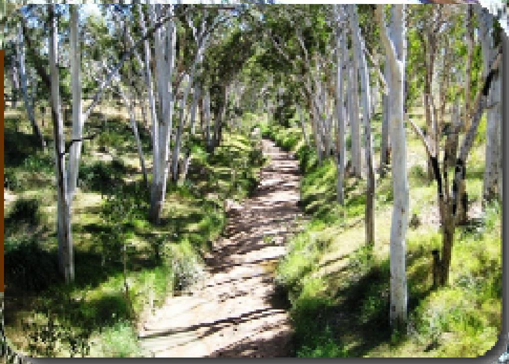
Aquatic Conservation Assessments (ACA)

using AquaBAMM



for the riverine wetlands of the Great Barrier Reef catchment

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Cover photos (from top to bottom):

1. Suttor River (be_00288) – Selena Inglis

2. *Litoria fallax* – Anthony Backer

3. Haughton River (ha_00017) – Selena Inglis

4. *Nymphea gigantea* – Selena Inglis

5. Connors River (is_00109) – Selena Inglis

6. Majors Creek (ha_00031) – Selena Inglis (background photo)

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1 Introduction

The Aquatic Biodiversity Assessment and Mapping Method, or AquaBAMM (Clayton *et al.* 2006), was developed to assess conservation values of wetlands in Queensland, and may also have application in broader geographical contexts. It is a comprehensive method that uses available data, including data resulting from expert opinion, to identify relative wetland conservation/ecological values within a specified study area (usually a catchment). The product of applying this method is an Aquatic Conservation Assessment (ACA) for the study area.

An ACA using AquaBAMM is non-social, non-economic and identifies the conservation/ecological values of wetlands at a user-defined scale. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature, in combination with novel ideas from the developmental team. The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. An ACA using AquaBAMM is a powerful decision support tool that is easily updated and simply interrogated through a geographic information system (GIS).

Where they have been conducted, ACAs can provide a source of baseline wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered (i.e. an early input to broader 'triple-bottom-line' decision-making processes). An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning processes
- providing input to broader social and economic evaluation and prioritisation processes.

The Department of Environment and Resource Management (DERM) conducted ACAs for the riverine freshwater wetlands in each of the 35 Great Barrier Reef (GBR) catchments. In effect, there are 35 ACAs for the entire GBR catchment. Estuarine wetlands are excluded from these assessments.

1.1 The Great Barrier Reef study area

Thirty-five (35) GBR catchments were the subject of ACAs focused on their freshwater riverine wetlands (

Figure ***1***). Table 1 shows the names of the 35 catchments/study areas for which ACAs were undertaken and the number of riverine subsections contained within each catchment.

Table 1 GBR catchments subject to an ACA using AquaBAMM

ACA study areas or catchments	Catchment code	Number of riverine subsections	Area (ha)
Baffle	ba	321	401,537
Barron	bn	59	218,759
Belyando	be	1,051	7,389,621
Black	bk	28	105,619
Bowen	bw	88	944,628
Boyne	bo	69	259,986
Burdekin Lower	bl	128	1,047,028
Burdekin Upper	bp	484	3,625,311
Calliope	ca	63	224,352
Comet	ct	113	1,642,016
Curtis Island	ci	18	57,856
Daintree	da	29	210,683
Dawson	dn	187	5,125,757
Don	do	96	369,316
Fitzroy	fi	91	1,101,572
Haughton	ha	101	404,786
Herbert	he	271	984,136
Hinchinbrook	hi	13	39,614
Isaac	is	169	2,234,674
Johnstone	jo	62	232,418
Mackenzie	ma	68	1,307,898
Mossman	mo	14	47,294
Mulgrave-Russell	mr	45	198,196
Murray	mu	68	110,609
Nogoa	no	142	2,846,017
O'Connell	oc	54	238,699
Other Islands	oi	25	50,370
Pioneer	pi	39	157,022
Plane	pl	45	254,009
Proserpine	pr	53	253,412
Ross	ro	40	170,551
Shoalwater	sh	14	361,192
Styx	st	8	301,494
Tully	tu	76	168,278
Waterpark	wa	13	184,093
	TOTAL	**4,143**	**33,268,803**

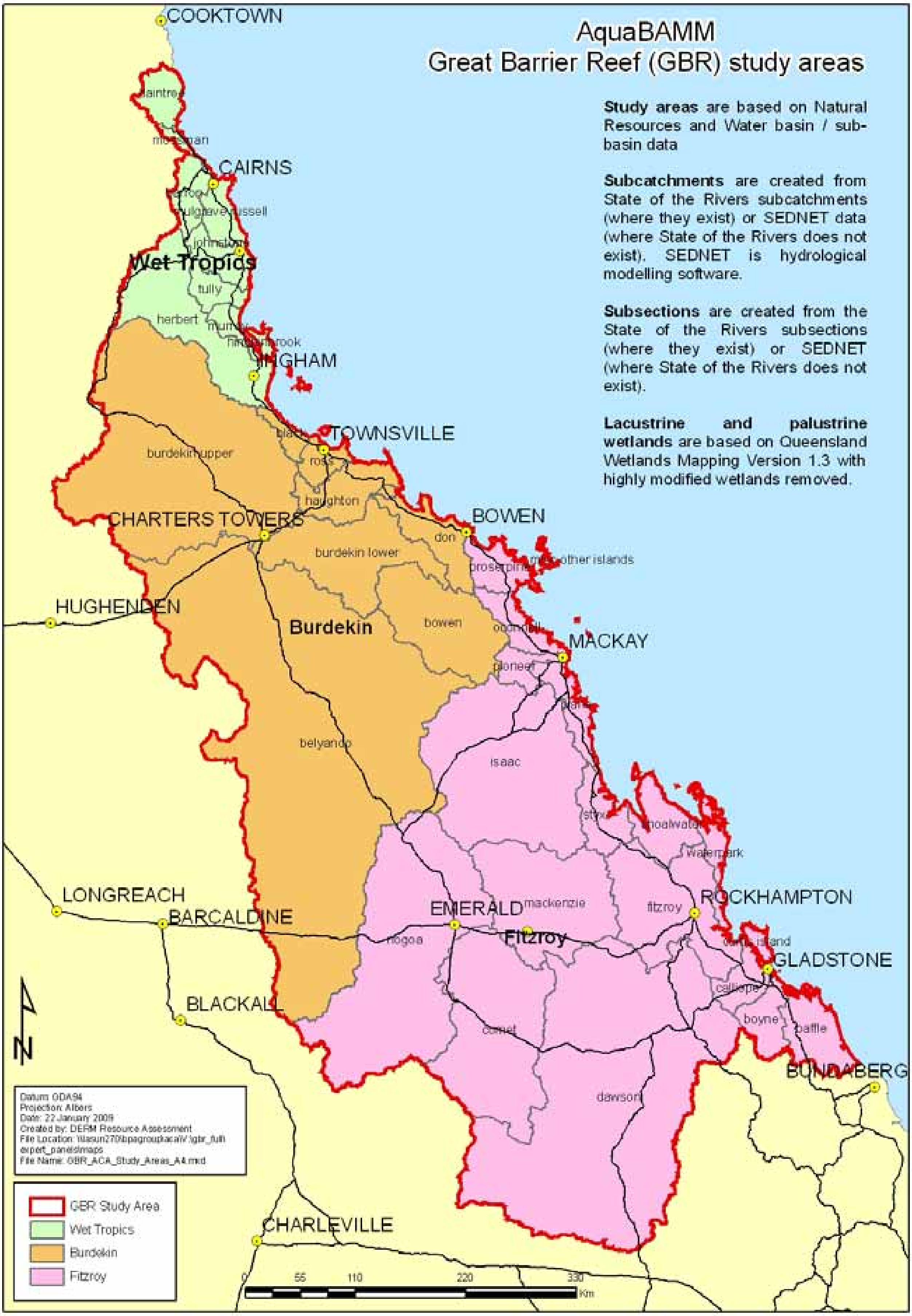

Figure 1 The 35 GBR catchments where ACAs have been conducted

The 35 catchments of the GBR extend from the Daintree River in the north, to the Baffle Creek in the south. The area contains a wide range of wetlands types contained within the boundaries of five bioregions including Wet Tropics, Brigalow Belt, Einasleigh Uplands, Central Queensland Coast and South East Queensland. As a result, a variance in wetland ecology, geomorphology, hydrology, habitat and species composition can also be found throughout the region.

For the purposes of the ACA, the 35 catchments of the GBR were divided into three main regions covering the Wet Tropics, Burdekin and Fitzroy (

Figure ***1***). The purpose of this division was primarily so that expert panel advice could be provided on the aquatic flora, aquatic fauna and wetland ecology in these regions. ACAs assess conservation values relative to within the catchment. Care was taken at the expert panels to ensure that each catchment was considered separately. A description of each of these regions is provided below.

1.2 Wet Tropics

The study areas used to implement the AquaBAMM assessments are based on the Department of Environment and Resource Management basin/sub-basin data. The Wet Tropics study area largely corresponds to the Wet Tropics Natural Resource Management (NRM) region and contains the majority of the Wet Tropics World Heritage Area. In total the study area covers approximately 22,100 km^2 and lies across the majority of the Wet Tropics bioregion and a part of the Einasleigh Uplands bioregion to the west in the Upper Herbert and Upper Barron basins. It includes nine basins including the coastal basins of the Daintree, Mossman, Barron, Mulgrave/Russell, Johnstone, Tully, Murray, Herbert and Hinchinbrook Island. Each of these was treated as an individual study area for the purpose of the AquaBAMM analyses.

As the name suggests the Wet Tropics is characterised by high rainfall largely due to the conspicuous topography. The major mountain masses exceed elevations of 1,000 m and all are granitic, although some have flanking acid volcanic and metamorphic rocks. Extensive areas of basalt occur, particularly through the Atherton Tablelands, an extensive plateau between 600 m and 900 m that covers a large part of the upper Barron River catchment. The region contains a number of high peaks including the two highest mountains in Queensland, Mount Bartle Frere (1,622 m) and Mount Belenden Ker (1,593 m). The mountain ranges generally have steep precipitous mountain sides with deeply incised valleys. They run north to south, rising sharply near the coast and capture the moisture-laden air from the warm waters of the Coral Sea, resulting in generally high rainfall across the region. The most extensive lowlands are in the south of the study area, associated with the floodplains of the Tully and Herbert rivers, with extensive coastal freshwater and estuarine wetlands.

Mean annual rainfall for the Wet Tropics bioregion is above 1,500 mm, three times the continental average of below 500 mm, with several areas within the study area receiving much higher rainfall. Rainfall patterns are strongly seasonal with a distinct wet season occurring in the warmer months between December and April and although generally wet can vary substantially from year to year. Interannual variability is mainly driven by major rainfall events which commonly occur, associated with cyclones and low pressure depressions. These can flood large areas of the region resulting in huge volumes of water being discharged to the inshore waters of the Great Barrier Reef lagoon. For example, in the Herbert River total mean annual discharge is approximately 3.7 million megalitres and in the Johnstone and South Johnstone it is 3.23 million megalitres. The amount of rain also varies throughout the region due to topography and there is a distinct gradient to drier conditions from the western side of the ranges towards where the study area crosses into the Einasleigh Uplands bioregion. Rainfall is not recorded from the peak of Mount Bartle Frere, but at the summit of the adjacent Mount Belenden Ker records show an annual average rainfall of 8,312 mm, making it the wettest meteorological station in Australia. It also holds the record for the highest rainfall in a calendar year of 12,461 mm in 2000. On the lowlands the Daintree area and the area from Cairns south to Tully receives the highest rainfall with Babinda typically receiving rainfall in excess of 4,000 mm annually. In contrast, the western side of the study area in the Upper Herbert and Upper Barron basins, on average, receives less than 800 mm annually.

The study area also has generally warm and uniform temperatures throughout the year. Typical daytime minimum and maximum temperatures range on the coast from 22ºC to 31ºC in summer and from 15ºC to 22ºC in winter. The tablelands and uplands are generally much cooler. On the western side of the study area temperatures vary slightly more and tend towards being hotter in summer.

As a consequence of the high rainfall, rainforest cover is extensive across the ranges and coastal lowlands and streams and wetlands are numerous and important features in the landscape. The consistent runoff results in most streams and many wetlands being perennial and they have been so for millions of years, in contrast to most other parts of Australia, including most of the tropical region. As a result the Wet Tropics has sustained a unique and diverse freshwater fauna and flora with many endemic species present.

The high degree of variation in rainfall, topography, combined with a complex evolutionary history has resulted in a diverse spectrum of forest types and plant and animal communities. The rainforests of the region which dominates the narrow, high rainfall coastal belt have been classified into 16 major structural types and 30 broad community types (Tracey and Webb, 1975; Tracey, 1982). In addition, the rainforests are fringed and dissected by a range of sclerophyll forests and woodlands as well as wetlands including estuarine mangrove communities. Tall woodlands, open *Eucalyptus* forests and grasslands extend into the drier western parts of the study area in to the Einasleigh Upland bioregion.

Wetland types include an enormous number of low order, perennial or near perennial, streams descending the steep ranges. These join in to several major river systems that define the basins within the study area. The coastal lowland floodplains are generally narrow, with the most extensive lowlands occurring in the south of the study area associated with the floodplains of the Tully/Murray and the Herbert rivers. These areas contain complex systems of numerous interconnecting wetlands and extensive coastal estuarine areas. The Herbert floodplain receives the lowest rainfall of the coastal lowlands in the study area but can have the highest discharge from runoff in the upper catchment. Its floodplain is dominated by woodlands with extensive areas of grass and sedge swamps laying adjacent to dune systems and connected estuaries. This area also contains the Herbert River delta which is formed at the southern end of the Hinchinbrook Channel, with its extensive stands of mangrove forest. In the Tully/Murray floodplain (and areas to the north) rainfall is higher and the coastal vegetation is dominated by forest, rainforest and extensive wetland areas. Unfortunately many of the coastal wetlands throughout the study area have been lost or are now largely modified through drainage and reclamation works. Many of the remaining wetlands are also heavily impacted by clearing of riparian and fringing vegetation, infestation by weeds and by declines in water quality through runoff from adjacent agriculture. Fractured basalt and other fractured rock aquifers occur throughout the study area supporting unique fauna and flora. These aquifer systems are particularly significant in some of the areas within the drier parts of the study area in the Einasleigh Upland. Crater lakes are also a unique feature of the plateaus of the study area.

Approximately 35 per cent of the study area is covered by the Wet Tropics World Heritage Area, taking in most of the ranges and large areas of lowland rainforest. The World Heritage Area consists of extensive areas of National Park and other protected estate as well as areas of private land. The major commercial land uses in the study area include extensive areas of lowlands, and some uplands, used for sugar cane production. Extensive areas in the lowlands are also used for banana production with a diverse range of other horticultural crops occurring throughout. On the fertile Atherton Tablelands dairy is a major industry along with a variety of horticulture and crops. Cattle grazing is a minor land use in the coastal lowlands but extensive cattle grazing is the major land use in the western part of the study area. The area was once heavily dependent on native forestry. However, this has declined with the protection of much of the native rainforest areas in the Wet Tropics World Heritage Area and in recent times forestry has depended on broad hectare softwood plantations on the Atherton Tablelands and the Cardwell area. Increasingly, other forestry plantations are being established on what was traditionally land used for sugar cane production.

1.3 Burdekin

The study areas used to implement the AquaBAMM assessments were based on the Department of Environment and Resource Management basin/sub-basin data. The Burdekin study area lies within the wet-dry tropics and includes, as well as, the adjacent continental islands of the Palm Island group and Magnetic Island. This area takes in the coastal basins of the Black, Ross, Haughton, and Don rivers, and the sub-basins of the greater Burdekin River catchment; the Burdekin Lower, Burdekin Upper, Belyando and Bowen sub-basins. Apart from the inclusion of the Don Basin, the Burdekin study area largely corresponds to the Burdekin dry tropics Natural Resource Management (NRM) region and covers an area of approximately 140,000 km^2.

The area includes the Burdekin River catchment; Australia's largest in terms of peak discharge. It covers a diversity of landscapes crossing five bioregions: the Wet Tropics, the Einasleigh Uplands, the Desert Uplands, the Brigalow Belt North, and a small section of the Central Queensland Coast bioregion on the southern edge. The physical environments include mountain ranges rising to 1,359 m at Mount McCartney in the Clarke Range to the south, 1,221 m at Mount Elliot near Townsville, 1,063 m at Mount Halifax in the Paluma Range to the north and 1,002 m at Mount Tabletop on the Great Dividing Range to the west. Other features include lower rock hills, coastal plains, floodplains, deltas, beach ridges and continental islands. Undulating plains with escarpments and dissected plateaus are found inland to the west. Vegetation types are equally diverse including tropical rainforest, vine thickets, forested swamps, drier woodlands, grassy plains, sedgelands, and coastal mangroves and saltpans.

The area has a tropical sub-humid climate with relatively high temperatures all year round and a pronounced wet and dry season with most rain falling in the warm, humid months of November through to April. Rainfall is highly variably across the region and influenced by monsoonal and cyclonic activity. There is a distinct gradient to drier conditions from the coast westward. Average annual rainfall varies through the area from above 3,000 mm in the coastal peaks of the Seaview and Paluma Ranges to the north, Mount Elliot near Townsville, and the Clarke Range to south, to below 500 mm in the south-west of the Belyando sub-basin.
The spatial and seasonal variability and the high interannual variability of rainfall are an overriding characteristic of the study area that greatly influences the nature and distribution of its wetlands. Most streams and wetlands are subject to seasonal flows and are subject to irregular flooding. The exceptions to this are the perennial streams that rise in the high rainfall ranges and the wetlands fed by the large basalt aquifers in the Upper Burdekin sub-basin.

In general the Burdekin study area can be broadly divided into higher rainfall, more densely populated coastal areas with urban, industrial and irrigated agriculture land uses predominant and lower rainfall, sparsely populated inland areas used principally for rangeland grazing with some dryland agriculture and mining activity. There are several major water storages and large weirs located within the Burdekin study area, the largest being the Burdekin Falls Dam, which was completed in 1987 forming Lake Dalrymple, with a capacity of 1.86 million megalitres. Other major dams include the Ross River Dam, Paluma and Eungella dams.

The Ross basin is the most developed in the study area containing the regional city of Townsville. Many of the streams and wetlands in this basin are highly modified and impacted by water quality contamination and altered hydrology associated with urban development. Other major towns in the study area include Ayr and Home Hill to the south in the Lower Burdekin and Charters Towers in the Upper Burdekin.

The completion of the Burdekin Falls Dam and the subsequent development of the Burdekin-Haughton Water Supply Scheme (BHWSS) (previously known as the Burdekin River Irrigation Area (BRIA)) for intensive sugar cane production, has dramatically altered the environmental conditions of the streams and wetlands in the lower floodplain of the Haughton and Lower Burdekin basins. The Lower Burdekin is dominated by the Burdekin River delta, where the coastal plain widens and is prone to widespread flooding, with vast areas of wetlands.
The Burdekin Delta and the floodplains and estuaries of the coastal rivers form the Townsville- Burdekin coastal wetland aggregation, one of the most extensive on the Australian east coast. This area includes the wetlands of Bowling Green Bay National Park

listed under the international Ramsar Convention. Prior to development streams in this coastal plain, such as Barratta Creek, consisted of a series of clear or tannin-coloured seasonal in-stream and off-stream lagoons that connected across the floodplain during flood events. Flows were very variable between seasons and interannually. These systems have now been extensively modified. Flows to the streams and wetlands across this floodplain have been radically altered as a result of supplementation through the irrigation delivery system and by irrigation tail waters. This has removed the seasonality in much of the system and in combination with riparian disturbance and nutrient contamination has contributed to extensive weed infestation of wetlands by pasture grasses and aquatic weeds. These impacts have resulted in severe water quality degradation and altered ecology in the wetlands of this coastal plain and presented an enormous task to natural resource managers.

The Don Basin to the south of the Burdekin delta also contains extensive aggregations of coastal wetlands and estuaries. This area has remained one of the least developed along this coast due to relatively low rainfall and the unsuitability of soil types for large-scale irrigated agriculture, although horticulture, largely dependent on ground water, is common in some areas. Although, proposed developments associated with industrial developments at Abbott Point and the Water for Bowen water transfer scheme is likely to increase the pressure on coastal wetlands in this area.

The study area extends over 300 km westwards with the Upper Burdekin sub-basin draining the western side of the coastal ranges and the eastern side of the Great Dividing Range. This basin is contained almost entirely in the Einasleigh Uplands. The area contains a major basalt feature with highly productive black and red soils and numerous springs emanating from many locations that drive permanent flow and clear-water waterholes in many streams. This creates not only many significant water bodies but a wide variety of wetland types. The Burdekin River channel, a large sand and gravel bed channel is another prominent feature. It consists of a small meandering low flow channel bordered by sand and gravel bars located within the high flow channel, with established riparian communities. Flow to this channel is almost perennial most years and comes from two sources: tributaries on the western slopes of the high rainfall coastal ranges; and the extensive basalt aquifers formed by the Toomba basalts flows.

The Belyando sub-basin covers a large part of the study area to the south west and includes the Cape-Campaspe, Belyando and Suttor River catchments. The source of the Belyando River in central western Queensland is almost 500 km from the mouth of the Burdekin River, and extends in to the black-soil grasslands of Central Queensland. The Belyando sub-basin contains two bioregions; the Desert Uplands in the west and the Brigalow Belt North bioregion to the east. The Belyando basin is the area that consistently receives the least rainfall in the study area, with streams and wetlands receiving ephemeral or intermittent flows. In contrast to the Burdekin River channel in the Upper Burdekin, the flow capacity of the main channels of the Cape-Campaspe, Belyando and Suttor River is relatively low resulting in braided (anastomosing) river channels with broad floodplains. The extent of water in the floodplain landscape is highly variable and strongly influenced by flood events which create large temporary wetlands and replenish several permanent waterholes that provide key refugia between flow events. Under flood conditions, flows are spread broadly across the floodplain.

The natural vegetation in the western part of the study area, away from the coast, largely consists of dry eucalypt and acacia savannah woodlands on typical infertile laterised soils and includes grasslands of perennial Mitchell and annual Flinders grasses to the west. Cattle grazing is widespread and a major industry in the inland areas. Land degradation, water quality contamination and erosion are major management problems. Consequently, the Burdekin River catchment has been identified as the biggest single source of sediment to the Great Barrier Reef lagoon and is targeted for improved management actions.

1.4 Fitzroy

The Fitzroy section of the GBR catchment is a vast and extremely varied area. It ranges from the high rainfall, short fast streams surrounded by rainforest on the Whitsunday coast to the slow, turbid meandering floodplain streams of the Fitzroy catchment. It encompasses parts of three bioregions, supports Ramsar listed wetlands and its waters impact on the southern and central GBR. It includes iconic sandstone gorges in places like the Carnarvon Ranges to perched lakes in the upper Comet sub-catchment to world recognised wetland complexes such as the Goorganga Plains as well as waterfalls, cascades and torrents in the rainforests of the Whitsundays.

The Fitzroy catchment itself is the largest eastward flowing system in Australia and only exceeded by the Murray-Darling system Australia wide. The area includes two catchments (Waterpark Creek and Repulse Creek) that are almost entirely surrounded by protected areas while in contrast some catchments are highly modified with a number of rivers heavily regulated by dams, weirs and irrigation development.

The climate of the area is also highly variable. It ranges from distinctly tropical in the north to subtropical in the south. Rainfall is distinctly seasonal with a pronounced wet season from December to March but the amount of rain that falls is amongst the most variable in the world. Between 1976 and 2008, wet season flow to the mouth of the Fitzroy varied from around 349,677 megalitres to 22,903,390 megalitres. Much of the aquatic ecology of the area is driven by variable boom and bust cycles and is consequently amongst the most resilient anywhere.

The largest land use in terms of area is cattle grazing. However, extensive cropping and intensive cultivation of sugar cane is also very important. The area also contributes a huge quantity of coal that is vital to the Queensland and Australian economy. Due to the scale of the Fitzroy area, it is not possible to adequately give an overview of such a vast and varied area, so a brief description of the 17 catchment areas has been provided as an attachment to the Fitzroy expert panel reports.

2 Methods and Implementation

2.1 AquaBAMM

The GBR ACAs were undertaken using AquaBAMM (Clayton *et al.* 2006). The method as published in 2006 has been updated since its development and minor changes have been made to the AquaBAMM tool, including updates to the filter table.

2.2 Subsections

In implementing an ACA, subsections need to be defined in order to assign conservation/ecological values when they are calculated. This issue is dealt with in detail in the published method documentation (Clayton *et al.* 2006).

For a riverine ACA the catchment is normally divided into smaller sub-catchment units. These sub-catchments, referred to as subsections, are used as the ACA spatial units in a riverine ACA and are best defined by considering hydrological patters/processes in the landscape. Subsections that make hydrological sense, and that are generally of a size that balances reporting needs with data availability, can be determined in a number of ways including modelling. In using this approach to define subsections based on their hydrology, an AquaScore achieved by a subsection following the completion of a riverine ACA can be applied to all riverine wetlands within that subsection, whether or not these wetlands appear in mapping products (such as the stream network). These results can be displayed in two ways—AquaScore results coloured by subsection (e.g. Figure 3) or AquaScore results coloured by buffered stream network (e.g. Figure 6).

The number of subsections included in an ACA can vary greatly between study areas. For the GBR catchment, there are 4,143 subsections in the riverine ACA. For these ACAs only natural (H1) or slightly modified (H2M1, H2M2, H2M3, H2M5) wetlands were included. See the Wetland Mapping and Classification Methodology (2005) for more information on these hydrological modifier codes.

2.3 Assessment parameters

There were 4,143 subsections defined for the GBR riverine wetland ACAs. These subsections were adopted from the Queensland State of the Rivers (SOR) program where they are also known as sub-sections. The SOR Program sub-sections are defined as homogenous stream sections in terms of their natural resources (Anderson 1993) but, in short they are hydrologically consistent. Where SOR subsections haven't been defined, SedNet modelling was used to define subsections based on their hydrologic connectivity. The 4,143 GBR subsections have an average area of 8,029.5 ha. The subsection unit area varied from 1.58 ha to 151,426 ha.

The criteria, indicators and measures (CIM) list outlined in Table 2 indicates the CIM that were implemented as part of the riverine ACA for the GBR catchment. The list has been developed from a default list of criteria, indicators and measures that may be considered for an ACA. The default CIM list is not mandatory for any particular ACA; however, it provides a starter set for consideration in setting the assessment parameters for each ACA.

Table 2 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic	1.2.1	SOR[1] aquatic vegetation condition

Criteria & indicators	Measures	
communities/ assemblages	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – Riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Per cent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (water resource plan) hydraulic habitat
	1.4.8	HEV (high ecological value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]

Criteria & indicators	Measures	
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. Spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the subsection to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the subsection
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the subsection to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the subsection to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

Stratification was applied in a number of GBR catchment study areas for the purpose of measures calculation. Stratification mitigates the effects of data averaging across large study areas, and is particularly important where ecological habitat diversity and complexity is high (refer to Clayton *et al.* 2006 for more information on stratification). The stratification levels applied in the GBR riverine ACA were identified by the expert panels (refer to the wetland ecology expert panel reports in Attachments C, F and I for more information). The GBR catchments stratified for the purposes of the GBR riverine ACA are outlined in Table 3.

