.0[1]
Recreation and aesthetics	Primary recreation		ng	ng	ng	ng	ng	6.5[5]	8.5[5]	ng
	Secondary recreation		ng	ng	ng	ng	ng	ng	ng	ng
	Visual appreciation		ng	ng	ng	ng	ng	ng	ng	ng
Drinking water	Treated water		ng	1000[4]	250[4]	ng	ng	6.5[4]	8.5[4]	50[4]
Industrial uses	Industrial uses		ng	ng	ng	ng	ng	ng	ng	ng
Cultural and spiritual	Cultural and spiritual values		ng	ng	ng	ng	ng	ng	ng	ng

Notes:

* See Appendix 5 and DERM (2009), Appendix B, for definitions of water types. ng = no guideline available na = not applicable ndr = nil detected residues

[1] = Queensland Water Quality Guidelines, (DERM 2009)

[2] = Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2008)

[3] = Australian and New Zealand Guidelines for Fresh and Marine Waters (ANZECC &ARMCANZ 2000)

[4] = Australian Drinking Water Guidelines, (NHMRC & NRMMC 2004)

[5] = Australian Guidelines for Managing Risk in Recreational Waters, (NHMRC 2008)

[6] = Australian and New Zealand Food Standards Code (ANZFSC 2007)

Table A5: Water quality guidelines for pesticide indicators for each 'human use' environmental value

Environmental values		Water quality guidelines for pesticide indicators for each EV											
		Water type*	Indicator										
			Diuron	Atrazine	Chlorpyrifos	Endosulfan	Ametryn	Simazine	Hexazinone	2,4-D	Tebuthiuron	MEMC	Diazinon
			µg/l										
Primary industries	Irrigation		2[3]	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
	Farm use		ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
	Stock water		30[4]	0.1[4]	10[4]	0.05[4]	5[4]	0.5[4]	2[4]	0.1[4]	ng	ng	1[4]
	Aquaculture	Freshwater	1.5[3]	ng	0.001[3]	0.003[3]	ng	10.0[3]	ng	0.004[3]	ng	ng	0.002[3]
		Saltwater	1.5[3]	ng	ng	0.001[3]	ng	10.0[3]	ng	0.004[3]	ng	ng	0.002[3]
	Human consumption of aquatic foods		ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]	ndr[6]
Recreation and aesthetics	Primary recreation		30[5]	40[5]	10[5]	30[5]	50[5]	20[5]	300[5]	30[5]	ng	ng	3[5]
	Secondary recreation		ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
	Visual appreciation		na	na	na	na	na	na	na	na	na	na	na
Drinking water	Treated water		30[4]	0.1[4]	10[4]	0.05[4]	5[4]	0.5[4]	2[4]	0.1[4]	ng	ng	1[4]

Environmental values		Water quality guidelines for pesticide indicators for each EV											
		Water type*	Indicator										
			Diuron	Atrazine	Chlorpyrifos	Endosulfan	Ametryn	Simazine	Hexazinone	2,4-D	Tebuthiuron	MEMC	Diazinon
			µg/l										
Industrial uses	Industrial uses		ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng
Cultural and spiritual	Cultural and spiritual values		ng	ng	ng	ng	ng	ng	ng	ng	ng	ng	ng

See footnotes at bottom of Table A4

Appendix 7: Current water quality

Current water quality varies throughout the Fitzroy Basin from excellent WQ in undisturbed national parks at the top of some catchments through to impacted WQ in more downstream areas where development occurs. WQ also varies over time with rainfall and run-off causing pollutants to be washed off the various catchment land uses and routed through waterways. WQ monitoring[22] occurs at a number of sites throughout the basin by a number of organisations and for a number of different objectives. FBA and DERM are working collaboratively on a project aiming to better coordinate relevant monitoring programs and this is discussed further in section 11.