Table 3 Stratification in study areas of the GBR catchment

Study Area	Stratification
Daintree	150 m above sea level
Mossman	150 m above sea level
Barron	150 m above sea level
Johnstone	150 m above sea level
Mulgrave Russell	150 m above sea level
Tully	150 m above sea level
Murray	150 m above sea level
Herbert	150 m above sea level
Burdekin Lower	150 m above sea level
Haughton	150 m above sea level
Belyando	Desert Uplands/Brigalow Belt bioregional boundary
Baffle	150 m above sea level

2.4 Datasets

Typically, an ACA using AquaBAMM draws on a wide range of datasets with a wide range of formats. This will generally include published scientific documents, unpublished data (grey literature) and officially collated data from various Queensland Government sources (including data from the Queensland Museum, Queensland Herbarium, DERM WildNet, Department of Employment, Economic Development and Innovation, and modelled hydrological data from the Department of Environment and Resource Management).

In addition, data derived from one or more expert elicitation processes is included for every ACA for a number of measures. Expert advice and data is sought formally through an expert panel process. For the GBR catchment ACAs, a series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology. Reports for each of these expert panels are presented as attachments to this report.

2.5 Implementation

Each ACA may have a different combination of assessment parameters (refer to section 2.3), is likely to draw on a different combination of datasets and will have a different set of criteria, indicators and measures. Implementation to complete the assessment can be complex and comprehensive implementation tables are maintained by DERM throughout each ACA. A description of how each measure was implemented as part of the ACA is provided in Table 4.

Table 4 Implementation table for the GBR catchment riverine ACA

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
1.1.1	Presence of 'alien' fish species within the wetland	An expert panel list of alien fish species found in riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more alien fish species recorded (point records or site based lists, >=1975, precision <= 2,000 m) from within its boundaries received a score of one. No score was allocated to any subsection (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Department of Primary Industries and Fisheries (DPIF), Queensland Historical Fauna Database (QHFD)	Presence negative	No
1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	An expert panel list of exotic aquatic plants was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, >=1950, precision <= 2,000 m) from within its boundaries received a score of one. No score was allocated to any subsection (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	WildNet, CORVEG, Herbrecs, ParkInfo, Wetland information capture project	Presence negative	No
1.1.3	Presence of exotic invertebrate fauna within the wetland	An expert panel list of exotic invertebrate fauna found in riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more exotic invertebrate fauna species recorded (point records or site based lists, >=1975, precision <= 2,000 m) from within its boundaries received a score of one. No score was allocated to any subsection (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Presence negative	No
1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	An expert panel list of feral/exotic vertebrate fauna found in riverine freshwater wetlands was used to calculate this measure. A subsection that had one or more feral/exotic vertebrate species recorded (point records or site based lists, >=1975, precision <= 2,000 m) from within its boundaries received a score of one, which was then attributed to all subsections in the subsection. No score was allocated to any subsection (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Presence negative	No
1.2.1	SOR aquatic vegetation condition	The SOR score (per cent) for the 'AQUVEG' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
1.2.2	SIGNAL2 score (Max)	The maximum Signal2 score for each subsection, where one or more Signal2 scores had been calculated, was used in the analysis. No score was allocated to any subsection that did not have a Signal2 score (i.e. they were treated as a missing value).	DERM AUSRIVAS	Quartile – continuous ascending	No
1.2.3	AUSRIVAS score – Edge (Min band)	The AUSRIVAS modelled bands (seasonal + habitat) were identified for each score. Band D was scored one, Band C was scored two, Bands B & X were scored three and Band A was scored four. No score was allocated to any subsection that did not have an AUSRIVAS score (i.e. they were treated as a missing value).	DERM AUSRIVAS	Categorical	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
1.2.4	AUSRIVAS score – Pool (Min band)	The AUSRIVAS modelled bands (seasonal + habitat) were identified for each score. Band D was scored one, Band C was scored two, Bands B & X were scored three and Band A was scored four. No score was allocated to any subsection that did not have an AUSRIVAS score (i.e. they were treated as a missing value).	DERM AUSRIVAS	Categorical	No
1.2.9	AUSRIVAS score – Riffle (Min band)	The AUSRIVAS modelled bands (seasonal + habitat) were identified for each score. Band D was scored one, Band C was scored two, Bands B & X were scored three and Band A was scored four. No score was allocated to any subsection that did not have an AUSRIVAS score (i.e. they were treated as a missing value).	DERM AUSRIVAS	Categorical	No
1.3.1	SOR bank stability	The SOR score (per cent) for the 'BSTAB' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
1.3.2	SOR bed & bar stability	The SOR score (per cent) for the 'B_B' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
1.3.3	SOR aquatic habitat condition	The SOR score (per cent) for the 'AQUHAB' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile - continuous ascending	Yes
1.3.4	Presence/ absence of dams/weirs within the wetland	A SOR sub-section that had one or more instream dams or weirs located within its boundaries received a score of one. Other ACAs have scored those with weirs only as a two but this was not applied due to lack of time. SOR sub-sections without instream dams or weirs received no score and this measure was thresholded as presence negative. (This differs to the earlier standalone Baffle Riverine ACA which scored subsections without dams or weirs as a four).	DERM dams and weirs coverage	Presence negative	No
1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)	A dams and weirs extend layer was determined by using the Dams, Weirs, Barrages – QLD 100 k point dataset to manually identify and select H2M1 polygons from the Queensland Wetlands Mapping. Were a H2M1 polygon from the Queensland Wetlands Mapping didn't exist, the wetlands mapping was checked for other polygons and, in some cases, H3C1 polygons which appeared to be misclassified in the wetlands mapping were used. The 100 k drainage lines were intersected with the Subsections and dissolved on the SUBS_ID to get total length of drainage lines for each subsection. The length of streams inundated by the selected dams and weirs layer was divided by the total stream length for each subsection. Thresholds used as follows: <100% inundation = one; <10% = two; <1% = three; 0% =four.	DERM dams and weirs coverage, DERM Queensland Wetlands Mapping, directionalised stream network with stream order based on DERM 100 k drainage layer	Categorical	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
1.3.14	Aquatic habitat condition using acknowledged metric	AH change scores in "1. ACTFR Report No.06/20: ASSESSING THE CONDITION OF WETLANDS IN THE BURDEKIN CATCHMENT USING EXISTING GIS DATA AND FIELD KNOWLEDGE, FOR THE COASTAL CATCHMENTS INITIATIVE" were scored on a one to five scale where 1 = best (i.e. close to natural) and 5 = worst (farthest from natural). These were converted to the 1–4 scale used the AquaBAMM methodology as 1--> 4; 2--> 3, 3--> 2; 4-->1; 5--> 1.	ACTFR wetland condition assessment – aquatic habitat departure from natural scores	Categorical	No
1.4.2	Per cent natural flows – modelled flows remaining relative to predevelopment	For the Boyne, Calliope, Comet, Dawson, Fitzroy, Isaac, Mackenzie, Misc Other Islands, Nogoa, O'Connell, Pioneer, Plane, Proserpine, Shoalwater and Styx and Belyando, the relevant IQQM data was categorised into ACA categories and attributed to the subsections it intersected. These categories were interpolated and extrapolated as far as reasonable based on DERM expert knowledge. Those subsections known to be close to natural scored a four. For the Baffle study area, the results from the previous ACA were attributed, as these had been applied by expert, DERM hydrographers. In the Barron catchment, this IQQM data was applied only to those subsections where IQQM nodes occurred and was not extrapolated or interpolated due to time restrictions. This measure was not applied in areas where measures 1.4.7 and 1.4.8 were applied or where IQQM data was not available. Thresholds used were as follows: >=95% is a four; >= 80% is a three; >= 67% is a two; <67% is a one.	Expert knowledge, DERM IQQM	Categorical Cullen (2003) heritage rivers	No
1.4.7	WRP (water resource plan) hydraulic habitat	This measure is an additional measure added for this GBR Riverine ACA because some areas (for example, the Burdekin) have data for this that covers a greater area than the IQQM data alone (1.4.1, 1.4.2, 1.4.3). Hydraulic habitat describes how the physical aquatic habitat changes due to changes in flow volumes. It represents the interaction between the flow rates (volumes) and the local topographic/geomorphic features. For this measure, the WRP Hydraulic Habitat scores had to be recategorised from five (WRP) to four (ACA) categories and manually attributed to subsections because they did not match the subsections exactly. This was carried out by regional DERM staff with expertise in working with the WRP data.	DERM water resource plans	Categorical	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
1.4.8	HEV Areas	This measure attributes the freshwater High Ecological Value (HEV) areas from the DERM's HEV Assessments to the ACA subsections. The HEV areas were manually attributed to the ACA subsections, selecting all subsections that intersected with HEV areas and then visually checking that they were not selected as a result of mapping overlapping inaccuracy at the edges of a subsection, nor that the HEV area was a very small riverine component of the subsection (less than 5%). (The wet areas were determined by overlaying the 100 k drainage layer). This measure is complimentary to 1.4.7 and picked up the pristine areas that were missed with measure 1.4.7. This measure is an additional measure added during this GBR Riverine ACA because some areas (for example, the Burdekin) have data for this that covers a greater area than the IQQM data alone (1.4.1, 1.4.2, 1.4.3) or the water quality/habitat measures (1.3.14 and 1.5.10).	DERM HEV areas	Presence positive	No
1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines.	WQ Change scores in "1. ACTFR Report No.06/20: ASSESSING THE CONDITION OF WETLANDS IN THE BURDEKIN CATCHMENT USING EXISTING GIS DATA AND FIELD KNOWLEDGE, FOR THE COASTAL CATCHMENTS INITIATIVE" were scored on a one to five scale where 1 = best (i.e. close to natural) and 5 = worst (farthest from natural). These were converted to the 1–4 scale used the AquaBAMM methodology as 1--> 4; 2--> 3, 3--> 2; 4-->1; 5--> 1. For the Fitzroy EP zone, the WQ data from water quality information summary for the Fitzroy region (Negus, 2007) was gathered together and expressed in 1–4 ratings at the sites according to regional DERM interpretation. This was then used to attribute the main river trunk in each sub-catchment. Salinity, nutrients and suspended solids were included and combined to give one score.	ACTFR wetland condition assessment – water quality departure from natural scores; water quality information summary for the Fitzroy region (Negus, 2007)	Categorical	No
2.1.1	Presence of exotic terrestrial plants in the assessment unit	An expert panel list of exotic plants found within the riparian zone of streams and wetlands was used to calculate this measure. A subsection that had one or more exotic species recorded (point records or site based lists, >=1950, precision <=2,000 m) from within its boundaries received a score of one. No score was allocated to any subsection (subsection) that had an absence of exotic species (i.e. they were treated as a missing value).	WildNet, CORVEG, Herbrecs, ParkInfo, wetland information capture project	Presence negative	No
2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses	Streams were buffered according to their stream order (1:100,000) (1&2 = 50 m; 3&4 = 100 m; >5 = 200 m). The per cent remnant verses non-remnant vegetation was calculated for each subsection (SOR subsections).	Directionalised stream network with stream order based on DERM 100 k drainage layer, Queensland Herbarium remnant vegetation mapping (Ver. 5.0, 2005)	Quartile – continuous ascending	Yes

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
2.2.2	Total number of REs relative to preclear number of REs within buffered riverine wetland or watercourses	Streams were buffered according to their stream order (1:100,000) (1&2 = 50 m; 3&4 = 100 m; >5 = 200 m). The stream buffers were intersected with rem. veg and preclear veg. These were then intersected with the subsections. The number of regional ecosystems remaining verses pre-clear vegetation mapping was calculated for each subsection. That is, this measure is an observed verses expected (O / E) value for regional ecosystems within each subsection.	Directionalised stream network with stream order based on DERM 100 k drainage layer, Queensland Herbarium remnant vegetation mapping (Ver. 5, 2005)	Quartile – continuous ascending	Yes
2.2.3	SOR reach environs	The SOR score (per cent) for the 'RENV' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
2.2.4	SOR riparian vegetation condition	The SOR score (per cent) for the 'RIPVEG' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	"Agricultural" land-use included (QLUMP secondary categories) intensive animal production, intensive horticulture, cropping, perennial horticulture, plantation forestry, irrigated cropping, irrigated perennial horticulture, irrigated seasonal horticulture and reservoir/dam. These land-use types were allocated an agriculture attribute and a per cent area was calculated for agricultural areas within each subsection. Thresholding applied the average of the three highest weighted per cent scores (by subsection).	DERM QLUMP	Quartile – continuous descending	Yes
2.3.2	% "grazing" land-use area	"Grazing" land-use included (QLUMP secondary categories) grazing natural vegetation. These land-use types were allocated a grazing attribute and a per cent area was calculated for grazing areas within each subsection. Thresholding applied the average of the three highest weighted per cent scores (by subsection).	DERM QLUMP	Quartile – continuous descending	Yes
2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	"Vegetation" land-use included (QLUMP secondary categories) managed resource protection, nature conservation, other minimal use, production forestry, estuary/coastal waters, lake, marsh/wetland, river. These land-use types were allocated a vegetation attribute and a per cent area was calculated for vegetation areas within each subsection. Thresholding applied the average of the three highest weighted per cent scores (by subsection).	DERM QLUMP	Quartile – continuous ascending	Yes
2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)	"Settlement" land-use included (QLUMP secondary categories) manufacturing and industrial, mining, residential, services, transport and communication, utilities, waste treatment and disposal, and channel/aqueduct. These land-use types were allocated a settlement attribute and a per cent area was calculated for settlement areas within each sub-section; this value was then applied to each subsection within the subsection. Thresholding applied the average of the three highest weighted per cent scores (by subsection).	DERM QLUMP	Quartile – continuous descending	Yes

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area	The total surface area, in hectares, of artificial wetlands (H2M6, H2M7, H2C1, H2C2, H2C3, H3C1 and H3C2) within each subsection was calculated.	Modified wetlands from DERM Queensland wetlands mapping	Continuous descending logarithmic	Yes
3.1.1	Richness of native amphibians (riverine wetland breeders)	An expert panel list of amphibians dependent on streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. No score was allocated to any subsection that had an absence of amphibians (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Quartile – continuous ascending	Yes
3.1.2	Richness of native fish	An expert panel list of fish dependent on freshwater streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any subsection that had an absence of species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Department of Primary Industries and Fisheries (DPIF), Queensland Historical Fauna Database (QHFD)	Quartile – continuous ascending	Yes
3.1.3	Richness of native aquatic dependent reptiles	An expert panel list of reptiles dependent on streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. A subsection was attributed with the number of species records it contained; this value was then attributed to all the subsections in the subsection. No score was allocated to any subsection where the associated subsection had an absence of species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Quartile – continuous ascending	Yes
3.1.4	Richness of native waterbirds	An expert panel list of waterbirds dependent on streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. No score was allocated to any subsection that had an absence of waterbirds (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Quartile – continuous ascending	Yes
3.1.5	Richness of native aquatic plants	An expert panel list of aquatic and semi-aquatic plants (macrophytes) was used to calculate this measure. Records >=1950 and a precision <2,000 m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any subsection (subsection) that had an absence of species (i.e. they were treated as a missing value).	WildNet, CORVEG, Herbrecs, wetland information capture project	Quartile – continuous ascending	Yes
3.1.7	Richness of native aquatic dependent mammals	An expert panel list of mammals dependant on freshwater streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any subsection (subsection) that had an absence of species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Quartile – continuous ascending	Yes

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
3.2.1	Richness of macroinvertebrate taxa	An expert panel list of macroinvertebrate taxa dependant on freshwater streams for all or part of their lifecycles was used to calculate this measure. Records >=1975 and a precision <2,000 m were included. A subsection was attributed with the number of species records it contained. No score was allocated to any subsection (subsection) that had an absence of species (i.e. they were treated as a missing value). Due to the low number of records the threshold was made presence positive.	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	Presence positive	No
3.2.2	Richness of REs along riverine wetlands or watercourses within a specified buffer distance	Streams were buffered according to their stream order (1:100,000) (1&2 = 50 m; 3&4 = 100 m; >5 = 200 m). The number of remnant regional ecosystems was calculated for each subsection.	Directionalised stream network with stream order based on DERM 100 k drainage layer, Queensland Herbarium remnant vegetation mapping (Ver. 5, 2005)	Quartile – continuous ascending	Yes
3.3.1	SOR channel diversity	The SOR score (per cent) for the 'CHDIV' field for each subsection was directly incorporated into the analysis. This was done by converting the SOR polygons to points, attributing the points to the GBR ACA Subsections and then taking the average value for each subsection.	DERM State of the Rivers	Quartile – continuous ascending	Yes
3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	The number of different wetland habitat types (based on TYPE_RE field – a concatenation of wetland class, hydromodifier, water regime, salinity modifier and "WETRE" fields from the QWM data) were calculated for each subsection. Threshold values were calculated based on the average of the three highest weighted richness scores (by subsection).	DERM Queensland wetlands mapping	Quartile – continuous ascending	Yes
3.3.3	Richness of wetland types within the sub-catchment	The number of different wetland habitat types (based on TYPE_RE field – a concatenation of wetland class, hydromodifier, water regime, salinity modifier and "WETRE" fields from the QWM data) were calculated for each sub-catchment, and subsequently applied to all subsections already allocated to that sub-catchment (each sub-catchment is made up of one or more subsections). Threshold values were calculated based on the average of the three highest weighted richness scores (by sub-catchment).	DERM Queensland wetlands mapping	Quartile –- continuous ascending	No
3.4.1	Richness of geomorphic features	Geomorphic Assessment of Rivers (GAR) was used to calculate the richness of geomorphic types within a subsection. Geomorphic reach breakdown maps from the DNRW GAR reports were georeferenced to the relevant study areas they applied to. The number of different geomorphic types was then visually determined and manually attributed for the relevant subsections.	DERM GAR	Quartile – continuous ascending	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NCAct, EPBCAct	A list of threatened fauna species dependent on freshwater streams for all or part of their lifecycles was used to calculate this measure. Subsections that had one or more threatened fauna species recorded (point records or site based lists >=1975; precision <=2,000 m) from within its boundaries received a score of four. No score was allocated to subsections where there was an absence of threatened species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Department of Primary Industries and Fisheries (DPIF), Queensland Historical Fauna Database (QHFD)	Presence positive	No
4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species - NCAct, EPBCAct	A list of threatened flora species dependent on freshwater streams for all or part of their lifecycles was used to calculate this measure. Subsections that had one or more threatened flora species recorded (point records or site based lists >=1950, precision <=2,000 m) from within its boundaries received a score of four. No score was allocated to subsections where there was an absence of threatened species (i.e. they were treated as a missing value).	WildNet, CORVEG, Herbrecs, wetland information capture project	Presence positive	No
4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NCAct, EPBCAct	The regional ecosystem biodiversity status was used to score subsections. The 'WETRE' (previously WB_RE) field in the RIVERINE polygons in the Queensland wetlands mapping version 1.3 was used to identify the associated REs for each subsection. Endangered REs scored a four, of concern REs scored a three, no concern at present REs scored a two and subsections without a RE category (i.e. "water") scored one. Where a subsection had several polygons of differing REs, the maximum RE score was assigned to the subsections (deconcatenation code was used to separate these).	DERM Queensland wetlands mapping	Categorical E = 4, OC = 3, NOC = 2, noRE = 1	No
5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc)	An expert panel list of priority fauna species dependent on streams for all or part of their lifecycles was used to calculate this measure. A subsection that had one priority fauna species recorded (point records or site based lists >1975, precision <2,000 m) from within its boundaries received a score of three. Where there were two or more priority fauna species recorded from within a subsection, it received a score of four. No score was allocated to any subsection that had an absence of priority species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Department of Primary Industries and Fisheries (DPIF), Queensland Historical Fauna Database (QHFD)	User Defined 1 = 3; >1 = 4	No
5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	An expert panel list of priority flora species dependent on streams for all or part of their lifecycles was used to calculate this measure. A subsection that had one priority flora species recorded (point records or site based lists >1950, precision <2,000 m) from within its boundaries received a score of three. Where there were two or more priority flora species recorded from within a subsection, it received a score of four. No score was allocated to any subsection that had an absence of priority species (i.e. they were treated as a missing value).	WildNet, CORVEG, Herbrecs, wetland information capture project	User Defined 1 = 3; >1 = 4	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA / CAMBA agreement lists and/or Bonn Convention)	An expert panel list of migratory species dependent on freshwater streams for all or part of their lifecycles was used to calculate this measure. A subsection that had one migratory species recorded (point records or site based lists >1950, precision <2,000 m) from within its boundaries received a score of three. Where there were two or more migratory species recorded from within a subsection, it received a score of four. No score was allocated to any subsection that had an absence of migratory species (i.e. they were treated as a missing value).	WildNet, Queensland Museum, Queensland Historical Fauna Database (QHFD)	User Defined 1 = 3; >1 = 4	No
5.1.4	Habitat for significant numbers of waterbirds	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
5.2.1	Presence of 'priority' aquatic ecosystem	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
6.1.1	Presence of distinct, unique or special geomorphic features	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	Subsections that occurred within the mapped boundaries of Ramsar and WHA (world heritage areas) were identified. Those subsections that had at least 50% of their area within this special areas layer were allocated a score of four. Similarly, subsections subsections that had at least 50% of their area within the mapped boundaries of Directory of Important Wetlands (DOIW) were identified and these subsections were allocated a score of three. No score was allocated to subsections that were not identified as significant by such methods (i.e. they were treated as a missing value).	DOIW, Ramsar, WHA	Categorical	No
6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Biodiversity Planning Assessments (BPAs) and other documented reports external to the ACA process	Categorical	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)	The expert panels identified these special features. The assigned conservation ratings for this measure were attributed. There was no need to apply thresholds as conservation ratings represent the final score for this measure.	Expert panel	Categorical	No
7.1.1	The contribution (upstream or downstream) of the subsection to the maintenance of significant species or populations, including those features identified through Criteria 5 and/ or 6	The connectivity value of subsections upstream from a special feature identified (and implemented) in expert panel measures 5.1.4, 6.3.1 and calculations for 6.3.2 scored in this measure. This measure was implemented using the same principles identified in the Burnett ACA. Every subsection above a particular special feature was scored with the upstream adjoining subsections to a special feature being scored a four, the next closest subsections received a score of two and the remainder above a special feature were scored a one. The subsection having the special feature located within it was not given a score because it has already received a score in Criterion 5 or 6. Where a subsection had more than one calculation, the maximum value was incorporated.	Riverine expert panel measures 5.1.4 and 6.3.1 and calculations for 6.3.2 (DOIW, RAMSAR, WHA) (only those that scored a four)	Categorical	No
7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the subsection	The expert panel adopted the model used in the Burnett ACA which integrates the 'inherent connectivity value' of a stream segment with the presence of fish barriers. An additional component to this assessment was incorporating subsections with stream segments that were identified by the panel to have unimpeded fish passage (regardless of stream order) and were allocated a score of four, however this did not alter the result because these were already scored as four from the calculation.	Expert panel, Burdekin Dry Tropics (BDT) and Fitzroy Basin Authority (FBA) fish barrier mapping	Categorical	No
7.2.1	The contribution (upstream or downstream) of the subsection to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through Criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)	The connectivity value of subsections upstream from a special feature identified (and implemented) in Measure 6.4.1 was scored in this measure. This measure was implemented using the same principles identified in the Burnett ACA. Every subsection above a particular special feature was scored with the upstream adjoining subsections to a special feature being scored a four, the next closest subsections received a score of two and the remainder above a special feature (all the way to the top of the catchment) were scored a one. The subsection having the special feature located within it was not given a score because it has already received a score in Measure 6.4.1. Where a subsection had more than one calculation, the maximum value was incorporated (but this did not need to be applied). Upstream segments were determined visually based on the stream network.	Riverine expert panel measure 6.4.1 (only those decisions that scored a four)	Categorical	No

Measure	Description	Implementation	Primary Data Sets Used	Threshold Type	Stratified
7.3.1	The contribution of the subsection to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through Criteria 5 and/or 6	The connectivity value of subsections that contained the special features identified in the **non riverine** ACA for measure 6.3.2 and 6.3.3 was assessed. Subsections (subsections) that contained features identified in the non riverine GBR ACA Version 1.2 (only those with a conservation rating of four), were given a value of four.	Non riverine measure 6.3.2 and expert panel measure 6.3.3 that scored a four.	Categorical	No
7.5.1	The contribution of the subsection to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through Criteria 5 and/or 6	Due to difficulties in applying the estuarine connectivity automated methodology, only the special features identified by experts in the expert panels as having value for this measure were implemented. They were given the conservation rating determined by the expert panel.	Expert panel	Categorical	No

Note: Flora records were extracted from the following sources:
WildNet on 28/08/2008
Herbrecs on the 14/01/2009
CORVEG on 25/08/2008
Wetland Information Capture Project on 28/01/2009
ParkInfo on 20/01/2009
Flora records were updated 17/09/2009 with Scientific Technical Committee changes
Note: Fauna records were extracted from the following sources:
Queensland Historical Fauna Database on 10/3/2009 with update of additional records on 17/4/2009. This database includes extracts from WildNet, Queensland Museum, Department of Primary Industries and Fisheries (DPIF) and Queensland Historical Fauna Database (QHFD)
Fauna records were updated 17/09/2009 with Scientific Technical Committee changes

2.6 Transparency of results

ACAs produce results at a number of levels despite its initial presentation as a single score called AquaScore. After running the AquaBAMM tool, ACA results are available at AquaScore, criterion, indicator, measure or raw data levels. The results are also available through the use of user-defined queries that may interrogate one or more levels within the assessment in an almost infinite number of possible combinations. This transparency of results provides the ACA end user (e.g. scientists, resource managers and conservation organisations) with a unique level of flexibility for ACA interrogation, interpretation and presentation. Links between the ACA results and a geographic information system (GIS) facilitate this and provide the complete ACA package (Figure 2).

This data access and interrogation flexibility is important and enables investigation of different data contributions to the overall conservation value, investigation of missing data, and an ability to tailor the ACA output for a particular purpose.

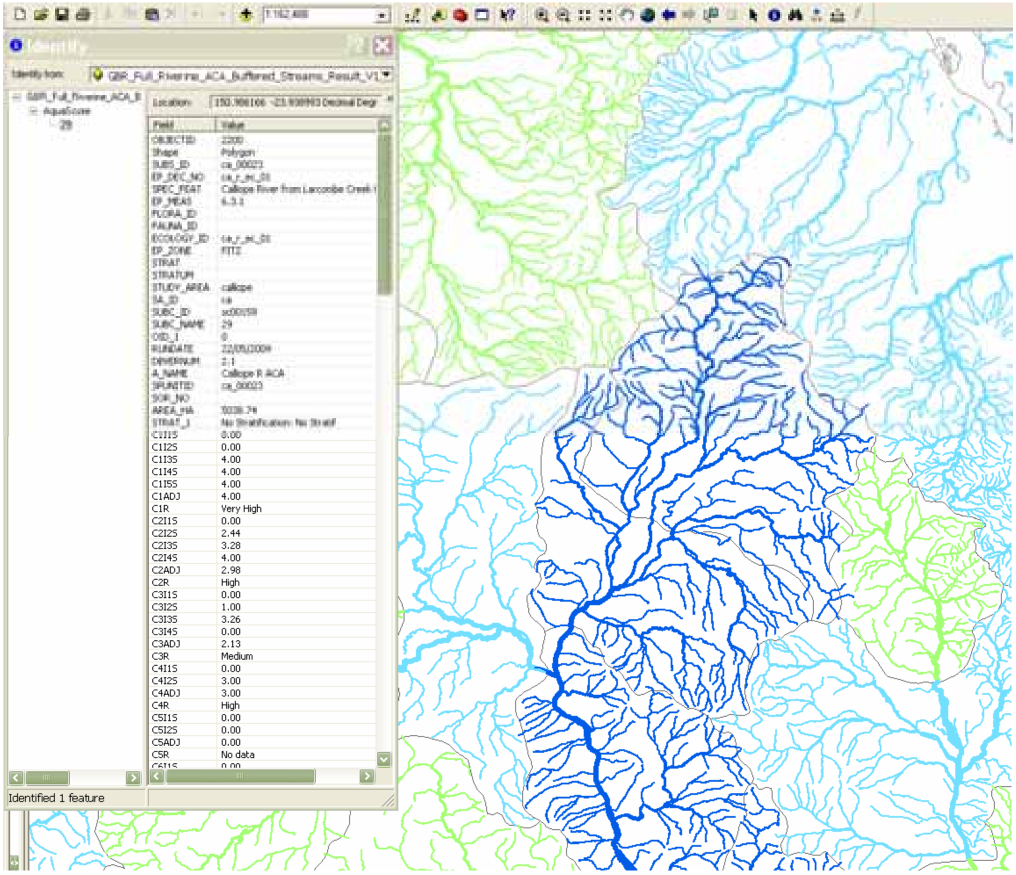

Figure 2 Interrogating the ACA results for a subsection in the GIS environment

3 Results

3.1 GBR catchment overall results

An ACA was conducted for each of the 35 catchments of the GBR catchment. The results outlined below are a summary of the results for all 35 study areas. The results presented here supersede the Baffle Creek riverine ACA (released on 2 February 2009) and an unreleased draft Herbert River riverine ACA.

The results for the Herbert and Mackenzie catchments ACA are contained in sections 3.3 and 3.4 to provide an example of the results achieved by two individual catchments.

3.1.1 AquaScore

Table 5 AquaScore summary

AquaScore	Number of subsections	Per cent of subsections (%)	Area (ha)	Area (%)
Very high	745	18%	4,717,372	14%
High	1,116	27%	8,031,878	24%
Medium	1,849	45%	17,537,204	53%
Low	356	9%	2,143,105	6%
Very low	77	2%	836,680	3%
Total	**4,143**	**100%**	**33,266,239**	**100%**

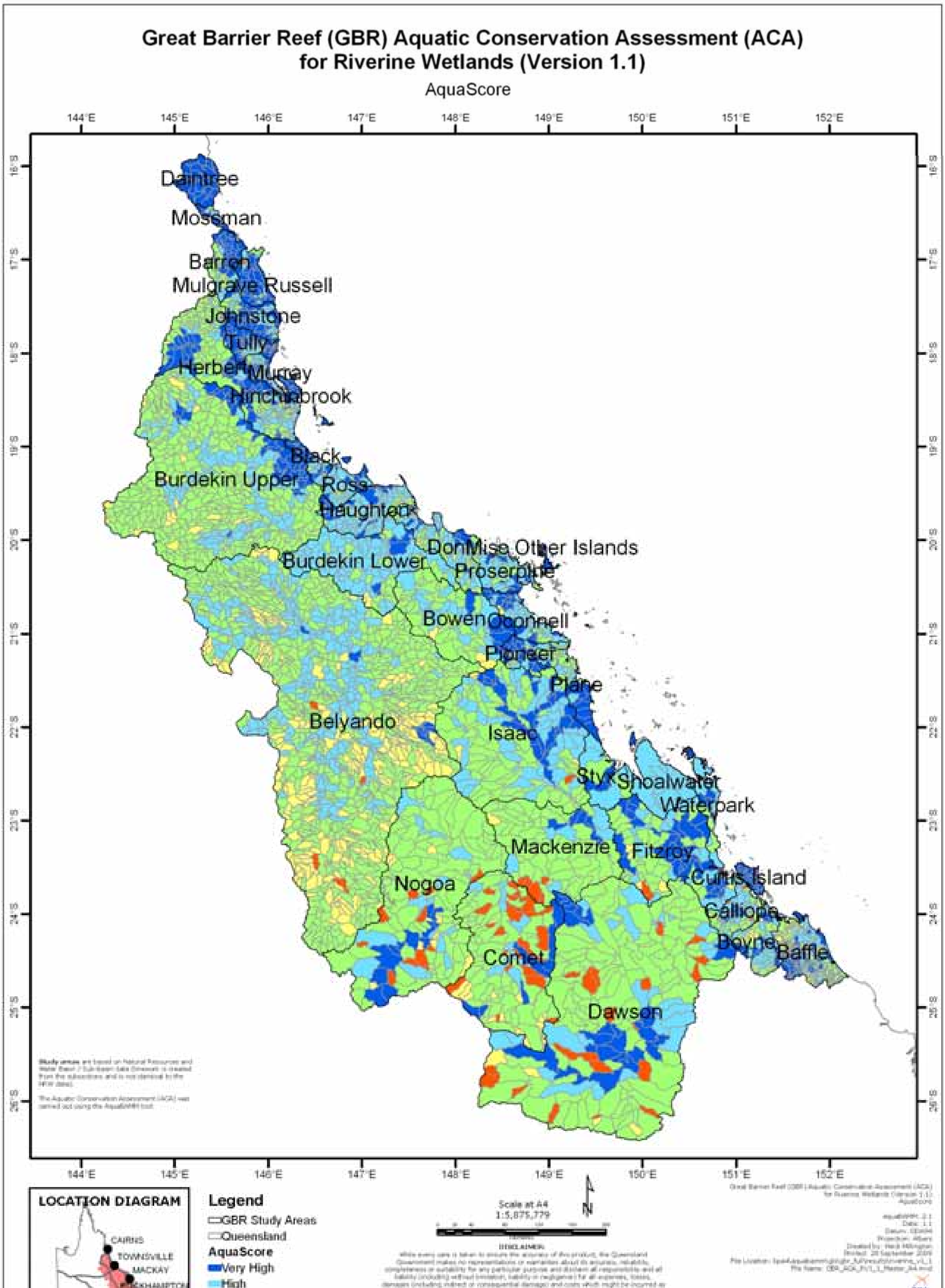

Figure 3 AquaScore for all catchments (coloured by subsection)

Table 6 AquaScore and dependability summary for all study areas

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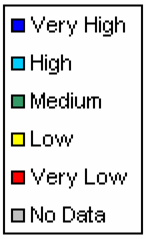
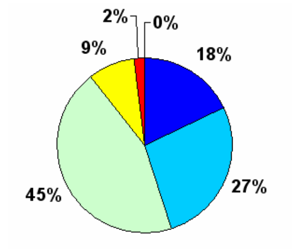
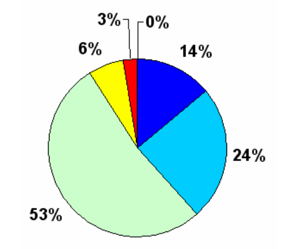
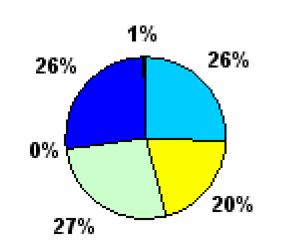
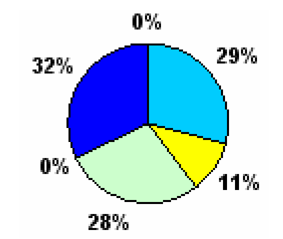
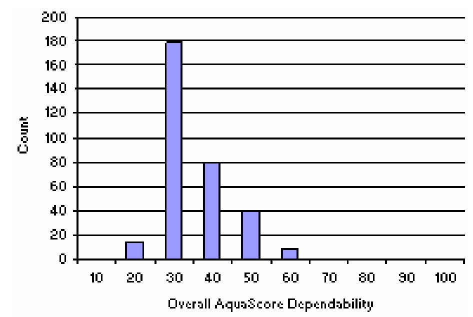
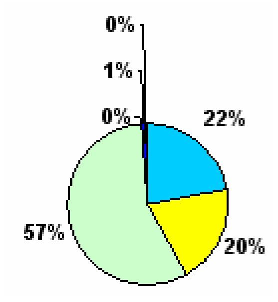
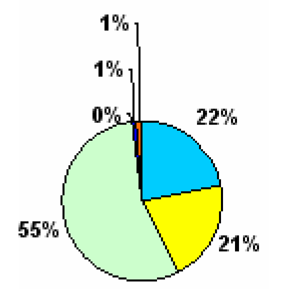
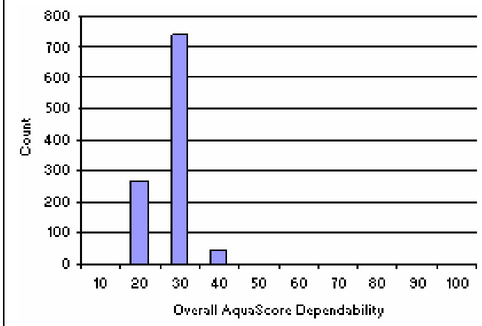
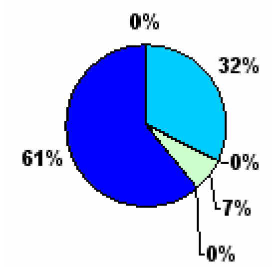
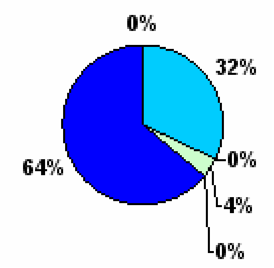
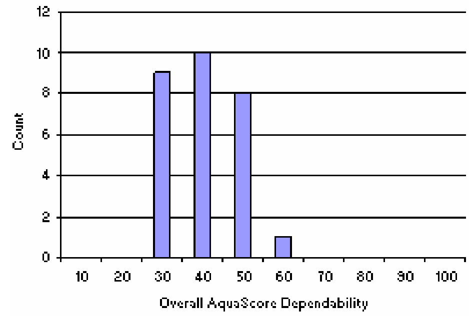
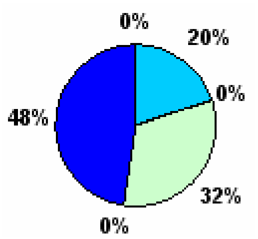
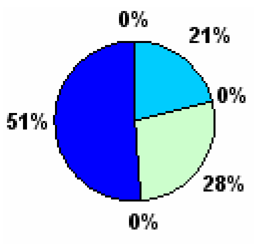
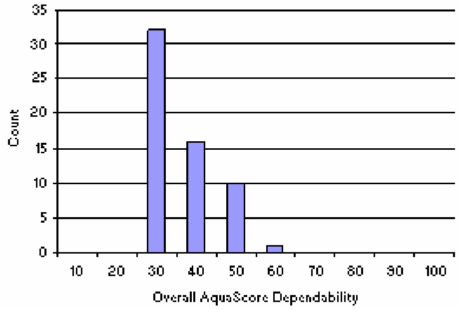
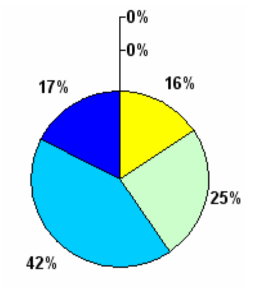
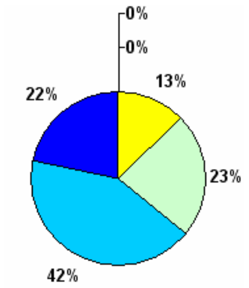
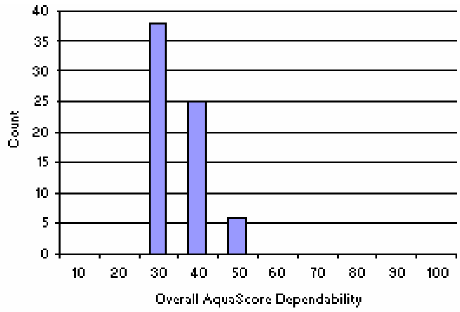
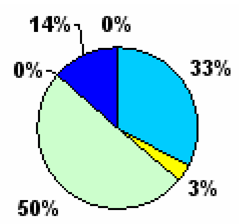
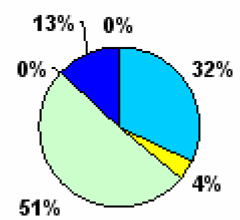
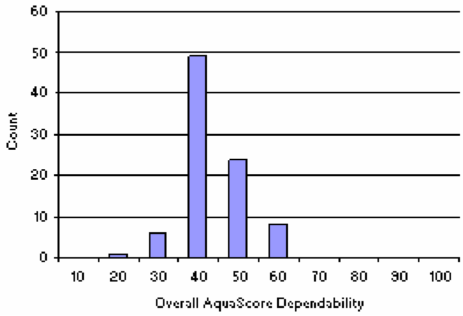
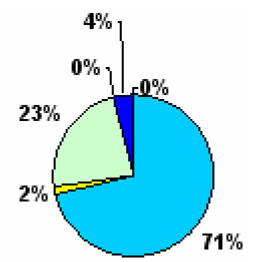
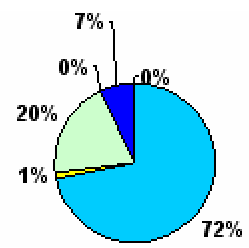
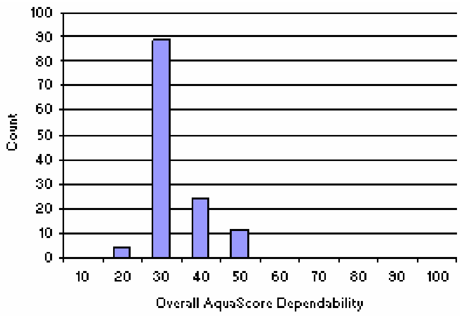
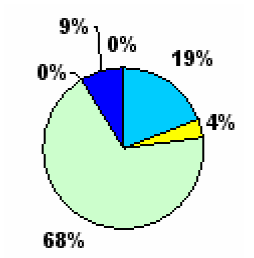
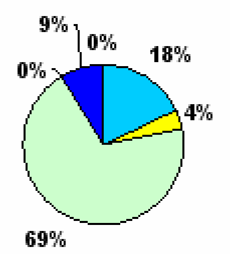
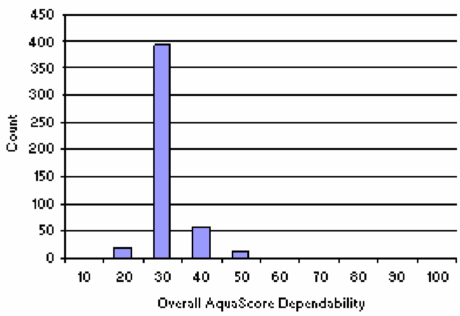
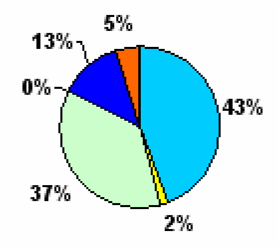
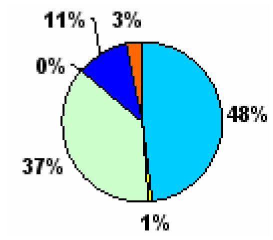
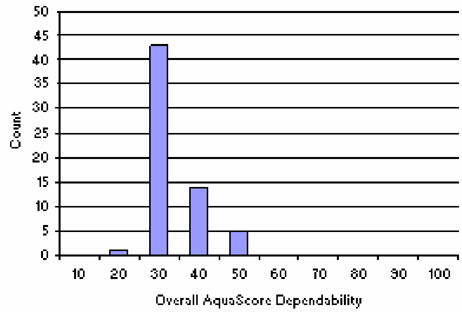
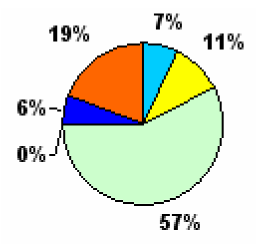
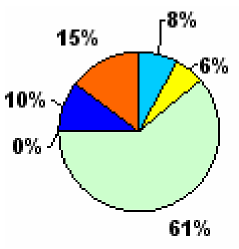
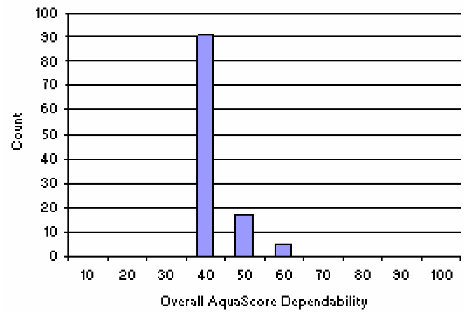
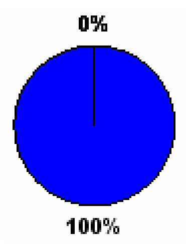
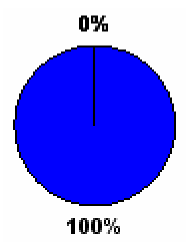
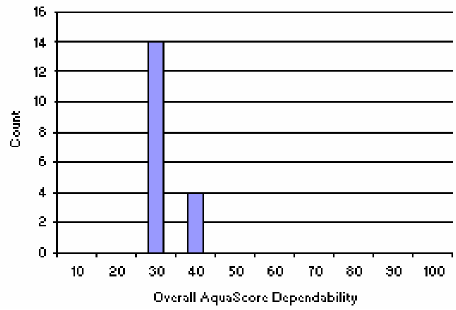
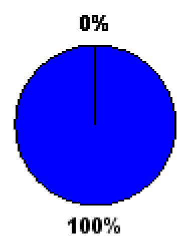
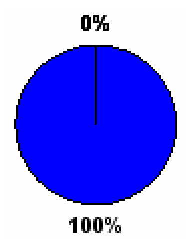
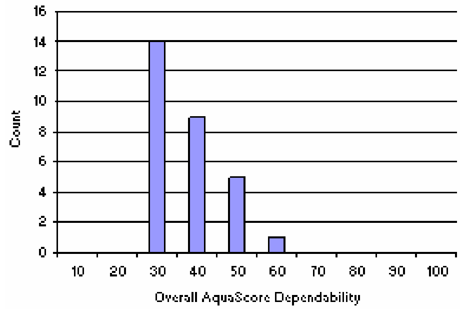
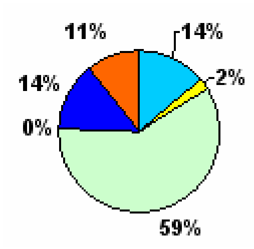
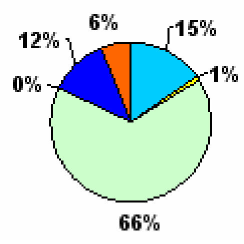
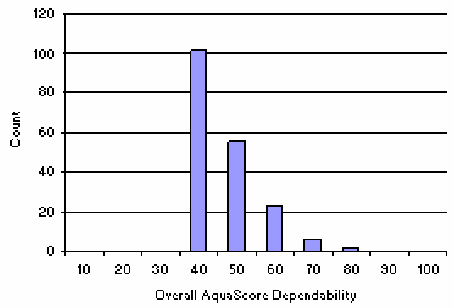
Key	

Catchment	AquaScore by number of subsections	AquaScore by total area of subsections	AquaScore dependability
All			
Baffle			
Belyando			
Black			

Catchment	AquaScore by number of subsections	AquaScore by total area of subsections	AquaScore dependability
Barron			
Boyne			
Bowen			
Burdekin Lower			
Burdekin Upper			

Catchment	AquaScore by number of subsections	AquaScore by total area of subsections	AquaScore dependability
Calliope			
Comet			
Curtis Island			
Daintree			
Dawson			

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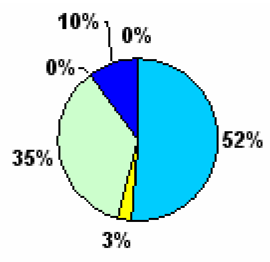
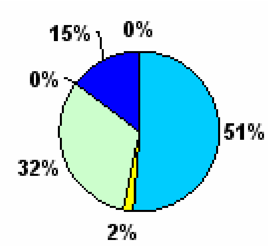
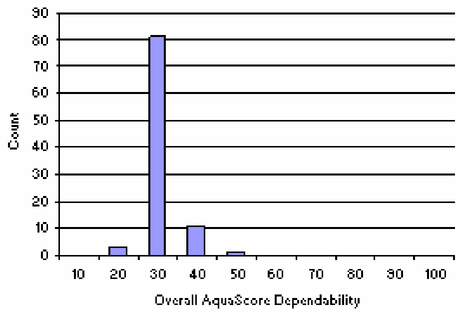
<tr><td>Don</td><td>
</td><td>
</td><td>
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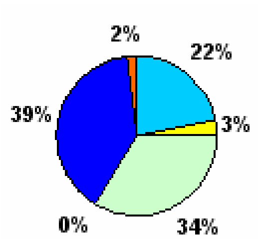
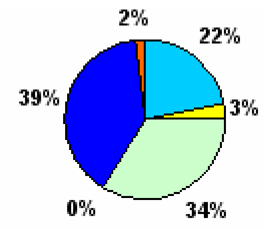
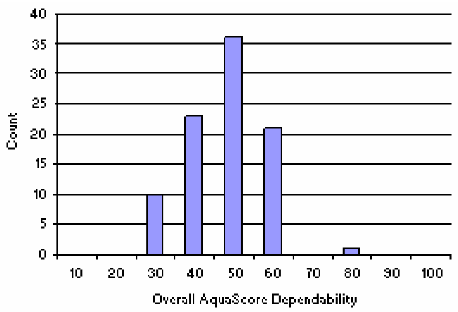
<tr><td>Fitzroy</td><td>
</td><td>
</td><td>
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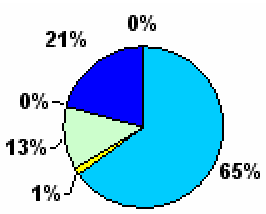
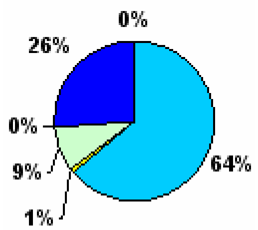
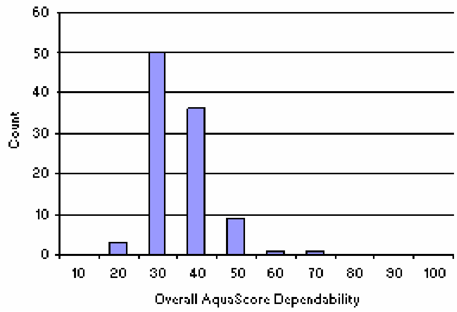
<tr><td>Haughton</td><td>
</td><td>
</td><td>
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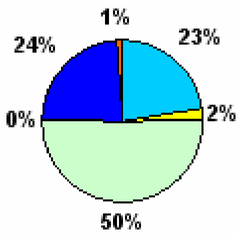
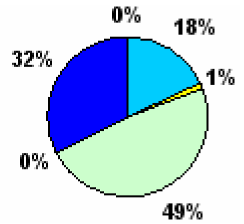
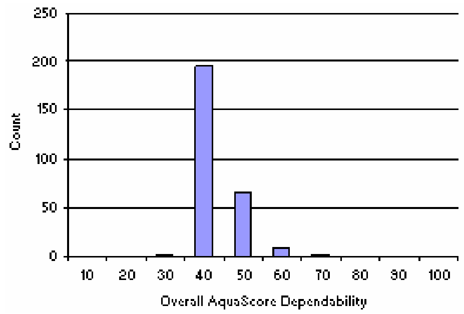
<tr><td>Herbert</td><td>
</td><td>
</td><td>
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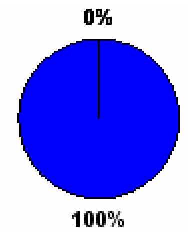
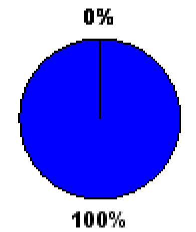
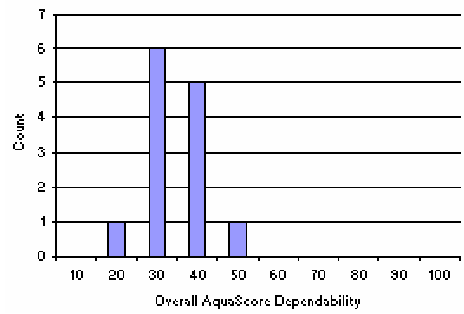
<tr><td>Hinchinbrook</td><td>
</td><td>
</td><td>
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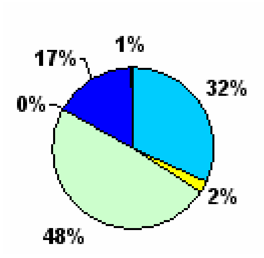
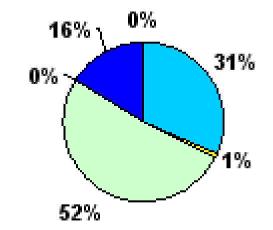
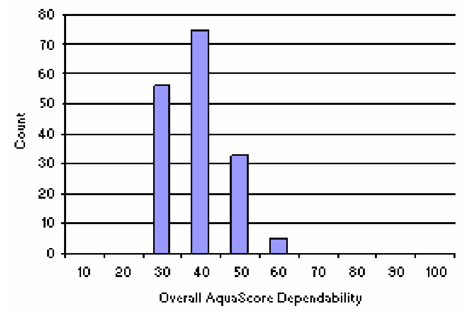
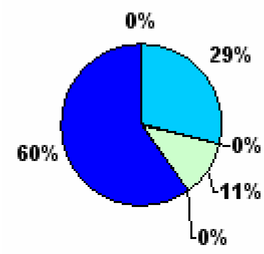
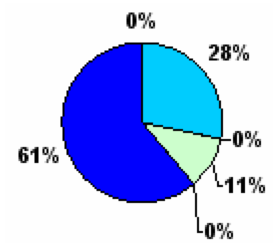
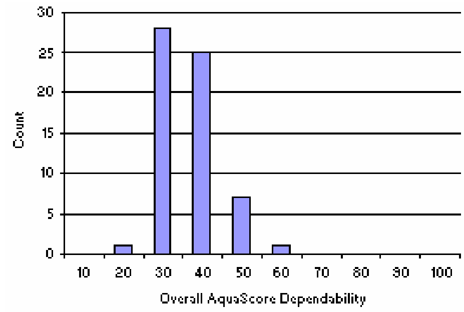
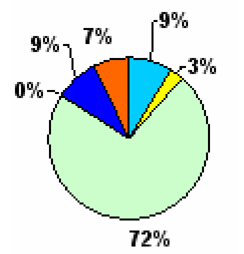
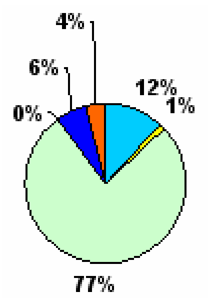
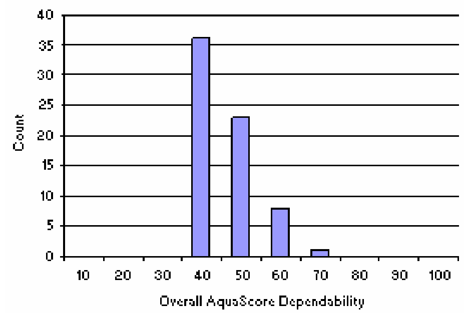
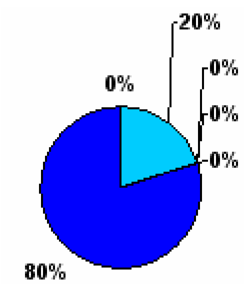
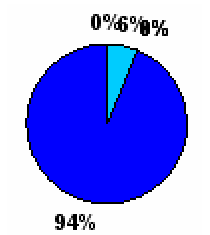
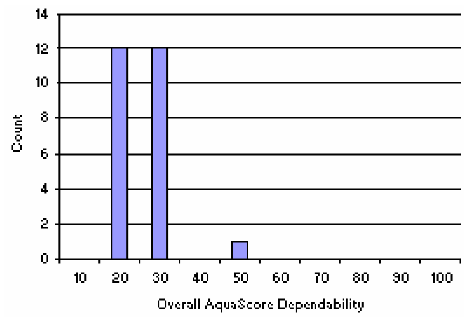
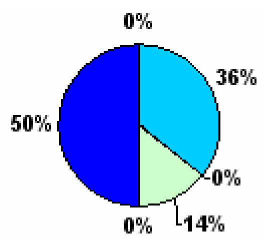
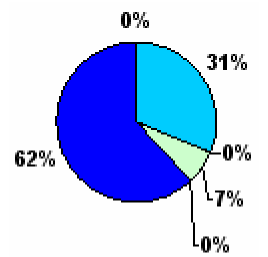
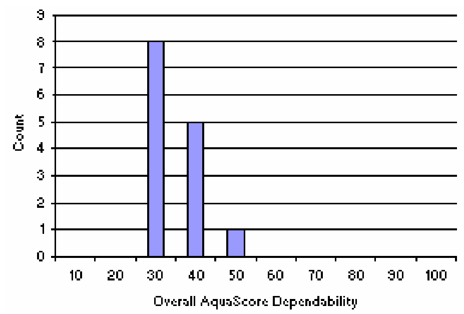
Isaac			
Johnstone			
Mackenzie			
Misc Other Islands			
Mossman			