The WQ guidelines and WQOs can be used in a number of ways as shown at the bottom of Figure 10. Planning and licensing/approvals uses of the WQOs are discussed in section 8. In this appendix, examples for sites in both freshwaters and the Fitzroy estuary are provided that compare the results of current monitoring with the WQ guidelines. The first examples provided in Figures A11–A16 are for the key freshwater WQ parameter i.e. electrical conductivity (EC) (microsiemens/centimetre) and include a comparison with the relevant sub-regional WQ guideline value for the protection of aquatic ecosystems from Table 1. These plots are for the following sampling stations:

- Coolmaringa (Mackenzie River)
- Yatton (Isaac River)
- Comet River at the Weir
- Craigmore (Nogoa River)
- Taroom (Dawson River)
- Eden Bann (Fitzroy River).

Locations of these sites are shown on Figure A6 in Appendix 5.

These examples show the WQ statistics for all the low flow data between 1 September 2007 and 1 October 2009. 'Box and whisker' plots are used and they show (as indicated in the legend) the following statistics from all the low flow data over this period at each sampling station:

- the minimum value from all the data

at that sampling station

- the 25th percentile from all the data

(i.e. a quarter of the values are below this level)

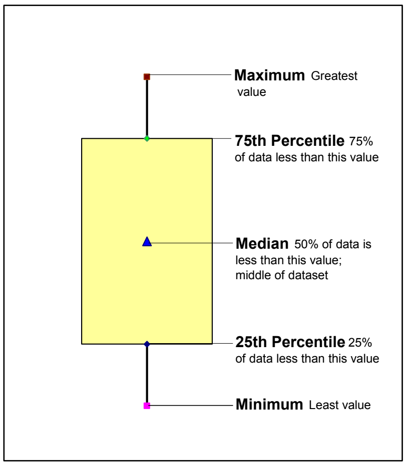
- the median from all the data

(i.e. half the values are below this level)

- the 75th percentile from all the data

(i.e. three quarters of the values are below this level)

- the maximum value from all the data.



The final piece of information on each graph is the relevant draft WQ guideline from Table 1 (shown as the extended red horizontal line). For a general comparison of current water quality (for non-toxic parameters) with the WQ guidelines, the national WQ guidelines recommend using the 'median'.

In summary, the median values for all the six freshwater examples below meet the WQ guideline value relevant to their catchment.

The second set of plots in Figures A17-A21 are for an upper estuary site (57.3 km from the mouth – about 2.5km downstream of the barrage at Rockhampton) and a mid-estuary site (20km from the mouth). The plots are for the following key estuarine

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[22] Region map for the Fitzroy, Pioneer, Plane, Waterpark areas on the DERM website at: <www.derm.qld.gov.au>.

Regional Water Quality Monitoring and Reporting on the FBA website at: <www.fba.org.au>.

Water quality information on the Fitzroy River website: <www.fitzroyriver.qld.gov.au>

WQ parameters of chlorophyll a; total nitrogen, total phosphorus, turbidity and dissolved oxygen (respectively). These plots just show the median values for all the low flow data between 1 October 2007 and 30 September 2009, together with the relevant WQ guideline values. The total nitrogen and phosphorus data show elevated levels due to the point source discharges around Rockhampton (e.g. treated sewage plant effluent) to these upstream reaches. However, because of the light limitations (see turbidity levels), these nutrient levels do not result in major growth of algae (as would be evidenced by elevated levels of chlorophyll a). In low flow situations, these estuarine stores of nutrients are gradually dispersed downstream in the estuary, then in high flows, are flushed out of the estuary and into Keppel Bay. The dissolved oxygen levels at the upstream site show some high values due to the algal growth that is able to occur in the upper layers where light is available. The mid-estuary turbidity levels reflect the higher tidal velocities in this area which resuspend the fine sediment that has been deposited.