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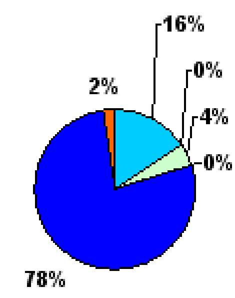
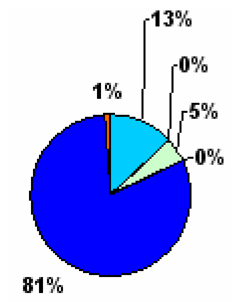
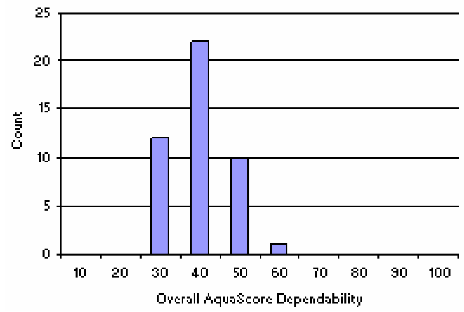
<tr><td>Mulgrave Russell</td><td>
</td><td>
</td><td>
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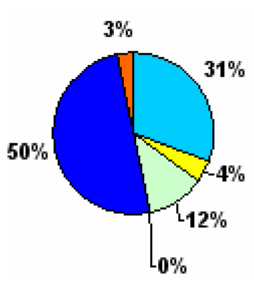
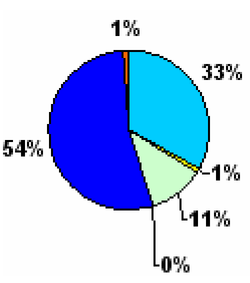
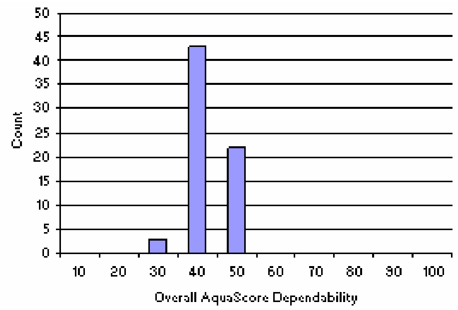
<tr><td>Murray</td><td>
</td><td>
</td><td>
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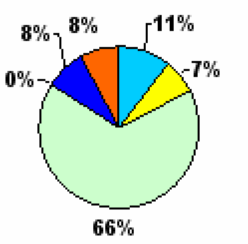
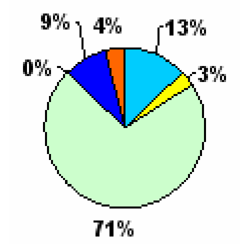
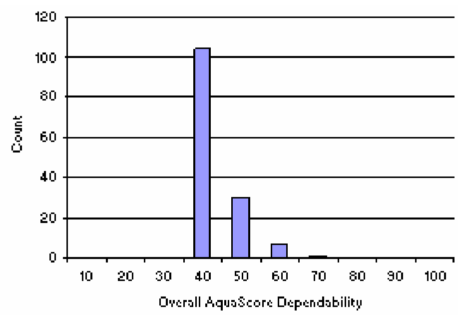
<tr><td>Nogoa</td><td>
</td><td>
</td><td>
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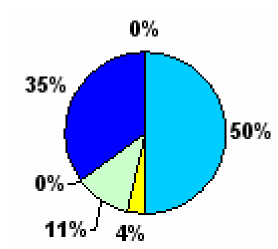
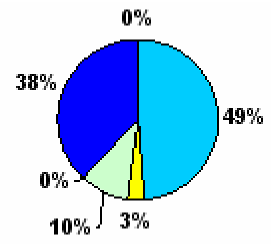
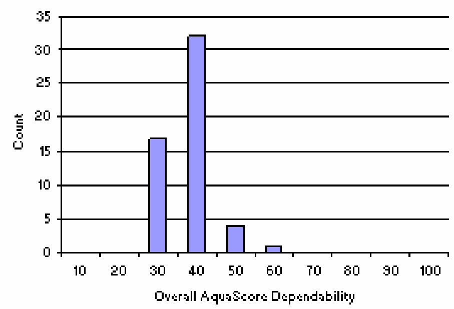
<tr><td>O'Connell</td><td>
</td><td>
</td><td>
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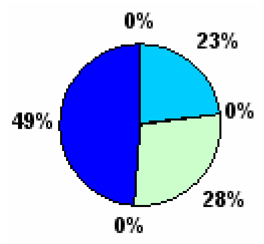
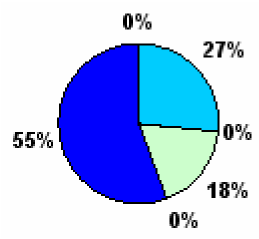
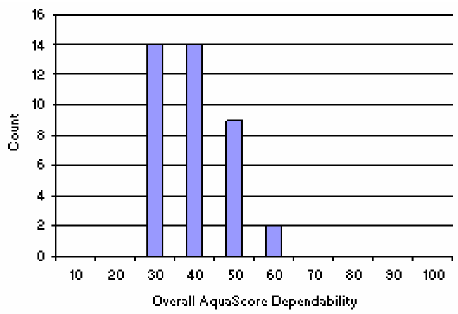
<tr><td>Pioneer</td><td>
</td><td>
</td><td>
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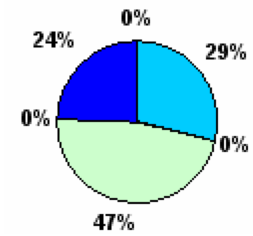
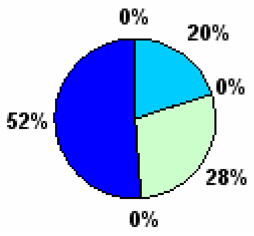
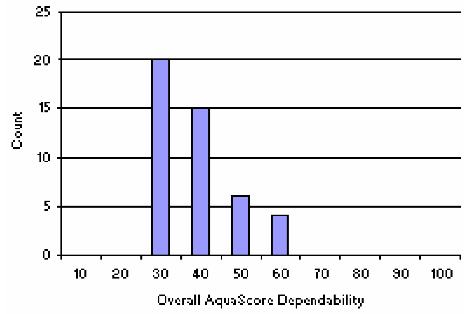
<tr><td>Plane</td><td>
</td><td>
</td><td>
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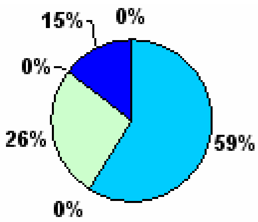
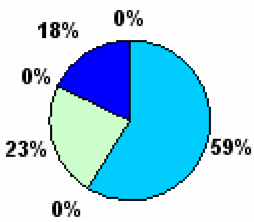
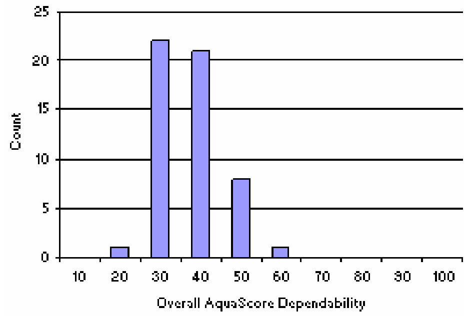
<tr><td>Proserpine</td><td>
</td><td>
</td><td>
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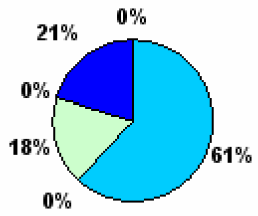
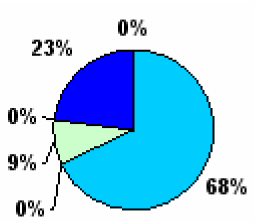
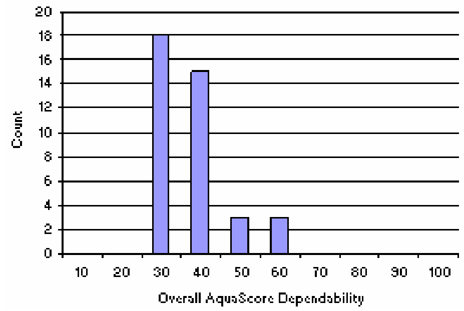
<tr><td>Ross</td><td>
</td><td>
</td><td>
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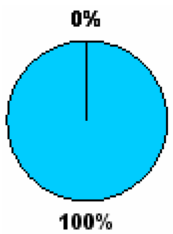
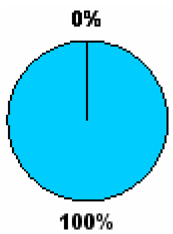
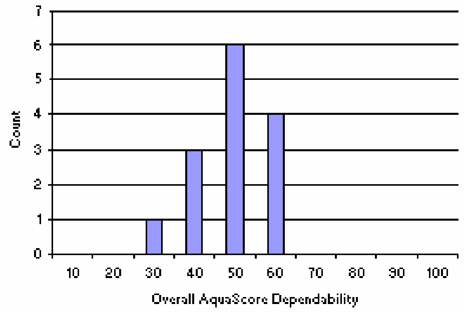
<tr><td>Shoalwater</td><td>
</td><td>
</td><td>
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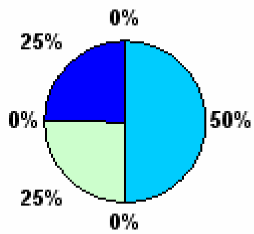
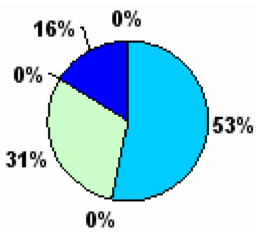
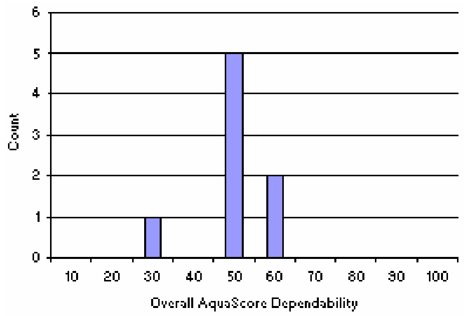
<tr><td>Styx</td><td>
</td><td>
</td><td>
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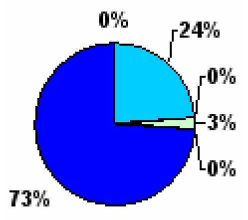
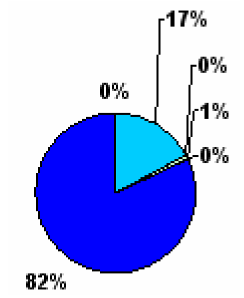
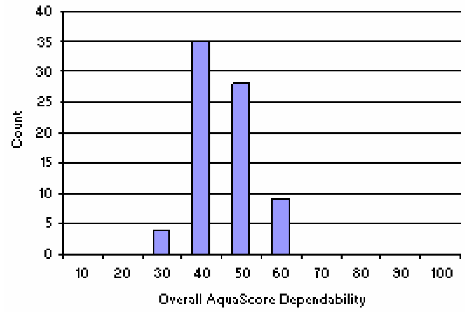
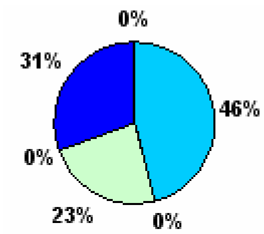
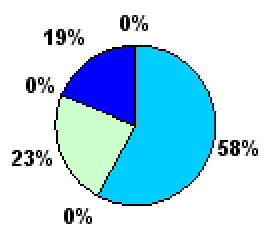
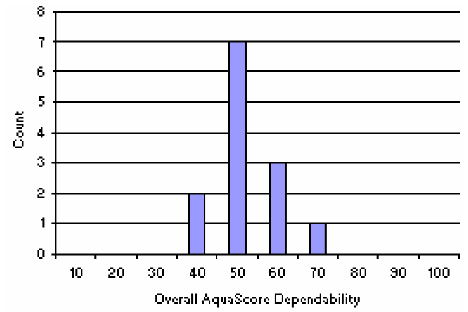
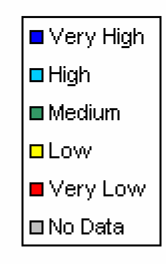
Catchment	AquaScore by number of subsections	AquaScore by total area of subsections	AquaScore dependability
Tully			
Waterpark			

3.1.2 Criteria scores

Table 7 Summary by criteria

Key



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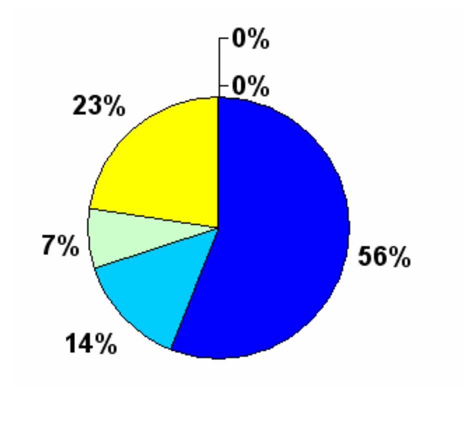
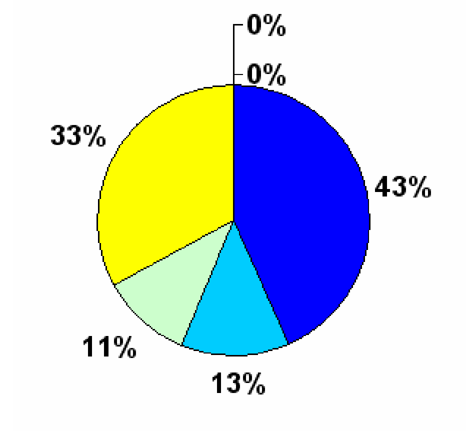
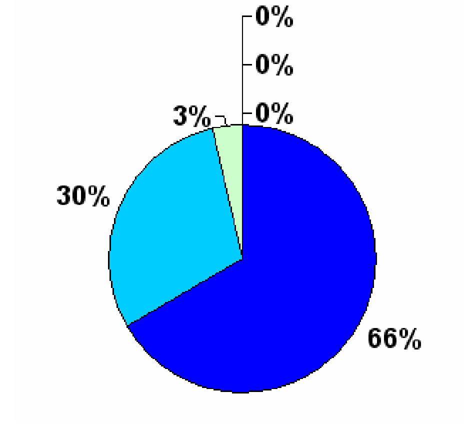
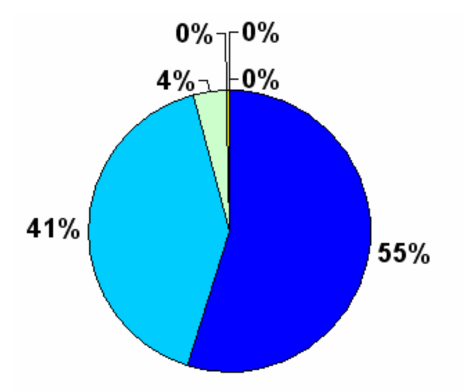
Criterion 1		
Criterion 2		

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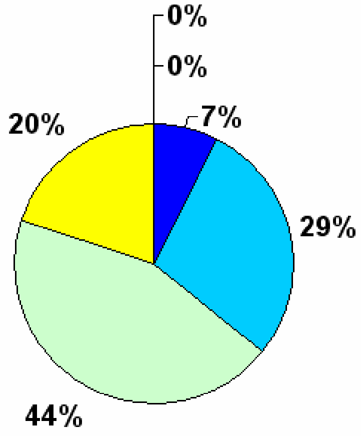
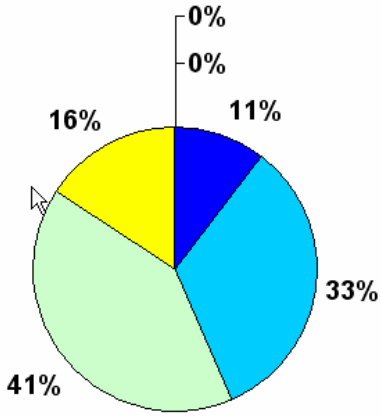
<tr><td>Criterion 3</td><td>
</td><td>
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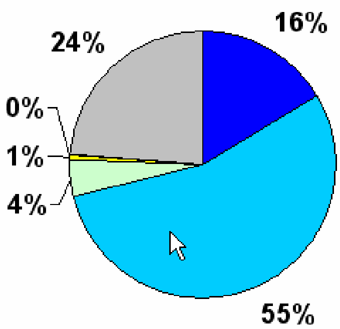
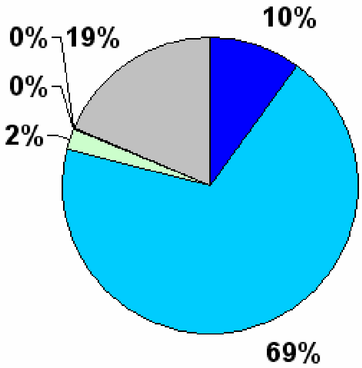
<tr><td>Criterion 4</td><td>
</td><td>
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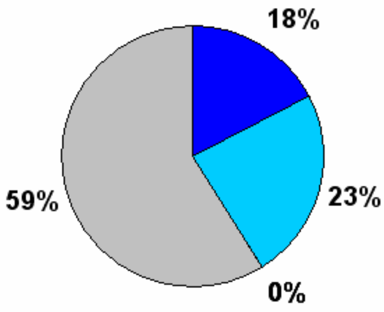
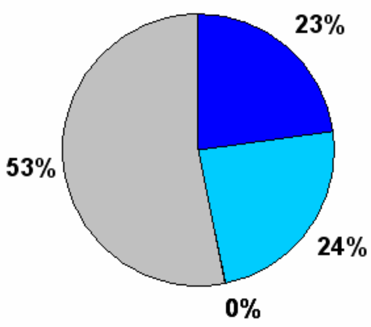
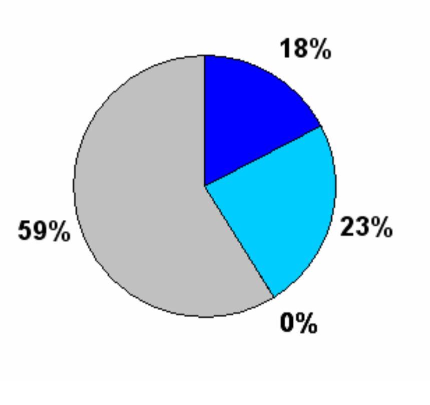
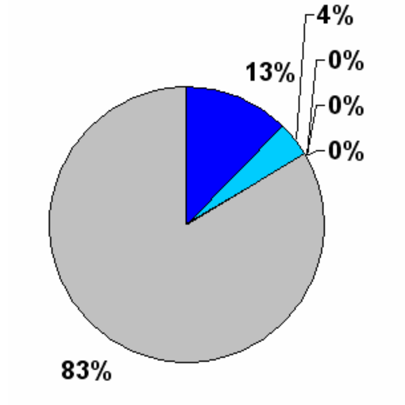
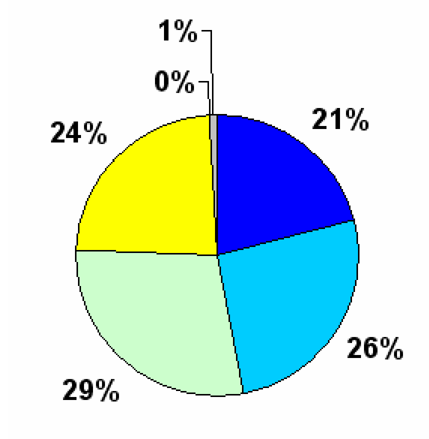
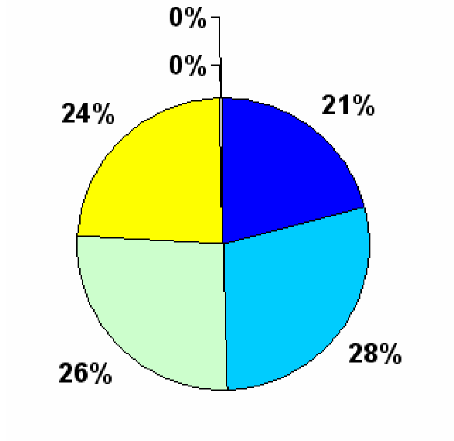
<tr><td>Criterion 5</td><td>
</td><td>
</td></tr>
</table>

Catchment	Criteria scores by number of subsections	Criteria scores by total area of subsections
Criterion 6		
Criterion 7		

3.2 Summary

3.2.1 Conservation value categories

The conservation value results for wetlands are referential within each study area, but each value category has characteristics in common. AquaBAMM uses combinations of criterion level scores to determine a wetland's final AquaScore and, based on these combinations, the following descriptions provide context for each AquaScore value category.

"Very high" wetlands:

> These wetlands have very high values across all criteria (aquatic naturalness, catchment naturalness, diversity & richness, threatened species, special features and representativeness), or they have very high representativeness values in combination with very high aquatic naturalness, catchment naturalness or threatened species values. They may also be wetlands nominated by an expert panel for their very high special feature values, regardless of values across other criteria.

"High" wetlands:

> These wetlands are mainly those that have very high aquatic naturalness or representativeness values in combination respectively with very high/high threatened species values or very high diversity and richness values. Other combinations of very high or high values amongst the criteria may also indicate one of these wetlands.

"Medium" wetlands:

> These wetlands have varied combinations of high and medium values amongst the criteria.

"Low" wetlands:

> These wetlands have limited aquatic and catchment naturalness values. They have varied combinations of medium and low values amongst the other criteria.

"Very Low" wetlands:

> These wetlands have very limited or no aquatic and catchment naturalness values and they lack any other known significant value. They may also be wetlands that are largely data deficient.

3.2.2 Broad trends

A few broad trends in wetland conservation values were shown in the results:-

- For some catchments, there are significant differences between the distribution of AquaScores when summarised by number of subsections vs per cent of total subsections. This is to be expected in catchments where not all subsections units are the same size. For example, the Nogoa or Shoalwater catchments. Which graph is used (number vs area) can depend on the type of questions being asked; however, it is recommended that both be considered.

- Significant environmental features (or geographic areas) that are nominated by agreements or instruments such as Ramsar, Directory of Important Wetlands, World Heritage Area, etc, influence conservation value results through the ACA process. These features/areas are not evenly distributed throughout the GBR catchments. Wetlands in these areas usually score very high or high with respect to their conservation values and, due to the distribution of the significant environmental areas, the wetlands are often spatially concentrated. For these reasons catchments such as Daintree River and Barron River have large numbers of very high value wetlands.

- The western catchments of the GBR are especially data poor. Across the GBR catchments, there is a trend toward greater numbers of very high and high value wetlands near the coast. This trend is evident in the distribution of the AquaScore dependability in the western catchments being at the lower end of the scale compared with those catchments on the coast, such as the Barron and Styx. During the expert panels, particular attention was paid to the western catchments. However the panels noted that there was a distinct lack of knowledge in these catchments.

- All subsections in the Curtis Island, Hinchinbrook Island and miscellaneous other islands catchments are very high. This is due to the influence of Criteria 6 special features. This criteria is based on the expert panel decisions and is weighted highly in the filtering table that produces the final AquaScore.

- Field validation (truthing) of the GBR ACA results is important to test the accuracy of the assessment. Field truthing is a critical step in any ACA and it precedes final data corrections and a final re-run of the assessment. Results from the field truthing were implemented where possible (refer to section 3.5).

- Data availability is never equal for all wetlands in a study area. In the same way, expert knowledge is not usually available for every wetland in a study area. Dataset completeness is influenced spatially by research effort, enthusiast search effort, political focus, etc. AquaBAMM is designed to cope with data deficiencies; however, wetlands with complete datasets are more likely to show an accurate final conservation value and they are more likely to have a species record of significance or other special feature (most likely due to increased investigative effort or functional understanding) that results in a very high or high conservation value score.

- The dependability score is a percentage of the how many available measures have data. The dependability does not influence or change the final AquaScore. The ACA results should be interpreted in conjunction with the dependability score. For example, where subsections with very low AquaScore values have low dependability, the results should be used cautiously as the AquaScore may be due to the inherent lack of values or the lack of data. In the case of missing data, further survey work may add more data that may, or may not, change the AquaScore.

- Whenever lines are drawn on a map, for example, from the expert panels or Directory of Important Wetlands, there is a risk that the boundary may not be correct at the scale of the individual subsection. For these types of decisions the boundary should always be considered at the appropriate scale. The wetlands mapping is the fundamental spatial input into this ACA and the positional accuracy of the wetlands mapping is 1:100,000, except for areas along the east cost which are mapped at the 1:50,000 scale.

- A sensitivity analysis has been undertaken for AquaBAMM and the results from this type of analysis can assist in interpretation of the ACA results. However, the sensitivity analysis report was not received in time for the findings to be included in the v1.1 release and will be taken into consideration for the next version.

3.3 Case study one – Herbert catchment

3.3.1 Introduction

The Herbert River catchment is located adjacent to the central part of the Great Barrier Reef, covering an area of 9,841 km^2. The Herbert River creates a gap in the Great Dividing Range linking areas included in the Einasleigh Upland bioregion with floodplains of the Wet Tropics bioregion. As a consequence of climatic variance between sections the Herbert River catchment has characteristics of both wet tropical and dry tropical catchments and can be stratified into three distinct areas within the catchment: the Wet Tropics lowland coastal floodplain, the Wet Tropics upland ranges and the drier Einasleigh Upland catchment section. Almost all of the upper catchment is greater than 600m ASL, with the highest areas in the northeast ranges reaching over 1,000 m.

The climate of the area is humid-tropical with pronounced dry and wet seasons. The summer is hot and humid, with most of the annual precipitation falling between January and March and associated with tropical low pressure systems, including cyclones. The mean annual rainfall for the whole catchment is 1,506 mm with an average runoff ratio of 27 per cent, although rainfall and runoff will be much greater in the sections of the catchment in the Wet Tropics and much lower in the Einasleigh Uplands. The Einasleigh upland sections receive approximately 750 mm rainfall per annum. Whereas, the sections in the Wet Tropics ranges receive up to 3,000 mm and the section of coastal lowlands receives between 1,500 and 2,200 mm rainfall per annum.

Prior to European settlement the Herbert catchment was largely heavily timbered, with extensive freshwater wetlands and areas of grasslands on the coastal lowlands. It has since undergone significant development with approximately 40 per cent of the coastal lowlands cleared for intensive agriculture and grazing.

The variability in rainfall distribution and intensity, and in geomorphic character of the sections of the catchment, results in highly variable hydrology throughout the area. The lowland floodplain includes an active delta and is subjected to regular flooding, inundating large areas of fertile alluvial soils. Major flooding occurs on average every 3.5 years and minor flooding almost every two years. This has driven significant hydrological modification of the floodplain to enable agricultural development, including many uncoordinated drainage systems.
It is estimated that approximately 70 per cent of the coastal wetlands have been lost as a result of this development and the character of many of the remaining has been significantly altered.

Land use within the catchment differs greatly between the Einasleigh Uplands and the Wet Tropics lowlands. Cattle grazing is the dominant land use in terms of area, covering 7,330 km^2 and is the principal land use type in the Einasleigh Uplands section of the catchment, dependent on native pastures, with some fodder cropping. Some horticulture occurs in the north and there exist a number of operational and abandoned tin mines. Significant areas of the lowland floodplain are utilised for developed pasture for cattle grazing. However, by far the most significant land use in the lowland coastal floodplain area is intensive sugar cane cultivation, covering 691 km^2 and supporting two sugar mills (Victoria and Macknade). Sugar cane cultivation has undergone significant and rapid expansion over the last two decades, largely on the more marginal lands for production. These lands included large areas of poorly drained coastal wetlands used previously for grazing.

State forests and timber reserves occupy 990 km^2 and total protected areas cover approximately 1,825 km^2. Approximately 1,417 km^2 of the catchment is in the Wet Tropics World Heritage Area. These protected areas are the dominant tenure and land use in the Wet Tropics highlands parts of the catchment. On the lowlands urban development is concentrated around the township of Ingham, with smaller settlements including Abergowerie, Trebonne, Halifax and coastal settlements Forest and Taylor's Beaches and Lucinda. There are few towns in the upper catchment, the largest being Mount Garnet and Herberton. The population of the catchment is approaching 9,000 people.

3.3.2 Summary of results for the Herbert catchment

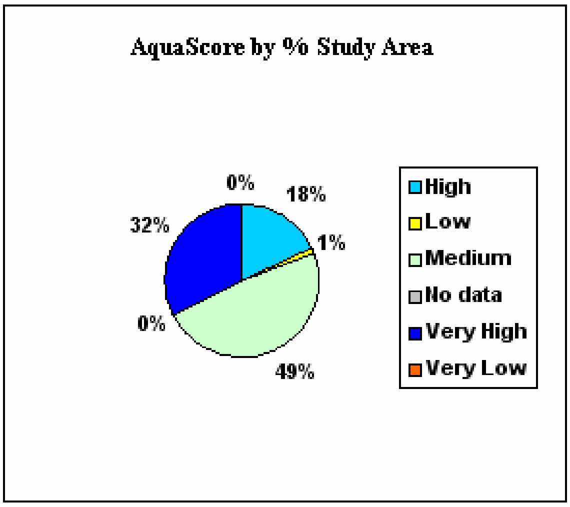
In the Herbert catchment ACA, 24 per cent of the subsections scored an AquaScore of very high, equating to approximately 32 per cent of the total area (Figure 4). These results were distributed throughout the Herbert catchment (Figure 6). The majority of very high subsections were very high as a result of expert panel decisions identified through criteria 5 and 6 (refer Table 8 and Figure 7 for criteria results). In total there were four riverine special feature decisions identified by the Wet Tropics expert panels—all of which were wetland ecology decisions (see Attachment C). Some of the expert panel decisions in the Herbert catchment are the result of decisions made during an expert panel process conducted as part of a draft ACA for the Herbert catchment, which was not released.

The AquaScore dependability for the Herbert catchment is concentrated around 45 per cent (Figure 5), which is to be expected for this coastal catchment. The summary section of this report contains more detailed information on the overall dependability trends across the GBR.

3.3.3 AquaScore results

AquaScore by % Study Area

AquaScore	Area (ha)	Area (%)
No data	0.00	0
Very Low	3440.56	0
Low	10029.81	1
Medium	477114.95	48
High	175585.15	18
Very High	318129.61	32



AquaScore by % Spatial Units

Aqua Score Value	Number of Spatial Units	% of SpatialUnits
No data	0	0.00
Very Low	4	1.48
Low	6	2.21
Medium	135	49.82
High	62	22.88
Very High	64	23.62

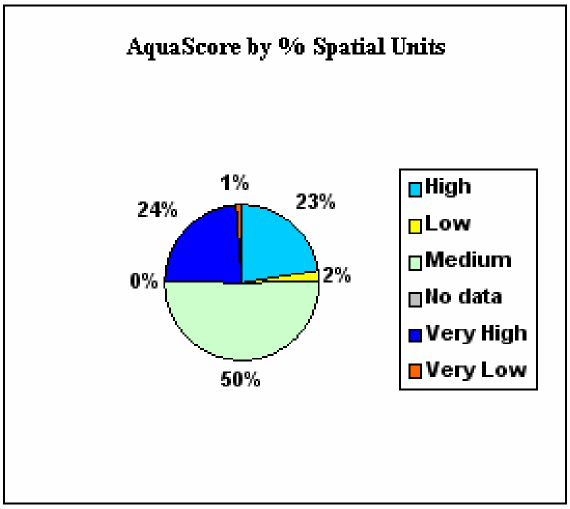


Figure 4 Herbert catchment AquaScore

AquaScore Dependability

Overall AquaScore Dependability	Count
10	0
20	0
30	2
40	195
50	65
60	8
70	1
80	0
90	0
100	0

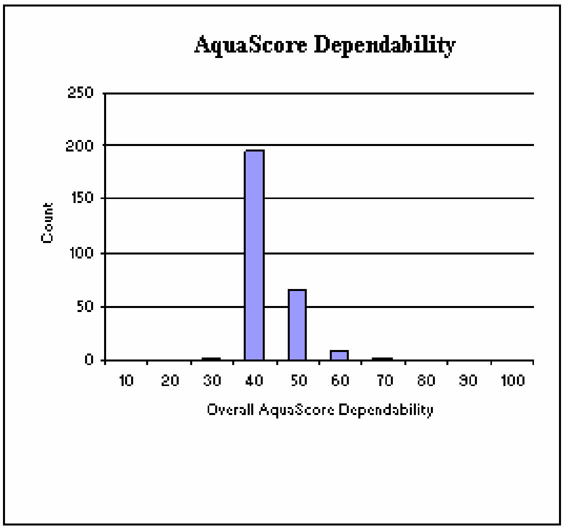


Figure 5 Herbert catchment dependability

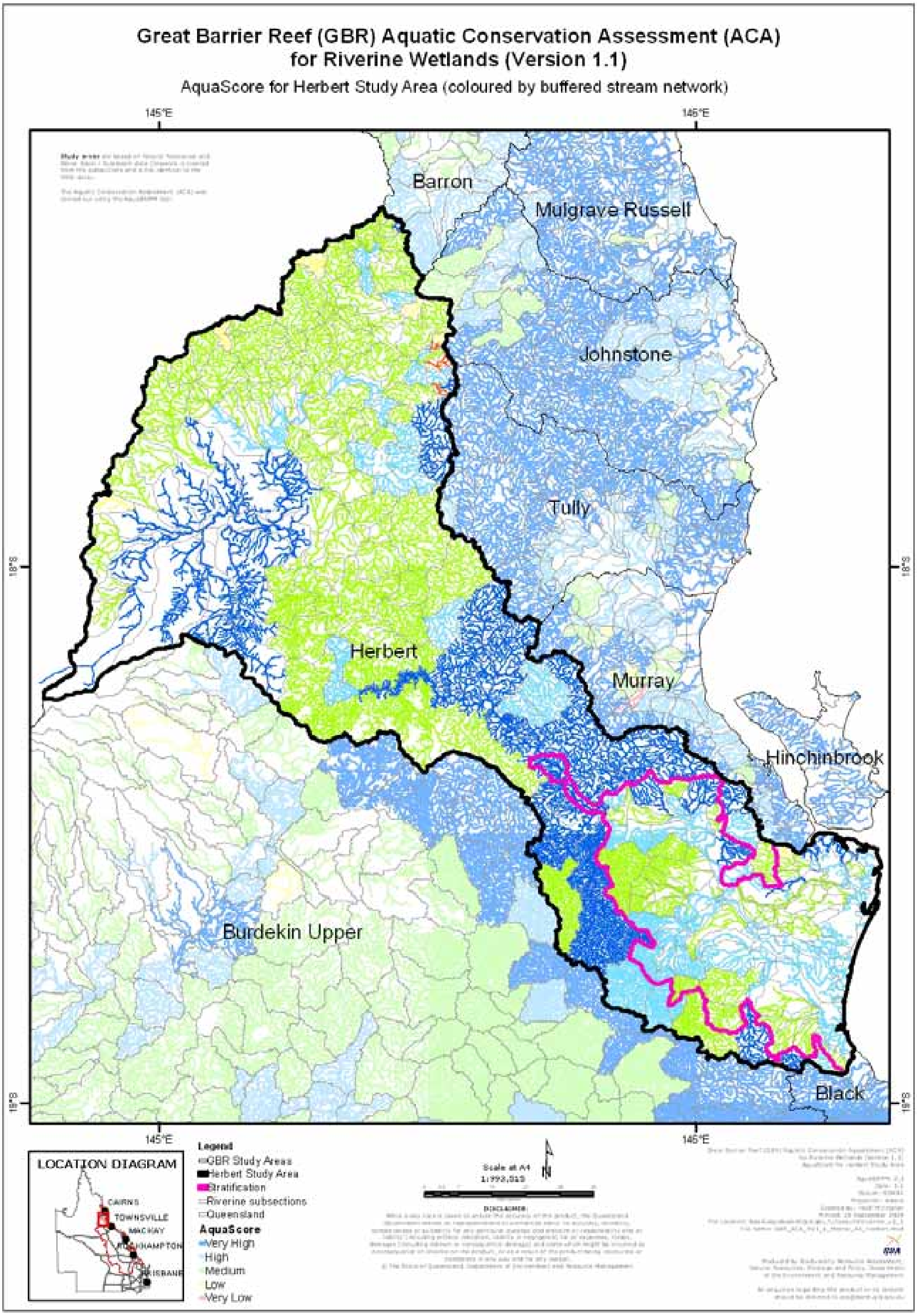


Figure 6 Herbert catchment AquaScore coloured by buffered stream network (Note: the AquaScore achieved by each subsection applies to all stream segments within the subsection whether or not they are mapped – refer to section 2.3)

3.3.4 Criteria results

Table 8 Herbert catchment criteria rating distribution by AquaScore value and dependability

Criteria	No data (%)	Low (%)	Medium (%)	High (%)	Very high (%)	Dependability (%)
1. Naturalness aquatic		76	6	7	10	30
2. Naturalness catchment		0	4	41	54	94
3. Diversity and richness		22	53	22	3	41
4. Threatened species and ecosystems	7		1	42	50	37
5. Priority species and ecosystems	79			15	5	5
6. Special features	72			6	23	8
7. Connectivity		19	41	23	17	34

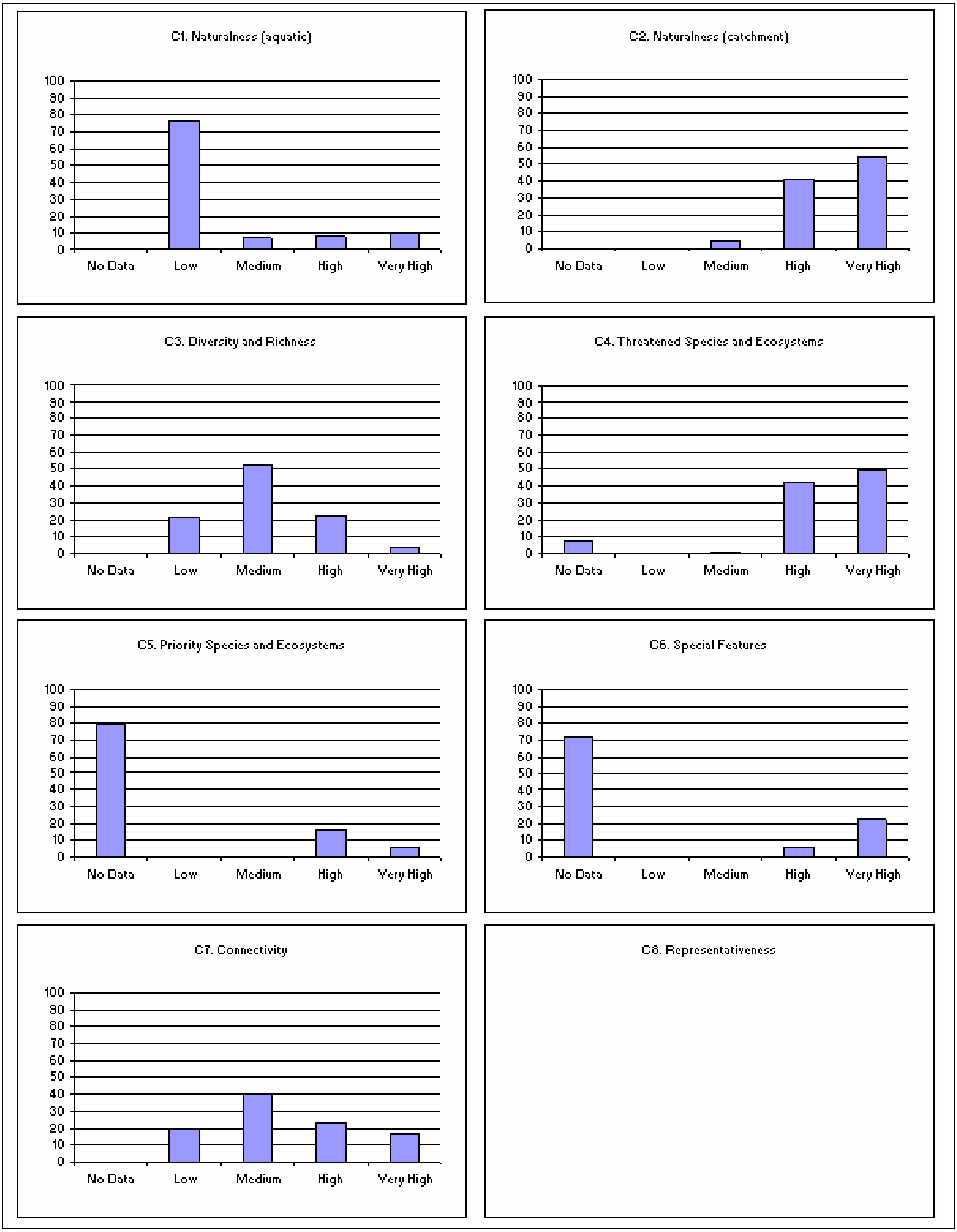


Figure 7 Herbert catchment criteria rating distribution by AquaScore

3.4 Case study two – Mackenzie catchment

3.4.1 Introduction

The Mackenzie sub-catchment of the Fitzroy receives flows from the Nogoa, Comet and Isaac rivers. The catchment extends downstream to the confluence with the Dawson River where it becomes the Fitzroy. Townships in the sub-catchment include Middlemount, Blackwater and Dingo.

Grazing is the predominant land use in the catchment but there are a significant number of coal mines and irrigated and dry land cropping which/that are also important. The catchment is highly regulated with flows being controlled through Bingegang, Bedford and Tartrus weirs as well as a number of water harvesting operations.

Most of the upper catchment flows through a single channel however at the confluence with the Isaac River the river has several large floodplain waterholes such as Lake Mary on its floodplain that may become river channels during floods.

There is one National Park – Taunton National Park and several state forests within the catchment. Blackdown Tableland National Park is partly within the catchment.

3.4.2 Summary of results for the Mackenzie catchment

In the Mackenzie catchment, 9 per cent of the subsections scored a very high AquaScore equating to approximately 6 per cent of the total area of subsections (Figure 9). These results were distributed throughout the Mackenzie catchment (Figure 11). The very high AquaScores were primarily due to the presence of expert panel decisions under criteria 6 (refer Table 9 and Figure 12 for criteria results).Only two expert panel decisions were identified by the expert panels (ma_r_ec_01, ma_r_ec_02 – refer to the Fitzroy wetland ecology expert panel report in attachment I for more details) and it was for this reason that not many subsections outside of these areas scored a very high (Table 9 and Figure 12). Despite this, the flora and fauna expert panels also identified a number of priority species and ecosystems through criteria 5 (Figure 12).

In the Mackenzie catchment, the AquaScore dependability was concentrated around 50 per cent (Figure 10), which is to be expected for this catchment. The summary section of this report contains more detailed information on the overall dependability trends across the GBR.

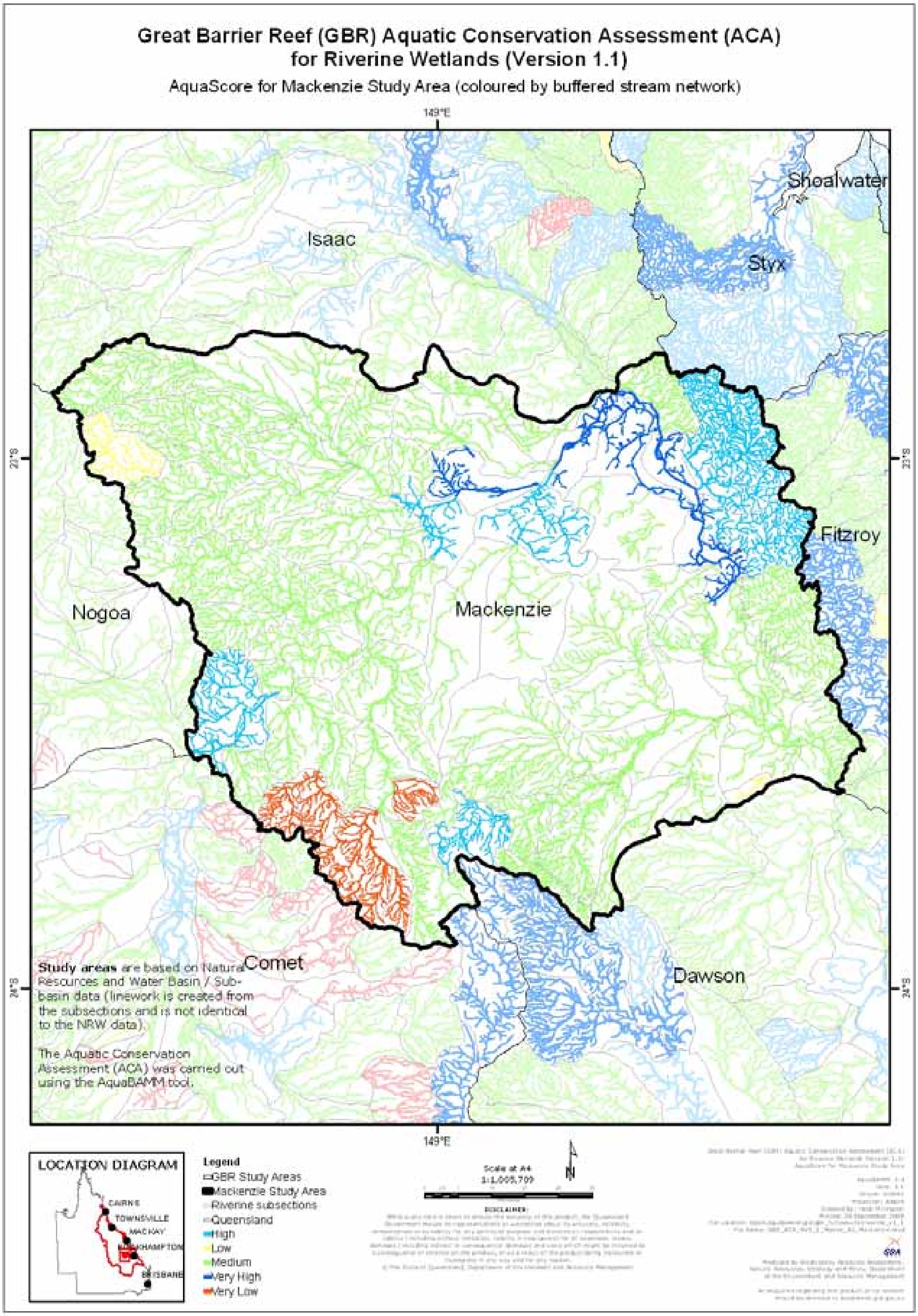
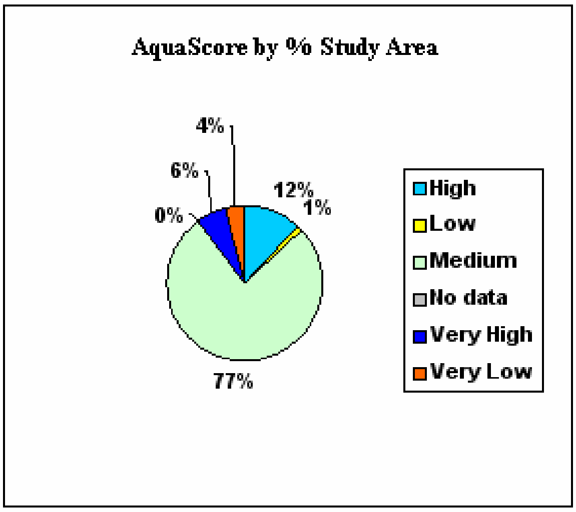


Figure 11Figure 8 Mackenzie catchment AquaScore

3.4.3 AquaScore results

AquaScore by % Study Area

AquaScore	Area (ha)	Area (%)
No data	0.00	0
Very Low	54993.34	4
Low	19017.79	1
Medium	999792.94	77
High	152572.33	12
Very High	72077.34	6



AquaScore by % Spatial Units

Aqua Score Value	Number of Spatial Units	% of SpatialUnits
No data	0	0.00
Very Low	5	7.35
Low	2	2.94
Medium	49	72.06
High	6	8.82
Very High	6	8.82

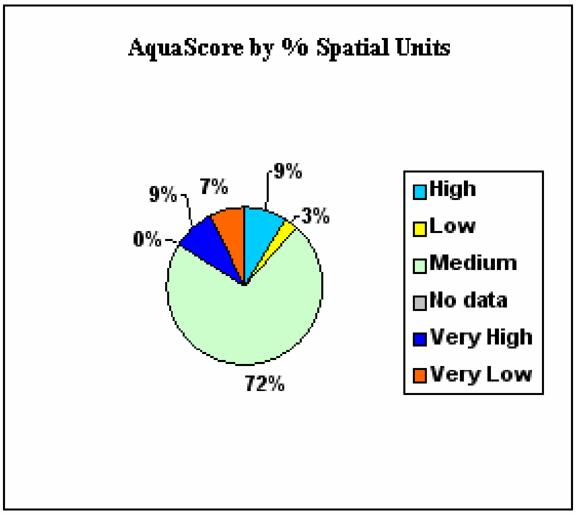


Figure 9 Mackenzie catchment AquaScore

AquaScore Dependability

Overall AquaScore Dependability	Count
10	0
20	0
30	0
40	36
50	23
60	8
70	1
80	0
90	0
100	0