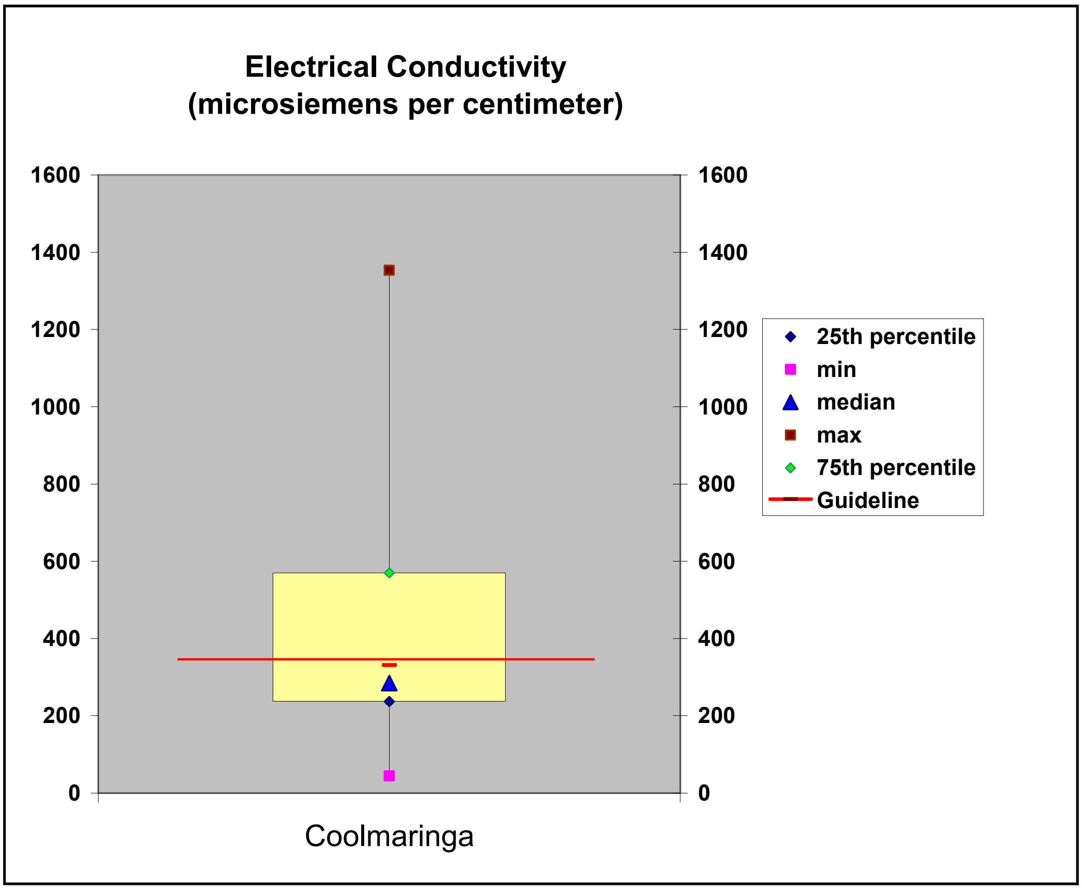

Figure A11: Current WQ at Coolmaringa (Mackenzie River)