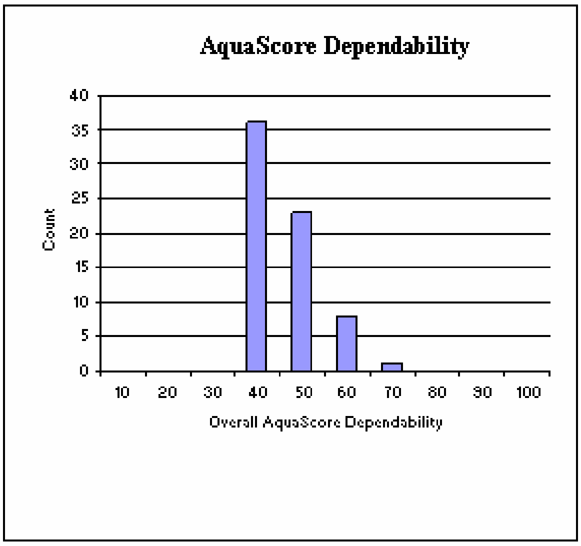


Figure 10 Mackenzie catchment dependability

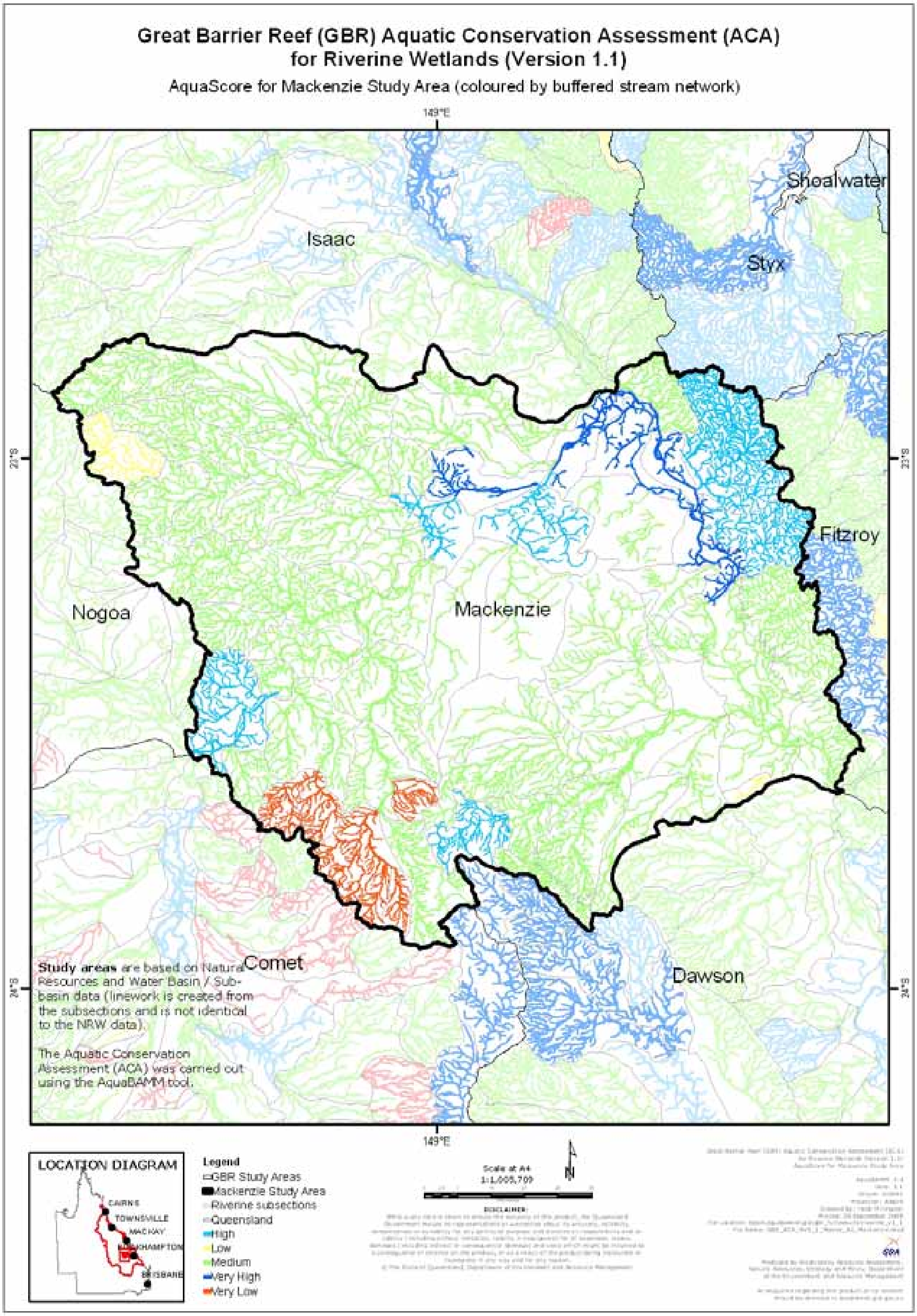


Figure 11 Mackenzie catchment AquaScore
(Note: the AquaScore achieved by each subsection applies to all stream segments within the subsection whether or not they are mapped – refer to section 2.3)

3.4.4 Criteria results

Table 9 catchment criteria rating distribution by AquaScore value and dependability

Criteria	No data (%)	Low (%)	Medium (%)	High (%)	Very high (%)	Dependability (%)
1. Naturalness aquatic		62	22	10	6	33
2. Naturalness catchment			9	75	16	95
3. Diversity and richness		4	32	53	10	46
4. Threatened species and ecosystems	12			87	1	36
5. Priority species and ecosystems	59			16	25	11
6. Special features	91				9	3
8.Representativeness		35	38	7	19	33

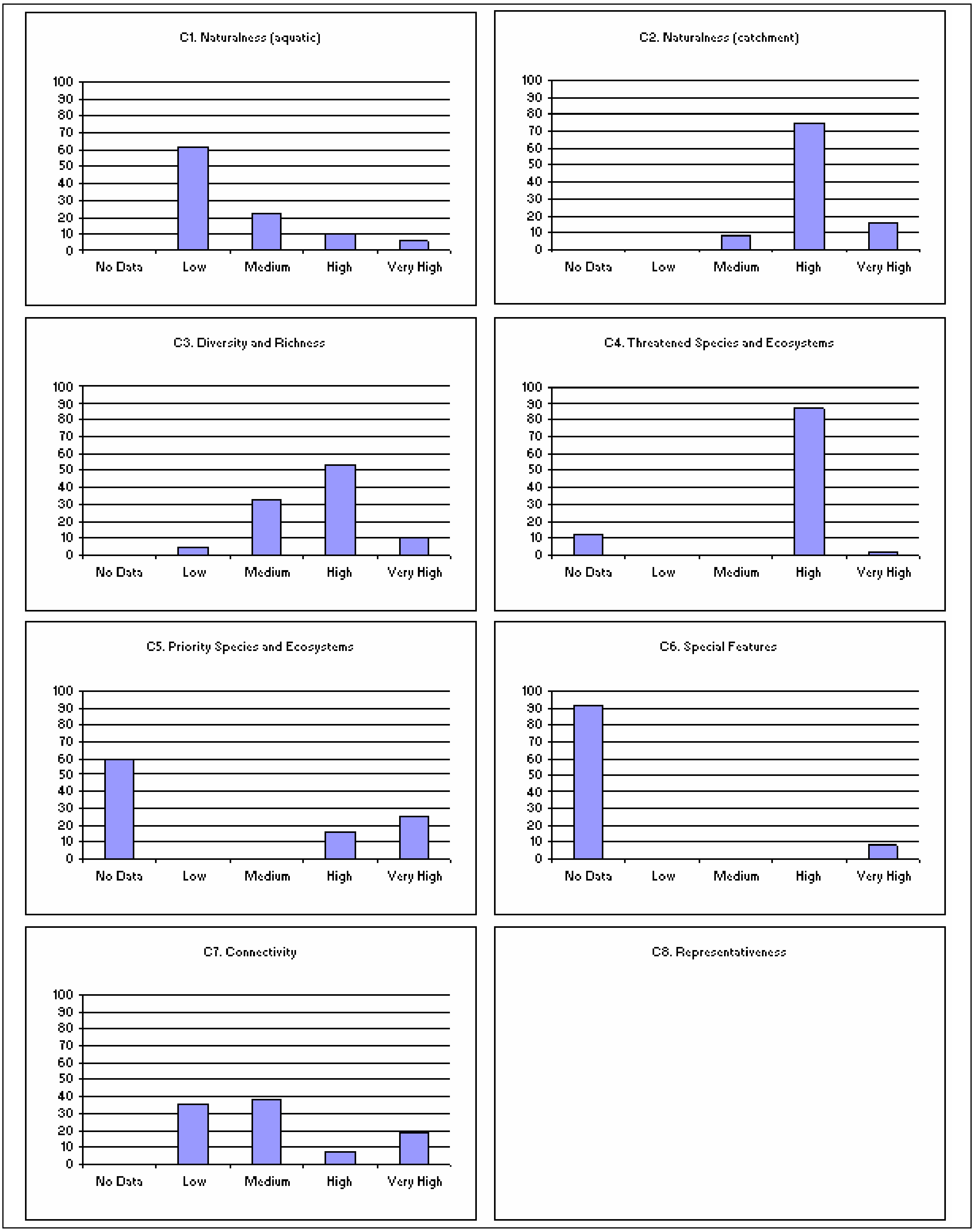


Figure 12 Mackenzie catchment criteria rating distribution by AquaScore

3.5 Field truthing

Field validation of the GBR ACA results was important to test the accuracy of the wetland values attributed. Field validation (truthing) is a critical step in any ACA using AquaBAMM and it precedes final data corrections, resulting from the field work, and a final re-run of the assessment.

Field truthing showed that the ACA results for the GBR catchment were an accurate reflection of wetland conservation values with only a few exceptions. Based on the results from the field truthing, a number of changes were made to the filtering table and measure calculations.

3.5.1 Subsections traversed

The 35 catchments of the GBR contain a total of 4,143 subsections. From the 1st June to the 12th June 2009, a total of 403 subsections across 19 catchments were traversed by vehicle as part of the field truthing exercise (Table 10). This equated to almost 10 per cent of the total subsections within the GBR catchment.

Subsections were observed on route and either inspected from gazetted roads at junctions between riverine systems and the road or where possible by foot. The issue of accessibility together with the scale of the GBR catchment area accounted for the relatively small number of subsections visited. Despite the small percentage of subsections traversed, the exercise allowed the direct checking of many riverine wetlands and covered a range of AquaScores (Table 11). A map of the route taken during the field truthing exercise is provided in Figure 13. Images of subsections inspected during the field are provided in the following plates.

In addition to those subsections mentioned in Table 10, a desktop analysis of the results for other wetlands was undertaken using satellite imagery (e.g. SPOT).

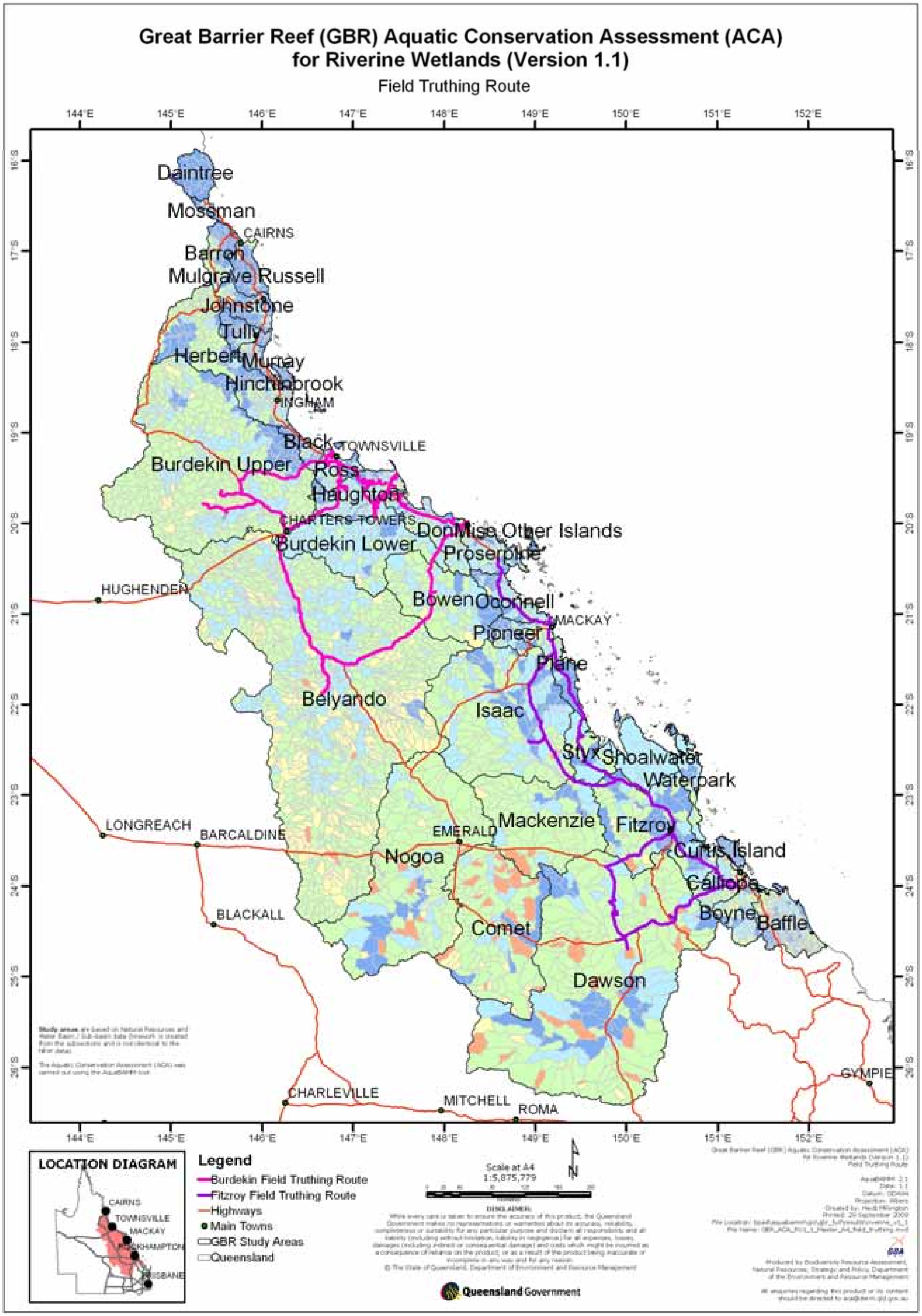


Figure 13 Route undertaken during field truthing exercise

Table 10 Subsections inspected during field truthing by catchment

ACA study areas or catchments	Subsections traversed	Per cent of subsections within study area
Baffle	0	0.0%
Barron	0	0.0%
Belyando	55	5.2%
Black	4	14.3%
Bowen	14	15.9%
Boyne	0	0.0%
Burdekin Lower	18	14.1%
Burdekin Upper	49	10.1%
Calliope	27	42.9%
Comet	0	0.0%
Curtis Island	0	0.0%
Daintree	0	0.0%
Dawson	20	10.7%
Don	39	40.6%
Fitzroy	34	37.4%
Haughton	37	36.6%
Herbert	26	0.0%
Hinchinbrook	0	0.0%
Isaac	26	15.4%
Johnstone	0	0.0%
Mackenzie	2	2.9%
Mossman	0	0.0%
Mulgrave Russell	0	0.0%
Murray	0	0.0%
Nogoa	0	0.0%
O'Connell	21	38.9%
Other Islands	0	0.0%
Pioneer	4	10.3%
Plane	22	48.9%
Proserpine	4	7.5%
Ross	20	50.0%
Shoalwater	1	7.1%
Styx	6	75.0%
Tully	0	0.0%
Waterpark	0	0.0%
	403	**Per cent of total subsections = 9.73%**

Table 11 Subsections traversed during field truthing by AquaScore

AquaScore	Total number of subsections	Number of subsections field truthed	Per cent field truthed
Very high	810	74	9.14%
High	956	126	13.18%
Medium	1,904	184	9.66%
Low	379	14	3.69%
Very low	94	5	5.32%
	4,143	**403**	**9.73%**

Photo: Selena Inglis, DERM

Plate 1 Majors Creek

This freshwater stream located approximately 40 km south of Townsville (subsection unit ha_00031) scored very high under the GBR ACA (AquaScore dependability 52 per cent). The subsection unit is located in the northern section of the Haughton catchment. It scored either high or very high in almost all criteria, only achieving a low for C7 connectivity.

Photo: Selena Inglis, DERM

Plate 2 Burdekin River

This section of the Burdekin River is located just south of the regional town of Clare (subsection unit bl_00008) in the northern part of the Burdekin Lower catchment and is directly downstream of the Clare weir. The subsection scored either very high or high for C2 naturalness catchment, C3 species richness and diversity, C4 threatened species and C5 priority species under the GBR ACA but had limited values or no data for the other criteria. As a result, the overall AquaScore for this subsection was medium (AquaScore dependability 33 per cent).

Photo: Selena Inglis, DERM

Plate 3 Seaforth Creek

This section of Seaforth Creek is located amongst the sugar cane region south of the township of Ayr (subsection unit ha_00029) in the eastern section of the Haughton catchment. Although it scored very high or high for C1 naturalness aquatic and C2 naturalness catchment it either had limited value or no data for all other criteria and as a result only managed to achieve a low overall AquaScore (AquaScore dependability 20 per cent).

Photo: Selena Inglis, DERM

Plate 4 Burdekin River tributary

This tributary of the Burdekin River is located approximately 12 km south of the township of Clare in the northern section of the Burdekin Lower catchment (subsection unit bl_00011). The subsection scored high for C2 naturalness catchment, C3 species richness and diversity, C4 threatened species and C5 priority species but had limited values or no data for the other criteria resulting in an overall AquaScore of medium (AquaScore dependability 35 per cent).

Photo: Selena Inglis, DERM

Plate 5 Suttor River

This ephemeral section of the Suttor River is located within the eastern section of the Belyando catchment approximately 60 km south west of the township of Collinsville (subsection unit be_00279). The area scored very high or high for C1 naturalness aquatic, C2 naturalness catchment and C4 threatened species but had limited values or no data for the other criteria. The overall AquaScore was therefore medium (AquaScore dependability 25 per cent).

Photo: Selena Inglis, DERM

Plate 6 Oakey Creek

This section of Oakey Creek was located approximately 15 km north of Biloela in the eastern section of the Dawson catchment (subsection unit dn_00042). The subsection only scored medium for C2 naturalness catchment, C3 species diversity and richness and C7 connectivity. As all other criteria contained either low values or no data, the subsection achieved a very low AquaScore (AquaScore dependability 42 per cent).

Photo: Selena Inglis, DERM

Plate 7 Don River

This section of the Don River is located approximately 15 km north east of the regional township of Baralaba in the northern section of the Dawson catchment (subsection dn_00022). The subsection received an overall AquaScore of medium (AquaScore dependability 52 per cent) scoring very high for C3 species richness and diversity and C5 priority species and ecosystems. Although C2 naturalness catchment and C4 threatened species and ecosystems also scored high the other criteria had limited values or no data.

Photo: Selena Inglis, DERM

Plate 8 Connors River

This section of the Connors River is located in the eastern section of the Isaac catchment, approximately 50 km northwest of St Lawrence (subsection id is_00109). All but one of the criteria (C1 naturalness aquatic) scored either very high or high contributing to an overall AquaScore of very high (AquaScore dependability 52 per cent).

3.5.2 Field interpretation of ACA results – ecological versus condition assessment

When looking at wetlands or subsections in a catchment and comparing them to their AquaScore, there is a strong tendency to observe a subsection's 'condition'. Wetland 'condition' or 'health' has been a major focus of aquatic assessment in Australia (such as the nationally agreed protocol of Monitoring River Health Initiative, Index of Stream Condition, Queensland State of the Rivers) (Dunn 2000). However, several authors make a clear distinction between 'river health' and 'ecological value' of a river (Dunn 2000; Bennett *et al.* 2002; Chessman 2002). Wetland health data may inform assessment of 'value', and usually does so where data are available, but is not interchangeable with it and the two are not necessarily correlated.

ACAs are primarily focussed on aquatic ecological or conservation value such that the condition contributes to, but does not solely determine a subsection unit's value. A subsection unit's value is a composite of several criteria, indicators and measures. Of the measures used in these assessments, usually less than 10 per cent are related to aquatic, riparian and/or catchment condition.

Consequently, when in the field, the successful interpretation of a subsection unit's conservation value is reliant on the observer to not view 'condition' in isolation from other values (seen or unseen).

Confidence in the AquaScore

Conservation assessments of landscapes, by their very nature, apply ratings along a continuum of values. Hence, the extremes in values (very highs and very lows) are relatively easier to determine in the field than defining the cut-offs in between these extreme values (e.g. lows, mediums and highs). This is particularly difficult to distinguish between subsections rated as either medium or high. Possible reasons for this difficulty whilst in the field may include:

- insufficient datasets for some subsections to allow for a precise determination of conservation value

- the differences between subsections are real, but are not easily observed in the field because of 'hidden' instream values

- often, only a small part of a subsection unit can be seen and assessed in the field. For instance, smaller tributaries within a subsection unit may be devoid of values but the main channel may have significant values that increase the subsection unit's overall value.

A lack of data for some subsections is recognised as a limitation to any ACA. This limitation has been addressed in part by calculating a per cent dependability score for each wetland. The subsection unit's dependability score is the proportion of measures with data for that subsection unit against measures that had 'missing values' or no data. The dependability score is an important parameter when interpreting the AquaScore, or any other conservation value score from criterion or indicator level within the ACA. The lower the dependability score for a subsection unit means a lower confidence level the user will have in the conservation value. Conversely, the higher the dependability scores for a subsection, the more confident the user is in the conservation value assigned to the subsection unit (Clayton *et al.* 2006).

In the end, wetlands or subsections are ecologically complex and field truthing must be undertaken with observer perspective driven strictly by the limitations of each ACA, such as scale, datasets, etc. With this approach, an indication of confidence in the accuracy of any ACA using AquaBAMM can be reached. In the case of the GBR catchment, the assessment results compared well with field truthing results.

4 Summary

The results of an Aquatic Conservation Assessment (ACA), or AquaBAMM assessment output, may be used in a number of ways and for a number of purposes. Well founded ecological or conservation values for aquatic ecosystems are a useful input to many natural resource management decision making processes including, for example, regional planning, development assessment, tenure negotiations or protected area estate review. In addition to the use of final AquaBAMM analysis scores, subordinate elements from each assessment may also be used for management and planning purposes. For example, prioritising natural resource management actions within a catchment (or other subsection) for rehabilitation, protection of high ecological value areas or other on-ground works may be achieved through the use of data from individual measures within AquaBAMM.

Interpretation of the GBR ACA results for the purposes of management priority or for development of management actions has not been undertaken as part of this project.

5 Recommendations

1. The spatial distribution of riverine wetlands of different conservation value is not even across the whole GBR study area and this distribution can not be easily demonstrated by the summary statistics in Table 6. Results for the individual catchments as presented in Table 6, and available through the spatial data, should be consulted to provide a comprehensive interpretation of the ACA results.

2. The results shown in this report are a summary of the information in the ACAs. A large amount of additional information lies at subordinate levels within any ACA. It is recommended that assessment detail at the criterion level (at least) should be considered when undertaking any queries about specific subsections.

3. The field truthing exercise undertaken as part of the ACA indicated that the results of the assessment are reflective of real ecological values on the ground. As a result, these results can be used to inform a wide range of planning and decision-making processes (keeping in mind the usual considerations of data gaps, etc).

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7 Attachments

Attachment A	Wet Tropics aquatic flora expert panel report
Attachment B	Wet Tropics aquatic fauna expert panel report
Attachment C	Wet Tropics wetland ecology expert panel report
Attachment D	Burdekin aquatic flora expert panel report
Attachment E	Burdekin aquatic fauna expert panel report
Attachment F	Burdekin wetland ecology expert panel report
Attachment G	Fitzroy aquatic flora expert panel report
Attachment H	Fitzroy aquatic fauna expert panel report
Attachment I	Fitzroy wetland ecology expert panel report

Attachment A GBR catchments ACA – Aquatic flora expert panel report (Wet Tropics region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment

for the riverine wetlands of the

Great Barrier Reef catchment

Aquatic flora
Expert panel report

Wet Tropics region

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List of Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels was conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic flora expert panel for the Wet Tropics region held in Cairns on Tuesday 2 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the aquatic flora panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments are based on the Department of Environment and Resource Management basin/sub-basin data. The Wet Tropics study area largely corresponds to the Wet Tropics Natural Resource Management (NRM) region and contains the majority of the Wet Tropics World Heritage Area. In total the study area covers approximately 22,100 km^2 and lies across the majority of the Wet Tropics bioregion and a part of the Einasleigh Uplands bioregion to the west in the Upper Herbert and Upper Barron basins. It includes the nine basins shown in Figure 1, which comprise the coastal basins of the Daintree, Mossman, Barron, Mulgrave/Russell, Johnstone, Tully, Murray and Herbert rivers and Hinchinbrook Island. Each of these is treated as an individual study area for the purpose of the AquaBAMM analyses.

As the name suggests the Wet Tropics is characterised by high rainfall largely due to the conspicuous topography. The major mountain masses exceed elevations of 1,000 m and all are granitic, although some have flanking acid volcanic and metamorphic rocks. Extensive

areas of basalt occur, particularly through the Atherton Tablelands, an extensive plateau between 600 m and 900 m that covers a large part of the upper Barron River catchment. The region contains a number of high peaks including the two highest mountains in Queensland, Mount Bartle Frere (1,622 m) and Mount Belenden Ker (1,593 m). The mountain ranges generally have steep precipitous mountain sides with deeply incised valleys. They run north to south, rising sharply near the coast and capture the moisture-laden air from the warm waters of the Coral Sea, resulting in generally high rainfall across the region. The most extensive lowlands are in the south of the study area, associated with the floodplains of the Tully and Herbert rivers, with extensive coastal freshwater and estuarine wetlands.

Mean annual rainfall for the Wet Tropics bioregion is above 1,500 mm, three times the continental average of below 500 mm, with several areas within the study area receiving much higher rainfall. Rainfall patterns are strongly seasonal with a distinct wet season occurring in the warmer months between December and April and although generally wet can vary substantially from year to year. Interannual variability is mainly driven by major rainfall events which commonly occur, associated with cyclones and low pressure depressions. These can flood large areas of the region resulting in huge volumes of water being discharged to the inshore waters of the Great Barrier Reef lagoon. For example, in the Herbert River total mean annual discharge is approximately 3.7 million megalitres and in the Johnstone and South Johnstone it is 3.23 million megalitres. The amount of rain also varies throughout the region due to topography and there is a distinct gradient to drier conditions from the western side of the ranges towards where the study area crosses into the Einasleigh Uplands bioregion. Rainfall is not recorded from the peak of Mount Bartle Frere, but at the summit of the adjacent Mount Belenden Ker records show an annual average rainfall of 8,312 mm, making it the wettest meteorological station in Australia. It also holds the record for the highest rainfall in a calendar year of 12,461 mm in 2000. On the lowlands the Daintree area and the area from Cairns south to Tully receives the highest rainfall with Babinda typically receiving rainfall in excess of 4,000 mm annually. In contrast, the western side of the study area, in the Upper Herbert and Upper Barron basins, on average, receives less than 800 mm annually.

The study area also has generally warm and uniform temperatures throughout the year. Typical daytime minimum and maximum temperatures range on the coast from 22ºC to 31ºC in summer and from 15ºC to 22ºC in winter. The tablelands and uplands are generally much cooler. On the western side of the study area temperatures vary slightly more and tend towards being hotter in summer.

As a consequence of the high rainfall, rainforest cover is extensive across the ranges and coastal lowlands and streams and wetlands are numerous and important features in the landscape. The consistent runoff results in most streams and many wetlands being perennial and they have been so for millions of years, in contrast to most other parts of Australia, including most of the tropical region. As a result the Wet Tropics has sustained a unique and diverse freshwater fauna and flora with many endemic species present.

The high degree of variation in rainfall, topography, combined with a complex evolutionary history has resulted in a diverse spectrum of forest types and plant and animal communities. The rainforests of the region which dominates the narrow, high rainfall coastal belt have been classified into 16 major structural types and 30 broad community types (Tracey and Webb, 1975; Tracey, 1982). In addition the rainforests are fringed and dissected by a range of sclerophyll forests and woodlands as well as wetlands including estuarine mangrove communities. Tall woodlands, open *Eucalyptus* forests and grasslands extend into the drier western parts of the study area in to the Einasleigh Upland bioregion.