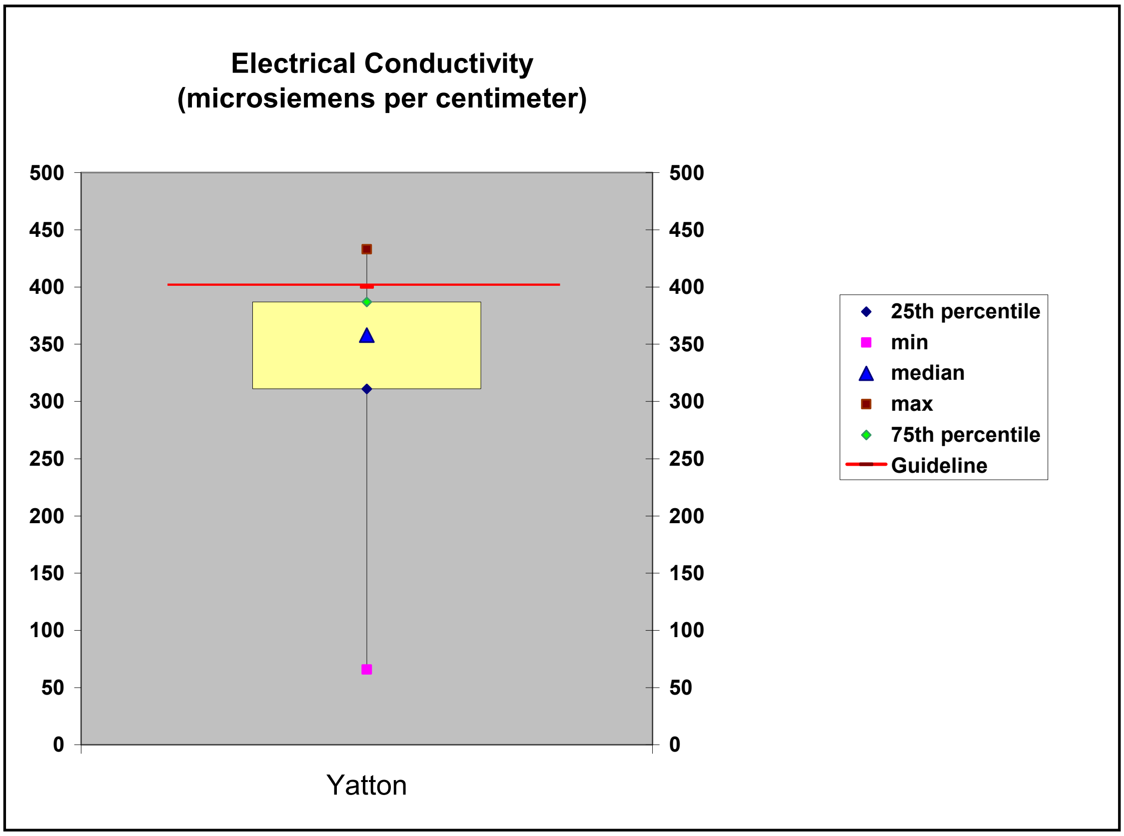

Figure A12: Current WQ at Yatton (Isaac River)

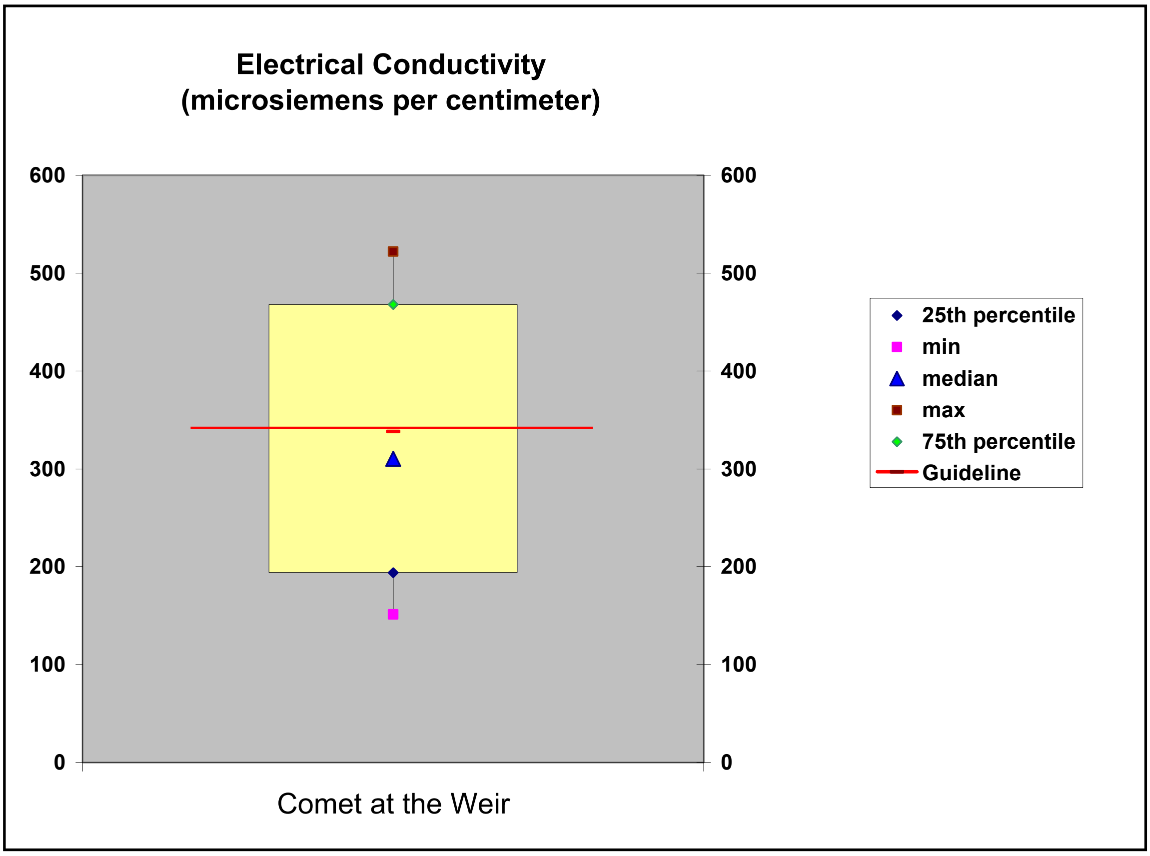

Figure A13: Current WQ at the Weir (Comet River)

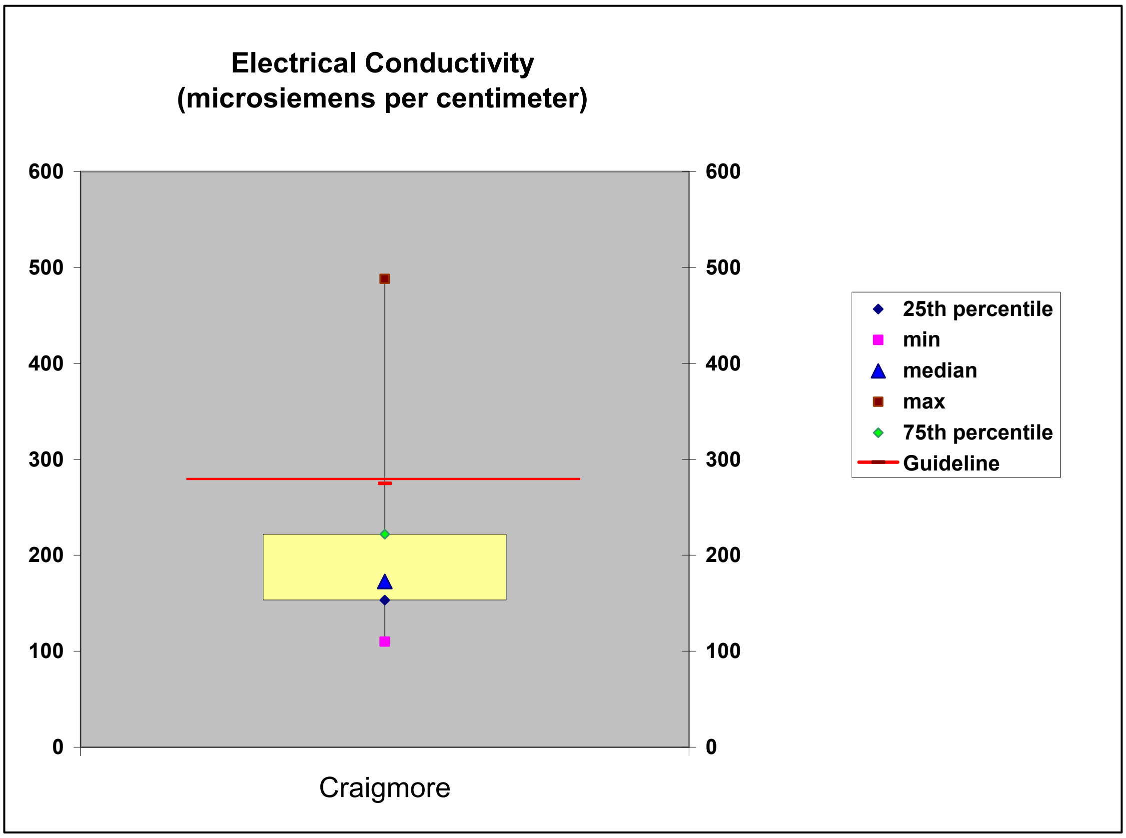

Figure A14: Current WQ at Craigmore (Nogoa River)