Wetland types include an enormous number of low order, perennial or near perennial, streams descending the steep ranges. These join in to several major river systems that define the basins within the study area. The coastal lowland floodplains are generally narrow, with the most extensive lowlands occurring in the south of the study area associated with the floodplains of the Tully/Murray and the Herbert rivers. These areas contain complex systems of numerous interconnecting wetlands and extensive coastal estuarine areas. The Herbert floodplain receives the lowest rainfall of the coastal lowlands in the study area but can have the highest discharge from runoff in the upper catchment. Its floodplain is dominated by woodlands with extensive areas of grass and sedge swamps laying adjacent to dune systems and connected estuaries. This area also contains the Herbert River delta which is formed at the southern end of the Hinchinbrook Channel, with its extensive stands of mangrove forest. In the Tully/Murray floodplain (and areas to the north) rainfall is higher and the coastal vegetation is dominated by forest, rainforest and extensive wetland areas. Unfortunately many of the coastal wetlands throughout the study area have been lost or are now largely modified through drainage and reclamation works. Many of the remaining wetlands are also heavily impacted by clearing of riparian and fringing vegetation, infestation by weeds and by declines in water quality through runoff from adjacent agriculture. Fractured basalt and other fractured rock aquifers occur throughout the study area supporting unique fauna and flora. These aquifer systems are particularly significant in some of the areas within the drier parts of the study area in the Einasleigh Upland. Crater lakes are also a unique feature of the plateaus of the study area.

Approximately 35 per cent of the study area is covered by the Wet Tropics World Heritage Area, taking in most of the ranges and large areas of lowland rainforest. The World Heritage Area consists of extensive areas of National Park and other protected estate as well as areas of private land. The major commercial land uses in the study area include extensive areas of lowlands, and some uplands, used for sugar cane production. Extensive areas in the lowlands are also used for banana production with a diverse range of other horticultural crops occurring throughout. On the fertile Atherton Tablelands dairy is a major industry along with a variety of horticulture and crops. Cattle grazing is a minor land use in the coastal lowlands but extensive cattle grazing is the major land use in the western part of the study area. The area was once heavily dependent on native forestry. However, this has declined with the protection of much of the native rainforest areas in the Wet Tropics World Heritage Area and in recent times forestry has depended on broad hectare softwood plantations on the Atherton Tablelands and the Cardwell area. Increasingly, other forestry plantations are being established on what was traditionally land used for sugar cane production.

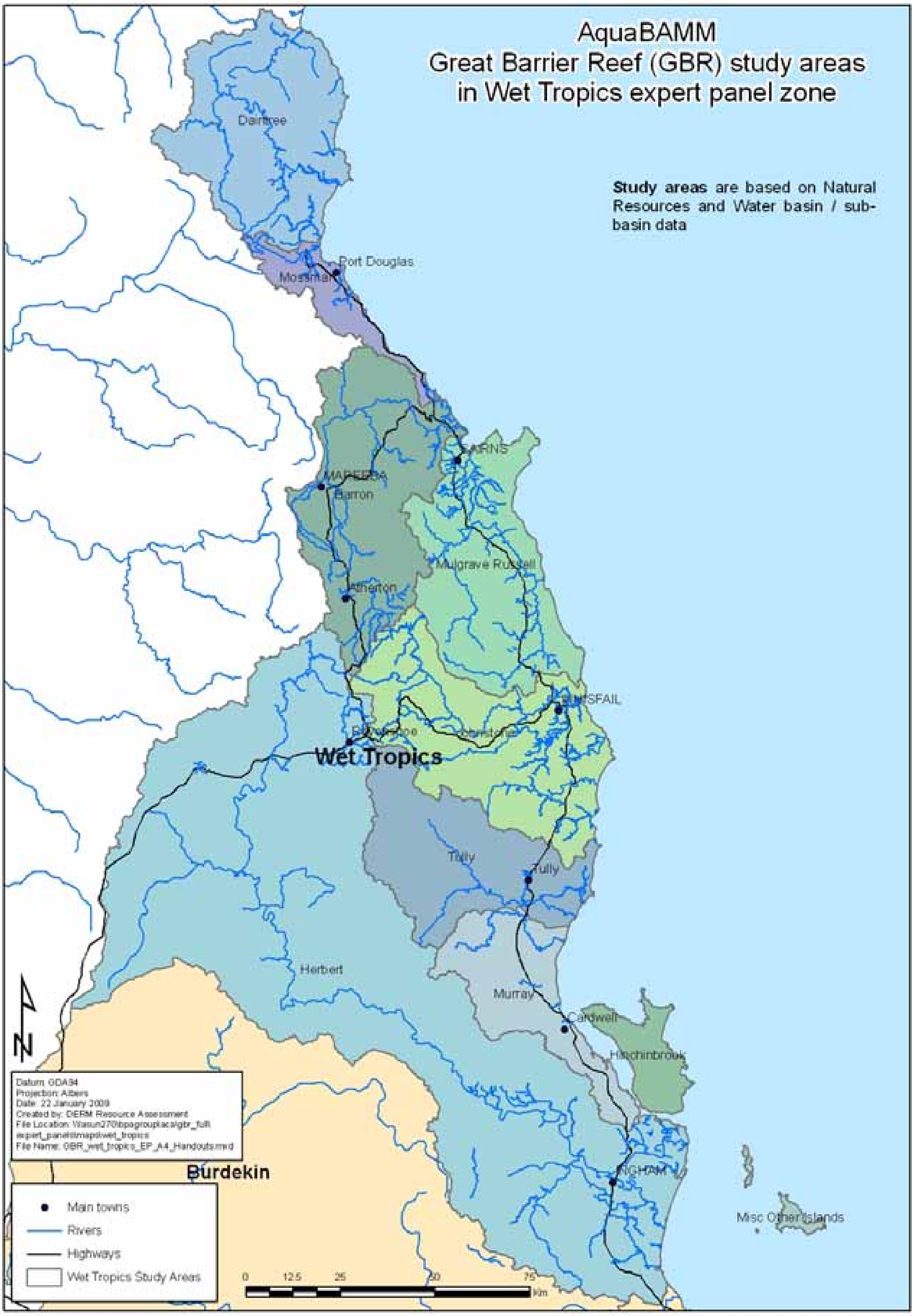

Figure 1 Wet Tropics section of the GBR catchment (incorporating nine individual catchments)

2.2 Panel composition

The expert panel comprised invited persons (Table 1) familiar with aquatic flora in the Wet Tropics section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning – Aquatic ecology and water quality
Nick Cuff	Senior Botanist, Queensland Herbarium, Department of Environment and Resource Management	Botany and regional ecosystem assessment
John Dowe	Botanist, Australian Centre for Tropical Freshwater Research, James Cook University	Riparian vegetation
Andrew Ford	Technical Officer (Botanist), CSIRO	Tropical flora and Wet Tropics biogeography
Prof. Paul Gadek	Professor, School of Marine and Tropical Biology, James Cook University	Tropical flora and biogeography
Jeanette Kemp	Principal Botanist, Department of Environment and Resource Management	Native and exotic flora
George Lukacs	Director, Australian Centre for Tropical Freshwater Research, James Cook University	Wetland ecology
Keith McDonald	Principal Technical Officer (Threatened Species), Department of Environment and Resource Management	Tropical ecology and conservation
Tim Perry	Principal Ecologist, NRA Environmental Consultants	Native and exotic vegetation
Michaelie Pollard	Project Officer (aquatic ecology), Department of Environment and Resource Management	Aquatic ecology
Travis Sydes	Hymenachne/Rehabilitation Project Officer, Hinchinbrook Shire Council	Invasive species management and planning
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
Michael Trenerry	Team Leader (Regional Services), Department of Environment and Resource Management	Tropical ecology and conservation
Bruce Wannan	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Tropical flora and conservation planning
Frank Zich	Curator, Australian Tropical Herbarium, James Cook University	Tropical flora

Selena Inglis and Heidi Millington provided administrative and technical support for the workshop, which was facilitated by Steven Howell.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened flora

The panel identified three ‘rare’ and two ‘endangered’ riverine flora taxa in the Wet Tropics section of the GBR catchment as being primarily aquatic, semi-aquatic or riparian in habit (Table 2). Threatened taxa were excluded from this list if they did not correspond to one of these categories. This list of flora was used as the basis for identifying areas of significance for ‘Criterion 4 Threatened species and ecosystems’ (4.1.2). Point records were used to identify the spatial units having that species present.

Table 2 Aquatic, semi-aquatic and riparian flora species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.2.

Scientific name	**Common name**	**Status**	**Habitat**	**Comments**
Aponogeton bullosus		E[1,2]		
Aponogeton proliferus		E[1,2]		
Aponogeton queenslandicus		R[1]		
Brasenia schreberi		R[1]		
Cladopus queenslandicus		R[1]		

- *recent records (>1,950) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

4 Priority flora

The panel deliberated on all aquatic, semi-aquatic and riparian species within the GBR catchment to identify ‘priority flora’ (excluding the rare or threatened species listed in Table 2). The panel adopted a revised version of the earlier definition of a priority species from the Burnett River ACA: namely, a priority species must exhibit one or more of the following significant values:

1. It forms significant macrophyte beds (in shallow or deep water).
2. It is an important/critical food source.
3. It is important/critical habitat.
4. It is implicated in spawning or reproduction for other fauna and/or flora species.
5. It is at its distributional limit or is a disjunct population.
6. It provides stream bank or bed stabilisation or has soil-binding properties.
7. It is a small population and subject to threatening processes.

The panel identified 14 priority flora species in the riverine wetlands of the Wet Tropics section of the GBR catchment (Table 3). These species were included in ‘Criterion 5 Priority species and ecosystems’ (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present.

Table 3 Identified priority flora species, and their significant values

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	**Common name**	**Habitat**	**Comments**
Aponogeton lancesmithii			
Azolla pinnata	Ferny azolla	Aquatic[3]	Good indicator of ecosystem health.
Baumea articulata	Jointed twigrush		Usually found in standing water or depressions forming palustrine swamps which are restricted in their distribution. It forms dense stands and significant macrophyte beds providing important habitat and food source for fauna.
Bolboschoenus fluviatilis			Small population subject to threatening processes.
Casuarina cunninghamiana		Riparian[3]	Fringes streams and is a distinctive feature in the upper Herbert and Barron River catchments and possibly other areas.
Casuarina cunninghamiana subsp. cunninghamiana			Fringes streams and is a distinctive feature in the upper Herbert & Barron River catchments and possibly other areas.
Ceratophyllum demersum	Hornwort	Aquatic[3]	Potentially important fish habitat.
Cyperus exaltatus	Tall flatsedge	Semi-aquatic[3]	Large sedge found on open plains which provides good habitat for fauna species and is quite rare as it is at its northern limit.
Eleocharis cylindrostachys		Semi-aquatic[3]	Species is out-competed by exotic grasses and is subject to threatening processes associated with sugar cane farming.

Scientific name	Common name	Habitat	Comments
Hydrilla verticillata	Hydrilla	Aquatic[3]	Mainly important in the Herbert River catchment as it forms significant macrophyte beds providing important habitat for fish spawning and reproduction. Species improves water quality but is susceptible to sedimentation and turbidity.
Leersia hexandra	Swamp rice grass		Forms significant macrophyte beds and provides bed stabilisation.
Lomandra hystrix		Semi-aquatic[3]	Species hosts more butterflies than any other species on the list and also provides stream bank stabilisation. It also has a restricted distribution.
Ludwigia adscendens			Forms significant macrophyte beds which provide important/critical habitat particularly for fish. It is at its distributional limit or is a disjunct population.
Melaleuca quinquenervia	Swamp paperbark	Riparian[3]	Forms extensive stands in freshwater wetlands and wetlands that fluctuate between fresh water and saline. Also provides important fauna habitat for species such as mahogany gliders (*Petaurus gracilis*) and cassowaries (*Casuarius casuarius johnsonii*).

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

5 Species richness

Species richness (i.e. total number of species) was scored for aquatic-dependant flora, stratified by 150 m above sea level (ASL) for all study areas in the Wet Tropics (see the Wet Tropics ecology expert panel report for more information on stratification).

The Wet Tropics section of the GBR catchment has 60 plants that are referred to in this report as ‘aquatic-dependent’ in riverine wetlands (Table 4). The datasets for these species were accessed from the DERM corporate databases of WildNet and Herbrecs and from panel member records.

The panel defined ‘aquatic-dependent flora’ to mean:

> ‘those species that are adapted to and dependant on living in wet conditions for at least part of their life cycle and found either within or immediately adjoining a non-riverine or riverine wetland’.

This definition of a wetland-dependent plant extends beyond the more traditional definition of submerged and floating aquatic plants to include plants inhabiting the littoral zone (waters edge) and plants that usually have ‘wet feet’ on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM indicator and measure of species richness: ‘Richness of wetland dependent plants’ (3.1.5). The indicator is a measure of floristic richness of a particular spatial unit’s aquatic environment, and hence, a broad definition better depicts the flora richness value at a given location.

Table 4 Wetland-dependent native flora species, including priority species

This list was used to calculate an aquatic and riparian flora richness score (3.1.5), threatened flora species (4.1.2) and priority flora species (5.1.2).

Scientific name	**Common name**	**Status**	**Habitat**	**Comments**
Ammannia multiflora	Jerry-jerry	LC[1]		
Aponogeton bullosus		E[1,2]		
Aponogeton lancesmithii		LC[1]		
Aponogeton proliferus		E[1,2]		
Aponogeton queenslandicus		LC[1]		
Aponogeton vanbruggenii		LC[1]		
Azolla pinnata	Ferny azolla	LC[1]	Aquatic[3]	
Barringtonia racemosa		LC[1]		
Baumea articulata	Jointed twigrush	LC[1]		
Baumea juncea	Bare twigrush	LC[1]		
Blechnum indicum	Swamp water fern	LC[1]		
Blyxa aubertii		LC[1]	Aquatic[3]	
Bolboschoenus fluviatilis		LC[1]		
Brasenia schreberi		R[1]		
Casuarina cunninghamiana		LC[1]	Riparian[3]	Riparian species
Casuarina cunninghamiana subsp. cunninghamiana		LC[1]		Riparian species

Scientific name	Common name	Status	Habitat	Comments
Ceratophyllum demersum	Hornwort	LC[1]	Aquatic[3]	Potentially important fish habitat
Cladopus queenslandicus		R[1]		
Cyperus exaltatus	Tall flatsedge	LC[1]	Semi-aquatic[3]	
Eleocharis cylindrostachys		LC[1]	Semi-aquatic[3]	
Eriocaulon athertonense		LC[1]		
Hydrilla verticillata	Hydrilla	LC[1]	Aquatic[3]	
Leersia hexandra	Swamp rice grass	LC[1]		
Lepironia articulata		LC[1]		
Leptospermum brachyandrum	Weeping tea-tree	LC[1]		
Lomandra hystrix		LC[1]	Semi-aquatic[3]	
Ludwigia adscendens		LC[1]		
Ludwigia peploides subsp. montevidensis		LC[1]	Aquatic[3]	
Melaleuca bracteata		LC[1]	Riparian[3]	
Melaleuca fluviatilis		LC[1]	Riparian[3]	
Melaleuca polandii		LC[1]		
Melaleuca quinquenervia	Swamp paperbark	LC[1]	Riparian[3]	
Melaleuca trichostachya		LC[1]	Riparian[3]	
Melaleuca viminalis		LC[1]	Riparian[3]	
Myriophyllum		LC[1]		
Myriophyllum dicoccum		LC[1]		
Myriophyllum gracile var. lineare		LC[1]		
Myriophyllum muricatum		LC[1]		
Myriophyllum simulans		LC[1]		
Myriophyllum verrucosum	Water milfoil	LC[1]	Aquatic[3]	
Nypa fruticans		LC[1]		
Philydrum lanuginosum	Frogsmouth	LC[1]	Riparian[3]	
Phragmites australis	Common reed	LC[1]	Aquatic[3]	
Phragmites karka		LC[1]		
Phragmites vallatoria		LC[1]		
Potamogeton crispus	Curly pondweed	LC[1]	Aquatic[3]	
Potamogeton tepperi		LC[1]		
Potamogeton tricarinatus	Floating pondweed	LC[1]	Aquatic[3]	
Schoenoplectus litoralis		LC[1]		
Syzygium angophoroides		LC[1]		
Syzygium australe	Scrub cherry	LC[1]	Riparian[3]	
Syzygium oleosum	Blue cherry	LC[1]		
Tristaniopsis exiliflora	Kanuka box	LC[1]		
Typha domingensis		LC[1]	Aquatic[3]	

Scientific name	Common name	Status	Habitat	Comments
Typha orientalis	Broad-leaved cumbungi	LC[1]		
Utricularia bifida		LC[1]	Aquatic[3]	
Utricularia caerulea	Blue bladderwort	LC[1]		
Utricularia uliginosa	Asian bladderwort	LC[1]		
Vallisneria		LC[1]		
Vallisneria nana		LC[1]	Aquatic[3]	

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

6 Exotic flora

The panel recommended that only exotic plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a riverine or non-riverine landscape be included for the GBR ACA using AquaBAMM. The panel identified 77 exotic plants that are known to occur within the riverine wetlands in the Wet Tropics section of the GBR catchment (Table 5). The presence of aquatic and semi-aquatic flora species were recorded under ‘Criterion 1 Naturalness (aquatic)’ (1.1.2). Riparian exotic flora species were recorded under ‘Criterion 2 Naturalness (catchment)’ (2.1.1).

The degree of infestation and abundance of an exotic plant at a particular locality was acknowledged by the panel as being an important factor in determining the level of impact to a natural ecosystem. Where available, information and mapping of exotic species’ extent (sourced from the former Department of Environment and Resource Management and regional bodies) were used instead of point records to flag the spatial units that have exotic species present. Where only a point record is available for a location, then the record was used to identify the spatial units as having an exotic species present. Hence, an individual point record may or may not correspond to localities of dense weed infestations.

Table 5 Exotic flora species

This list was used to calculate the measures for 1.1.2 and 2.1.1 in the AquaBAMM assessment.

Scientific name	Common name	Habitat	Comments
Alternanthera philoxeroides			Not common and its absence is an indicator of good condition. Currently on the national alert list as it may become a serious issue in the future.
Ageratina riparia	Mistflower		
Allamanda cathartica			Becoming a significant problem around Mission Beach and El Arish.
Annona glabra			
Argemone mexicana	Prickly poppy		Well established weed that out-competes native species.
Arundo donax			Restricted to locations with flowing water.
Bauhinia monandra			Well established on banks of rivers.
Brillantaisia lamium			
Calotropis procera			
Cabomba caroliniana var. caroliniana	Cabomba		
Canna indica	Indian shot		
Cascabela thevetia	Yellow oleander		Problem on the Walsh River. Common in drier areas of upper catchments, however, only seen on road edges and rocky gullies in these areas.
Cecropia peltata			Present in region, class 1 weed.
Chromolaena odorata	Siam weed		
Cryptostegia grandiflora	Rubber vine		Indication of condition.
Cyperus aromaticus			
Cyperus involucratus			Problem weed.
Cyperus rotundus	Nutgrass	Semi-aquatic[1]	

Scientific name	Common name	Habitat	Comments
Echinochloa polystachya cv. Amity	Aleman grass		Deep water, ponded pasture species.
Eichhornia crassipes	Water hyacinth		Very data poor with only two records. It is mainly a problem in non-riverine areas as riverine flows may be too high in this area.
Eleutheranthera ruderalis			Prevalent in disturbed area with heavier soils along rivers.
Flacourtia jangomas			Common around the Daintree River and upper Daintree River catchment.
Hedychium coronarium			
Hiptage benghalensis			Concentrated near Mossman.
Hymenachne amplexicaulis cv. Olive			
Hyptis capitata			Problem in grasslands around Ingham and has been seen on disturbed areas on banks of streams.
Jatropha gossypiifolia			Competitive species that grows aggressively wherever it is.
Lantana camara	Lantana		Impacts riparian areas.
Leucaena leucocephala	Leucaena		Favours creeks.
Leucaena leucocephala subsp. glabrata	Leucaena		Favours creeks.
Leucaena leucocephala subsp. leucocephala	Leucaena		Favours creeks.
Leucas lavandulifolia			
Ligustrum sinense	Small-leaved privet		
Lophospermum erubescens			
Ludwigia hyssopifolia			Considered by some to be a native species.
Malvastrum americanum			
Malvastrum americanum var. americanum			
Manihot glaziovii			
Megathyrsus maximus			
Megathyrsus maximus var. coloratus			
Megathyrsus maximus var. maximus			
Megathyrsus maximus var. maximus cv. Hamil			
Megathyrsus maximus var. pubiglumis			
Melinis minutiflora	Molasses grass		
Miconia calvescens	Miconia		
Miconia nervosa			
Miconia racemosa			
Mikania micrantha	Mikania vine		
Pennisetum purpureum	Elephant grass		Invasive along river banks.
Phytolacca rivinoides			
Praxelis clematidea			

Scientific name	Common name	Habitat	Comments
Ricinus communis	Castor oil bush		
Rubus alceifolius	Giant bramble		
Sagittaria platyphylla			Species should be on alert list as a potential future problem. It is an indicator of declining ecosystem health.
Salvinia molesta	Salvinia		
Sanchezia parvibracteata			
Senna obtusifolia			Resides on banks.
Senna tora			
Solanum americanum			
Solanum americanum subsp. nodiflorum			
Solanum americanum subsp. nutans			
Solanum mauritianum	Wild tobacco		
Solanum nigrum			
Solanum nigrum subsp. nigrum			
Solanum seaforthianum	Brazilian nightshade		
Solanum torvum	Devil's fig		
Spathodea campanulata	West African tulip tree		
Spathodea campanulata subsp. nilotica			
Sphagneticola trilobata			
Steinchisma laxa			
Syngonium podophyllum			
Tradescantia fluminensis			
Tradescantia spathacea			
Tradescantia zebrina			
Turbina corymbosa			Especially a problem on the Barron River.
Urochloa mutica	Para grass	Semi-aquatic[3]	Coastal weed that creates ponded pastures.
Xanthium occidentale			

- *recent records (>1950) and records with precision <2,000 m only*

1. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

7 Priority ecosystems and special features

The panel identified several riverine priority ecosystems/special features in the Wet Tropics section of the GBR catchment (Table 6). These were identified for their aquatic and riparian flora values. Where special features nominated by the aquatic flora expert panel were also considered to have additional values (e.g. fauna, ecology) values by the aquatic fauna or wetland ecology expert panels, the special area was implemented as a wetland ecology special feature.

Each spatial unit that intersected with a particular ecosystem or feature in Table 6 was given a score equal to the conservation rating.

Table 6 Priority ecosystems and special features

Decisions listed by catchment. These features were intersected with the spatial units to identify the values for 'Criterion 6 Special features'. All implemented special features were given a conservation rating of between 1 and 4 assigned by the panel.

Priority ecosystem/ special feature	**Values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Flaggy Creek	Flaggy Creek is the last unmodified stream within the highly modified Barron River catchment. The creek is influenced by tannin inputs and provides refugial habitat for macrophyte species.	Barron	bn_r_fl_01	6.2.1 6.3.1	4
Noah and Oliver creeks	The Noah and Oliver creeks contain the highest concentration of local endemics in the entire wet tropics. The area boasts high species diversity supporting a large number of cassowaries and the highest concentration of large fruited flora species in the wet tropics.	Daintree	da_r_fl_01	6.3.1	4
Daintree River	The Daintree River contains significant areas of *Melaleuca cajuputi* in a series of large swamp ecosystems. The area also contains many unique and disjunct habitats as well as disjunct and threatened species. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number da_nr_fl_02). See the Wet Tropics non-riverine report for more details. This decision was not implemented as its extent is covered under a wetland ecology decision (da_r_ec_02).	Daintree	da_r_fl_02	6.3.1	4

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Southeast Hinchinbrook Island	The southeast section of Hinchinbrook Island contains good freshwater seeps coming off the granite mountains. The area is a largely intact ecosystem that provides a good transitional zone from mountain to mangroves. The island is subject to threatening processes from tourism especially in the Zoe Bay area. Note: This decision was also included in the non-riverine ACA assessment (decision number hi_nr_fl_02). See the Wet Tropics non-riverine report for more details.	Hinchinbrook	hi_r_fl_01	6.2.1 6.3.1 6.4.1 7.5.1	4

Attachments

Attachment A – GBR catchment study area

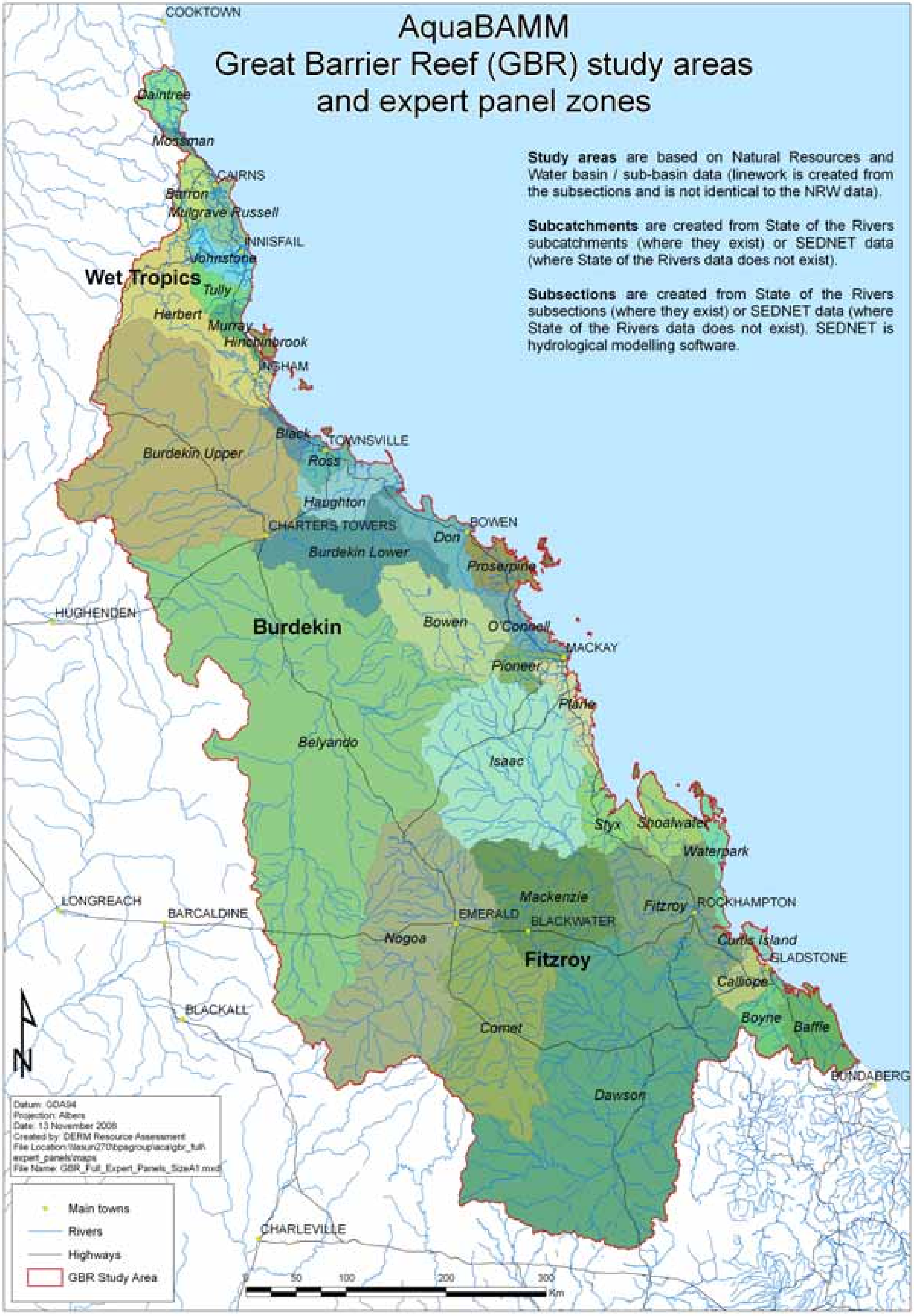

Figure 2 GBR catchment study area

Attachment B – Terms of reference (aquatic flora expert panel)

The terms of reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic flora

The aquatic flora expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to both the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic flora and floristic communities.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on non-riverine and riverine ecosystem threatened flora species, habitat and localities
- provide advice on non-riverine and riverine ecosystem priority flora species, habitat and localities
- identify priority ecosystems or areas important for significant floral communities or species
- provide advice on non-riverine and riverine ecosystem exotic flora species, localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a "starter set" for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 7 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.1	APFD[3] score – modelled deviation from natural under full development
	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.3	Percent no flows – modelled low flows relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)

Criteria & indicators	Measures	
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit

Criteria & indicators	Measures	
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

References

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Attachment B GBR catchments ACA – Aquatic fauna expert panel report (Wet Tropics region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Aquatic fauna
Expert panel report

Wet Tropics region

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
CAMBA	China Australia Migratory Birds Agreement
CMS	Convention of Migratory Species of Wild Animals
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
JAMBA	Japan Australia Migratory Birds Agreement
NC Act	*Nature Conservation Act 1992*
RAMSAR	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address ‘aquatic fauna’, ‘aquatic and riparian flora’ and ‘wetland ecology’ for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic flora expert panel for the Wet Tropics region held in Cairns on Wednesday 3 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the aquatic fauna panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments are based on the Department of Environment and Resource Management basin/sub-basin data. The Wet Tropics study area largely corresponds to the Wet Tropics Natural Resource Management (NRM) Region and contains the majority of the Wet Tropics World Heritage Area. In total the study area covers approximately 22,100 km^2 and lies across the majority of the Wet Tropics bioregion and a part of the Einasleigh Uplands bioregion to the west in the Upper Herbert and Upper Barron basins. It includes the nine basins shown in Figure 1, which comprise the coastal basins of the Daintree, Mossman, Barron Mulgrave/Russell, Johnstone, Tully, Murray, and Herbert rivers and Hinchinbrook Island. Each of these is treated as an individual study area for the purpose of the AquaBAMM analyses.