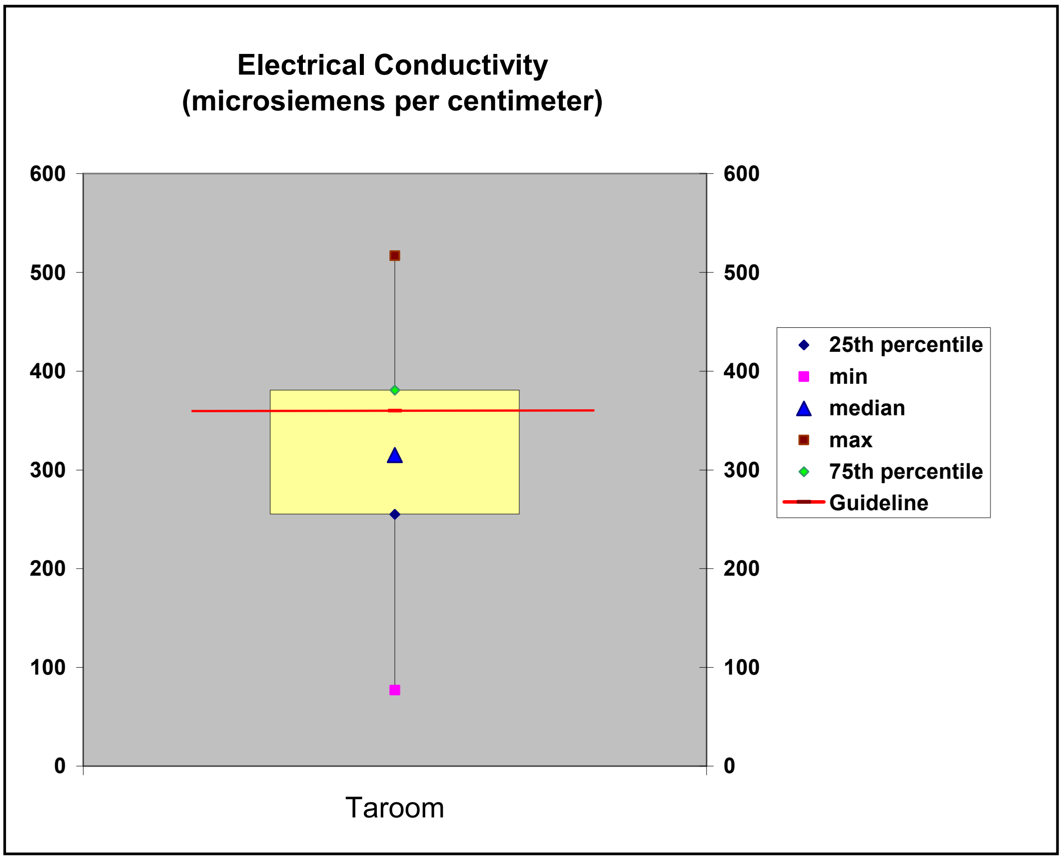

Figure A15: Current WQ at Taroom (Dawson River)

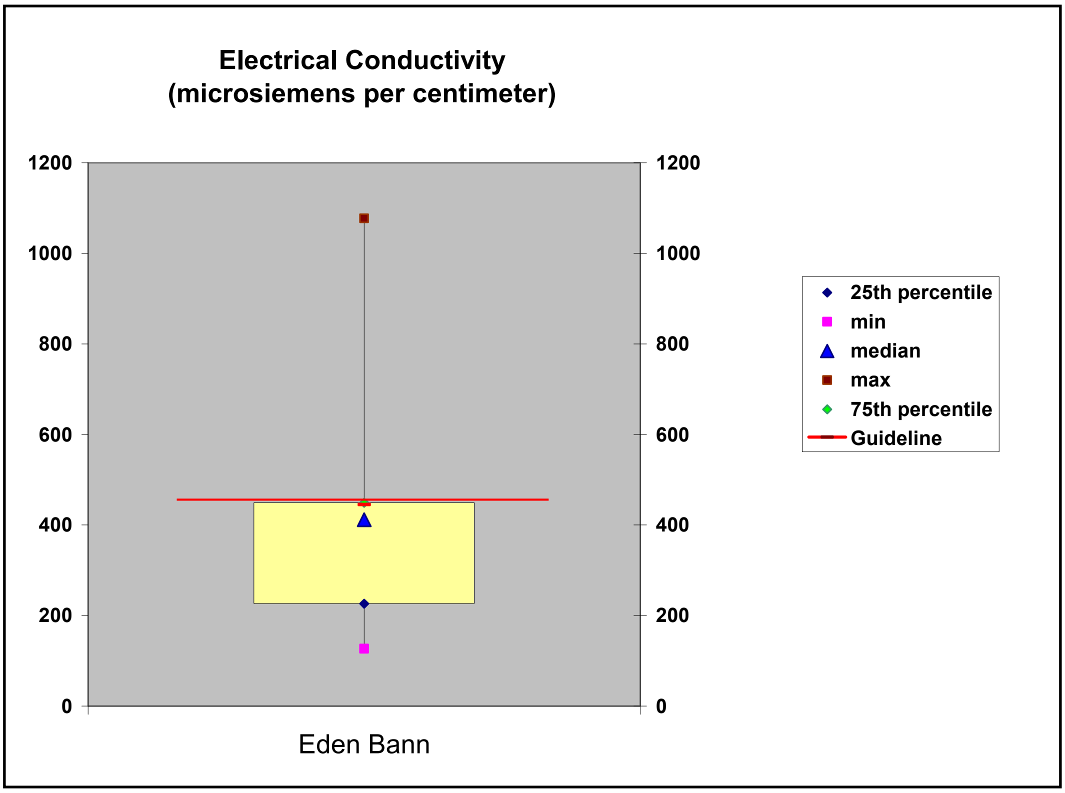

Figure A16: Current WQ at Eden Bann (Fitzroy River)

FITZROY ESTUARY PLOTS – low flow data – 1 Oct 2007 to 30 Sept 2009

◆ **Median (i.e. 50th Percentile)** — **Upper WQ Guideline** — **Lower WQ Guideline**

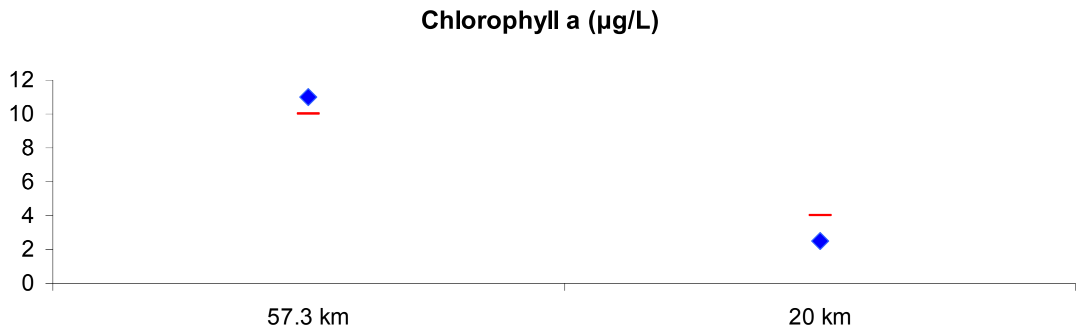

Figure A17: Current Chlorophyll a levels (Fitzroy Estuary)

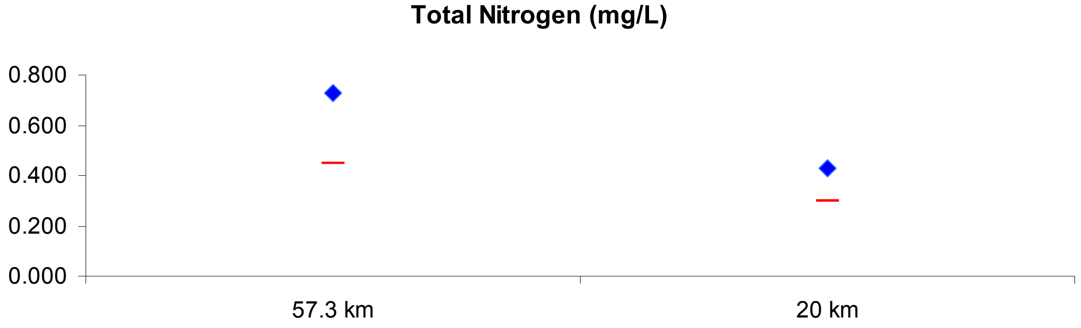

Figure A18: Current Total Nitrogen levels (Fitzroy Estuary)

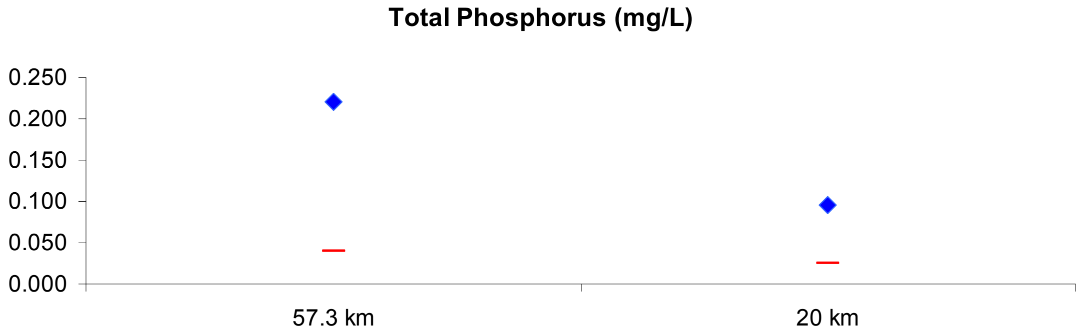

Figure A19: Current Total Phosphorus levels (Fitzroy Estuary)

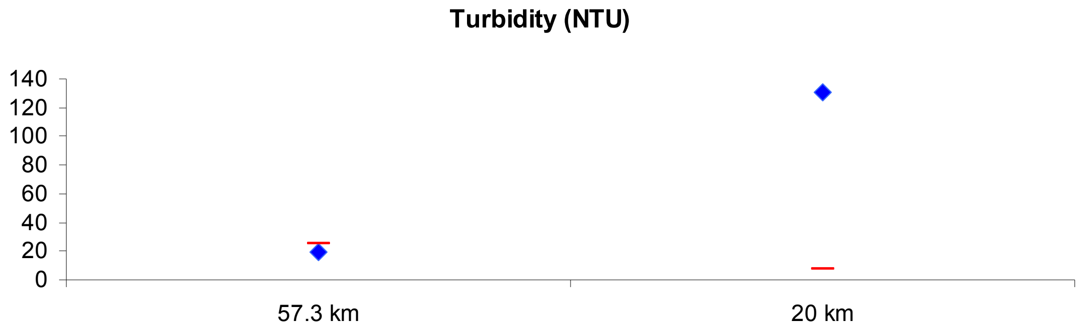

Figure A20: Current Turbidity levels (Fitzroy Estuary)

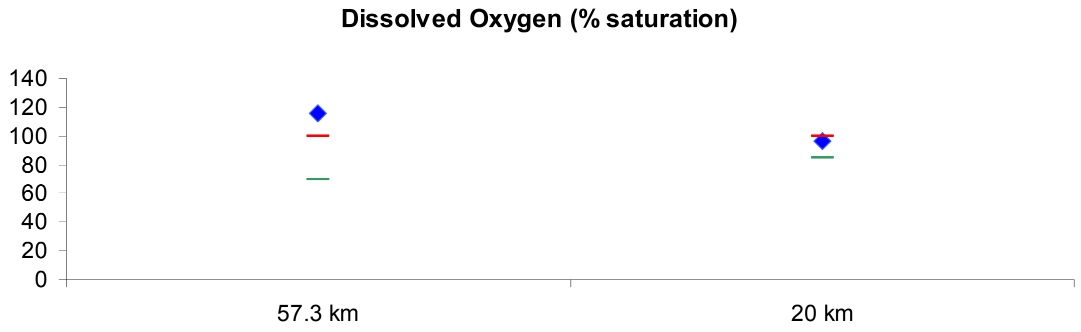

Figure A21: Current Dissolved Oxygen levels (Fitzroy Estuary)