As the name suggests the Wet Tropics is characterised by high rainfall largely due to the conspicuous topography. The major mountain masses exceed elevations of 1,000 m and all are granitic, although some have flanking acid volcanic and metamorphic rocks. Extensive

areas of basalt occur, particularly through the Atherton Tablelands, an extensive plateau between 600 m and 900 m that covers a large part of the upper Barron River catchment. The region contains a number of high peaks including the two highest mountains in Queensland, Mount Bartle Frere (1,622 m) and Mount Bellenden Ker (1,593 m). The mountain ranges generally have steep precipitous mountain sides with deeply incised valleys. They run north to south, rising sharply near the coast and capture the moisture-laden air from the warm waters of the Coral Sea, resulting in generally high rainfall across the region. The most extensive lowlands are in the south of the study area, associated with the floodplains of the Tully and Herbert rivers, with extensive coastal freshwater and estuarine wetlands.

Mean annual rainfall for the Wet Tropics bioregion is above 1,500 mm, three times the continental average of below 500 mm, with several areas within the study area receiving much higher rainfall. Rainfall patterns are strongly seasonal with a distinct wet season occurring in the warmer months between December and April and although generally wet can vary substantially from year to year. Interannual variability is mainly driven by major rainfall events which commonly occur, associated with cyclones and low pressure depressions. These can flood large areas of the region resulting in huge volumes of water being discharged to the inshore waters of the Great Barrier Reef lagoon. For example, in the Herbert River total mean annual discharge is approximately 3.7 million megalitres and in the Johnstone and South Johnstone it is 3.23 million megalitres. The amount of rain also varies throughout the region due to topography and there is a distinct gradient to drier conditions from the western side of the ranges towards where the study area crosses into the Einasleigh Uplands bioregion. Rainfall is not recorded from the peak of Mount Bartle Frere, but at the summit of the adjacent Mount Belenden Ker records show an annual average rainfall of 8,312 mm, making it the wettest meteorological station in Australia. It also holds the record for the highest rainfall in a calendar year of 12,461 mm in 2000. On the lowlands the Daintree area and the area from Cairns south to Tully receives the highest rainfall with Babinda typically receiving rainfall in excess of 4,000 mm annually. In contrast, the western side of the study area, in the Upper Herbert and Upper Barron basins, receives, on average, less than 800 mm annually.

The study area also has generally warm and uniform temperatures throughout the year. Typical daytime minimum and maximum temperatures range on the coast from 22ºC to 31ºC in summer and from 15ºC to 22ºC in winter. The tablelands and uplands are generally much cooler. On the western side of the study area temperatures vary slightly more and tend towards being hotter in summer.

As a consequence of the high rainfall, rainforest cover is extensive across the ranges and coastal lowlands and streams and wetlands are numerous and important features in the landscape. The consistent runoff results in most streams and many wetlands being perennial and they have been so for millions of years, in contrast to most other parts of Australia, including most of the tropical region. As a result the Wet Tropics has sustained a unique and diverse freshwater fauna and flora with many endemic species present.

The high degree of variation in rainfall, topography, combined with a complex evolutionary history has resulted in a diverse spectrum of forest types and plant and animal communities. The rainforests of the region which dominates the narrow, high rainfall coastal belt have been classified into 16 major structural types and 30 broad community types (Tracey and Webb, 1975; Tracey, 1982). In addition, the rainforests are fringed and dissected by a range of sclerophyll forests and woodlands as well as wetlands including estuarine mangrove communities. Tall woodlands, open *Eucalyptus* forests and grasslands extend into the drier western parts of the study area in to the Einasleigh Upland bioregion.

Wetland types include an enormous number of low order, perennial or near perennial, streams descending the steep ranges. These join in to several major river systems that define the basins within the study area. The coastal lowland floodplains are generally narrow, with the most extensive lowlands occurring in the south of the study area associated with the floodplains of the Tully/Murray and the Herbert rivers. These areas contain complex systems of numerous interconnecting wetlands and extensive coastal estuarine areas. The Herbert floodplain receives the lowest rainfall of the coastal lowlands in the study area but can have the highest discharge from runoff in the upper catchment. Its floodplain is dominated by woodlands with extensive areas of grass and sedge swamps laying adjacent to dune systems and connected estuaries. This area also contains the Herbert River delta, which is formed at the southern end of the Hinchinbrook Channel, with its extensive stands of mangrove forest. In the Tully/Murray floodplain (and areas to the north) rainfall is higher and the coastal vegetation is dominated by forest, rainforest and extensive wetland areas. Unfortunately many of the coastal wetlands throughout the study area have been lost or are now largely modified through drainage and reclamation works. Many of the remaining wetlands are also heavily impacted by clearing of riparian and fringing vegetation, infestation by weeds and by declines in water quality through runoff from adjacent agriculture. Fractured basalt and other fractured rock aquifers occur throughout the study area supporting unique fauna and flora. These aquifer systems are particularly significant in some of the areas within the drier parts of the study area in the Einasleigh Upland. Crater lakes are also a unique feature of the plateaus of the study area.

Approximately 35 per cent of the study area is covered by the Wet Tropics World Heritage Area, taking in most of the ranges and large areas of lowland rainforest. The World Heritage Area consists of extensive areas of National Park and other protected estate as well as areas of private land. The major commercial land uses in the study area include extensive areas of lowlands, and some uplands, used for sugar cane production. Extensive areas in the lowlands are also used for banana production with a diverse range of other horticultural crops occurring throughout. On the fertile Atherton Tablelands dairy is a major industry along with a variety of horticulture and crops. Cattle grazing is a minor land use in the coastal lowlands but extensive cattle grazing is the major land use in the western part of the study area. The area was once heavily dependent on native forestry. However, this has declined with the protection of much of the native rainforest areas in the Wet Tropics World Heritage Area and in recent times forestry has depended on broad hectare softwood plantations on the Atherton Tablelands and the Cardwell area. Increasingly, other forestry plantations are being established on what was traditionally land used for sugar cane production.

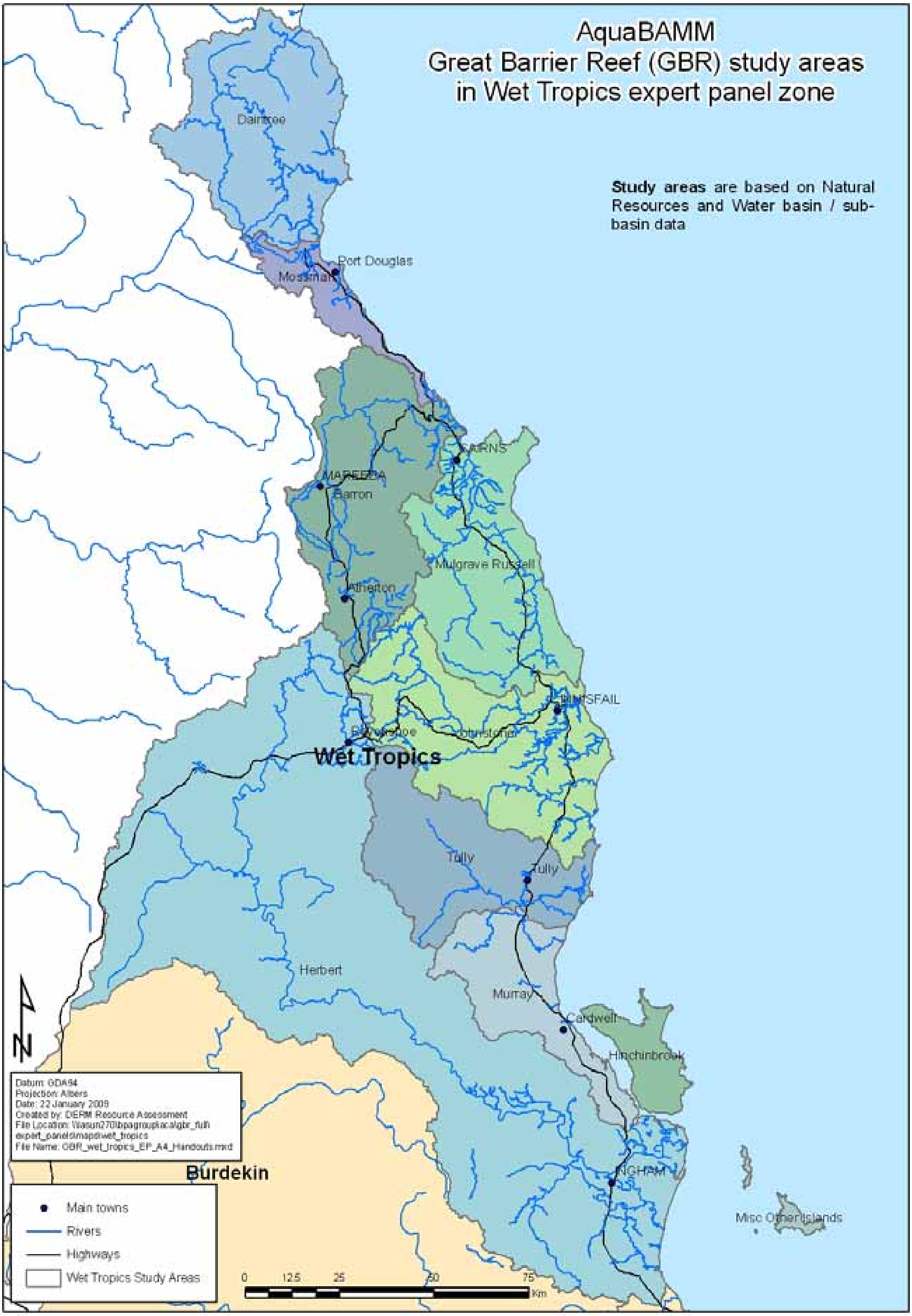

Figure 1 Wet Tropics section of the GBR catchment (incorporating nine individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of persons listed in Table 1 who are familiar with aquatic fauna in the Wet Tropics section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Ant Backer	Senior Planning Officer, Department of Environment and Resource Management	Biodiversity planning, terrestrial ecology
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning – Aquatic ecology and water quality
Paul Godfrey	Research scientist, Australian Rivers Institute, Griffith University	Fish and aquatic ecology
Alf Hogan	Fisheries Scientist, Alf Hogan and Associates Fish Ecologists	Fish ecologist
Keith McDonald	Principal Technical Officer (threatened species), Department of Environment and Resource Management	Tropical ecology and conservation
Malcom Pearce	Senior Fisheries Biologist, Department of Primary Industries and Fisheries	Fish
Michaelie Pollard	Project Officer (aquatic ecology), Department of Environment and Resource Management	Aquatic ecology
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
Paul Thuesen	Fisheries Biologist, Department of Primary Industries and Fisheries	Fish
Michael Trenerry	Team Leader (Regional Services), Department of Environment and Resource Management	Tropical ecology and conservation
Dr David Wescott	Principal research scientist, CSIRO	Tropical ecology

Selena Inglis, Heidi Millington and Steven Howell provided administrative and technical support for the workshop which was facilitated by Darren Fielder.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened fauna

The panel identified two ‘rare’, three ‘vulnerable’, six ‘endangered’ and two ‘critically endangered’ fauna taxa in riverine wetlands in the Wet Tropics section of the GBR catchment (Table 2). Only threatened taxa listed either on a schedule of the Queensland *Nature Conservation Act 1992* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and considered to be wetland dependent by the panel were included in Table 2. This list of fauna was used as the basis for identifying areas of significance for Criterion 4 Threatened species and ecosystems (4.1.1). A spatial unit with one or more of these species present scored the highest category of 4.

Table 2 Aquatic, semi-aquatic and riparian fauna species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.1.

Scientific name	**Common name**	**Status**	**Comments**
Crocodylus porosus	Estuarine crocodile	V[1]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Hypochrysops apollo apollo	Apollo jewel (Wet Tropics subsp.)	V[1]	
Litoria genimaculata	Tapping green eyed treefrog	R[1]	
Litoria lorica	Little waterfall frog	E[1,] CE[2]	
Litoria nannotis	Waterfall frog	E[1,2]	
Litoria nyakalensis	Mountain mistfrog	E[1,] CE[2]	
Litoria rheocola	Common mistfrog	E[1,2]	
Melanotaenia eachamensis	Lake Eacham rainbowfish	E[2]	
Nyctimystes dayi	Australian lacelid	E[1,2]	
Pristis microdon	Freshwater sawfish	V[2]	Used to be present in the Wet Tropics but rare
Taudactylus acutirostris	Sharp snouted dayfrog	E[1,] EX[2]	
Taudactylus rheophilus	Northern tinkerfrog	E[1,2]	

- *recent records (>1975) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (Ex – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

4 Priority fauna

The panel deliberated on all aquatic-dependent fauna species within the Wet Tropics section of the GBR catchment to identify ‘priority fauna’ (excluding the rare or threatened species listed in Table 2). The panel agreed to a definition of a priority species: namely, a priority species must exhibit one or more of the following significant values.

1. It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
2. It has experienced, or is suspected of experiencing, a serious population decline.
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
4. It is currently a small population and threatened by loss of habitat.
5. It is a significant disjunct population.
6. It is a migratory species (other than birds).
7. A significant proportion of the breeding population (>1 per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar Criterion 6 for waterbirds).

4.1 Priority species

The panel identified 34 priority fauna species (Table 3). These species were included in ‘Criterion 5 Priority species and ecosystems’ (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present. A spatial unit with one or more of these species present scored the highest category 4.

Table 3 Identified priority fauna species, and their significant values

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	Common name	Comments
Bunaka gyrinoides	Greenback gudgeon	Significant disjunct population.
Cairnsichthys rhombosomoides	Cairns rainbowfish	Endemic to the Wet Tropics region, currently a small population subject to threatening processes. All populations are genetically distinct.
Craterocephalus stercusmuscarum	Flyspecked hardyhead	Significant disjunct population.
Elseya stirlingi	Johnstone river snapping turtle	Endemic to the Wet Tropics region.
Euastacus balanensis	Freshwater crayfish	Endemic to the Wet Tropics region.
Euastacus fleckeri	Freshwater crayfish	Has experienced or is suspected of experiencing a significant population decline.
Euastacus robertsii	Freshwater crayfish	Has experienced a significant reduction in its already naturally restricted distribution within the study area/catchment.
Euastacus yigara	Freshwater crayfish	Currently a small population subject to threatening processes.
Glossogobius bellendenensis	Mulgrave goby	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Glossogobius circumspectus	Mangrove flathead goby	Small population, endemic to the Wet Tropics region.

Scientific name	Common name	Comments
Guyu wujalwujalensis	Tropical nightfish	Very rare, restricted endemic species. It is the only tropical species from the family Percichthyidae. Only known population occurs above Bloomfield falls.
Gymnothorax polyuranodon	Freshwater moray	Significant disjunct population.
Hephaestus tulliensis	Khaki grunter	Endemic to the Wet Tropics region.
Kuhlia marginata	Spotted flagtail	Currently a small population subject to threatening processes.
Litoria jungguy	Stony-creek frog	Endemic to the Wet Tropics region.
Litoria myola	Kuranda treefrog	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Litoria xanthomera	Orange thighed treefrog	Endemic to the Wet Tropics region.
Lophogobius bleekeri		Significant disjunct population.
Melanotaenia maccullochi	McCulloch's rainbowfish	Significant disjunct population.
Melanotaenia trifasciata	Banded rainbowfish	Significant disjunct population.
Melanotaenia utcheensis	Utchee rainbowfish	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Mixophyes carbinensis		Endemic to the Wet Tropics region.
Mixophyes coggeri		Endemic to the Wet Tropics region.
Mixophyes schevilli		Endemic to the Wet Tropics region.
Ophisternon bengalense	One-gilled eel	Endemic to the Wet Tropics region.
Ornithorhynchus anatinus	Platypus	Significant disjunct population.
Schismatogobius sp. A	Scaleless goby	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Sicyopterus lagocephalus	Rabbithead cling-goby	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Sicyopterus sp.	Goby sp.	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Stenogobius psilosinionus	Teardrop goby	Significant disjunct population.
Stiphodon alleni	Allen's cling-goby	Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Stiphodon sp. Cf alleni		Endemic to the Wet Tropics region, currently a small population subject to threatening processes.
Synclidopus hogani	Alf's fish	Endemic to the Wet Tropics region, only known from one location in the Daintree.
Tropidechis carinatus		Significant disjunct population.

- *recent records (>1975) and records with precision <2,000 m only*

4.2 Migratory species

In addition to the priority species identified above, the panel nominated migratory species listed under the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA) or the Convention on the Conservation of Migratory Species of Wild Animals (CMS) as priority fauna. Only one migratory species known to be associated with riverine wetlands (Table 4) was included in the AquaBAMM assessment in 'Criterion 5 Priority species and ecosystems' (5.1.3). Any spatial unit containing a record for this species within its boundary will score a four under measure 5.1.3.

Table 4 A list of migratory species

This list was used to generate the values for the AquaBAMM measure (5.1.3). Sourced from the China-Australia Migratory Bird Agreement (CAMBA) at:
http://www.environment.gov.au/biodiversity/migratory/waterbirds/index.html

Scientific name	**Common name**	**Agreements/ conventions**	**Comments**
Acrocephalus orientalis	Oriental reed-warbler	CAMBA[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1 *China-Australia Migratory Birds Agreement (CAMBA)*

5 Species richness

Species richness (i.e. total number of species) was scored for each class (frogs, fish, reptiles, waterbirds) of fauna stratified by 150 m above sea level (ASL) for all study areas in the Wet Tropics (see the Wet Tropics ecology expert panel report for more information on stratification). Stratifying the catchment is important to describe variability in richness. For example, fish richness is expected to be greater in the floodplain river channels than headwater streams which are smaller, with less food availability and unable to support high fish richness.

5.1 Fish richness

There were 93 native fish species identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. A further 11 species were considered to be alien to the region and included some translocated species. Table 5 lists fish species that were used under the diversity and richness criterion (3.1.2).

Table 5 Native fish

This list was used to generate the values for the AquaBAMM measure (3.1.2).

Scientific name	Common name	Status	Comments
Acanthopagrus berda	Pikey bream	LC[1]	
Ambassis agassizii	Agassiz's glassfish	LC[1]	
Ambassis agrammus	Sailfin glassfish	LC[1]	
Ambassis macleayi	Macleay's glassfish	LC[1]	
Ambassis miops	Flag-tailed glassfish	LC[1]	Found across several catchments
Amniataba percoides	Barred grunter	LC[1]	
Anguilla obscura	Pacific shortfin eel	LC[1]	Found virtually everywhere
Anguilla reinhardtii	Longfin eel	LC[1]	
Arrhamphus sclerolepis	Snubnose garfish	LC[1]	
Awaous acritosus	Roman-nose goby	LC[1]	
Bunaka gyrinoides	Greenback gudgeon	LC[1]	
Butis butis	Crimsontip gudgeon	LC[1]	Primarily in the lower reaches of the Wet Tropics rivers, found from estuaries to interfaces
Cairnsichthys rhombosomoides	Cairns rainbowfish	LC[1]	All populations are genetically distinct
Caranx sexfasciatus	Big eye trevally	LC[1]	
Chanos chanos	Milkfish	LC[1]	
Craterocephalus stercusmuscarum	Flyspecked hardyhead	LC[1]	
Eleotris acanthopoma	Spine-cheek gudgeon	LC[1]	Rare species not commonly encountered in the region
Eleotris fusca	Brown spine-cheek gudgeon	LC[1]	Appears in main channels
Eleotris melanosoma	Black spine-cheek gudgeon	LC[1]	Appears in main channels
Eleotris sp.	Gudgeon sp.	LC[1]	
Gerres filamentosus	Threadfin silverbiddy	LC[1]	
Gerres sp.	Silver biddy sp.	LC[1]	
Giurus margaritacea	Snakehead gudgeon	LC[1]	
Glossamia aprion	Mouth almighty	LC[1]	
Glossogobius bellendenensis	Mulgrave goby	LC[1]	Formerly *Glossogobius sp. D*

Scientific name	Common name	Status	Comments
Glossogobius bicirrhosus	Bearded flathead Goby	LC[1]	
Glossogobius circumspectus	Mangrove flathead goby	LC[1]	
Glossogobius giurus	Tank goby	LC[1]	Associated with estuarine areas
Glossogobius sp.	Goby sp.	LC[1]	
Glossogobius sp. A cf. celebius	False Celebes goby	LC[1]	
Guyu wujalwujalensis	Tropical nightfish	LC[1]	Very rare, restricted endemic species. It is the only tropical species from the family Percichthyidae. The only population occurs above Bloomfield falls.
Gymnothorax polyuranodon	Freshwater moray	LC[1]	Records from Mulgrave River
Hephaestus fuliginosus	Sooty grunter	LC[1]	Translocated and genetics have been mixed
Hephaestus tulliensis	Khaki grunter	LC[1]	Translocated to the tablelands
Hippichthys heptagonus	Madura pipefish	LC[1]	
Hypseleotris compressa	Empire gudgeon	LC[1]	
Hypseleotris sp. A	Midgley's carp gudgeon	LC[1]	
Kuhlia marginata	Spotted flagtail	LC[1]	
Kuhlia rupestris	Jungle perch	LC[1]	
Lates calcarifer	Barramundi	LC[1]	
Leiognathus equulus	Common ponyfish	LC[1]	
Leiopotherapon unicolor	Spangled perch	LC[1]	Translocated native
Liza subviridis		LC[1]	
Lophogobius bleekeri		LC[1]	Found in Mowbray River and Smithfield areas
Lutjanus argentimaculatus	Mangrove jack	LC[1]	
Megalops cyprinoides	Oxeye herring/tarpon	LC[1]	
Melanotaenia eachamensis	Lake Eacham rainbowfish	E[2]	Known to occur in the Daintree
Melanotaenia maccullochi	McCulloch's rainbowfish	LC[1]	Disappearing out of the wetlands in the Tully catchment but still common in the Cardwell region
Melanotaenia sp.	Rainbowfish sp.	LC[1]	
Melanotaenia splendida	Eastern rainbowfish	LC[1]	
Melanotaenia trifasciata	Banded rainbowfish	LC[1]	Found in Cooper creek and Gap Creek
Melanotaenia utcheensis	Utchee rainbowfish	LC[1]	
Mesopristes argenteus	Silver grunter	LC[1]	
Microphis brachyurus	Short-tailed pipefish	LC[1]	Found in the lower reaches of most rivers in the study area
Mogurnda adspersa	Southern purple spotted gudgeon	LC[1]	Found in the upper reaches and sometimes in channels and lagoons
Mogurnda mogurnda	Northern purple spotted gudgeon	LC[1]	Found in the upper reaches and sometimes in channels and lagoons
Mogurnda sp.	Gudgeon sp.	LC[1]	
Monodactylus argenteus	Diamondfish	LC[1]	
Monopterus albus	Belut	LC[1]	Rare
Mugil cephalus	Sea mullet	LC[1]	
Mugilogobius notospilus	Pacific mangrove goby	LC[1]	

Scientific name	Common name	Status	Comments
Nematalosa erebi	Bony bream	LC[1]	
Neopomacentrus taeniurus	Freshwater demoiselle	LC[1]	Known to occur in saline and freshwater rivers, however it is mainly found in saline waters.
Neosilurus ater	Black catfish	LC[1]	
Neosilurus hyrtlii	Hyrtl's catfish	LC[1]	
Neosilurus sp.	Eel-tailed catfish sp.	LC[1]	
Notesthes robusta	Bullrout	LC[1]	
Ophisternon bengalense	One-gilled eel	LC[1]	There was serious doubt over whether this species is present in study area as it is difficult to distinguish from *Ophisternon gutturale*. This could be a new species endemic to the Wet Tropics but it is currently considered to be data deficient.
Ophisternon gutturale	Swamp eel	LC[1]	
Oxyeleotris aruensis	Aru gudgeon	LC[1]	
Oxyeleotris lineolata	Sleepy cod	LC[1]	
Oxyeleotris nullipora	Poreless gudgeon	LC[1]	
Oxyeleotris selheimi	Black banded gudgeon	LC[1]	Debate over whether or not it is an introduced native
Porochilus rendahli	Rendahl's catfish	LC[1]	
Pristis microdon	Freshwater sawfish	V[2]	Used to be present in the Wet Tropics but rare
Pseudomugil signifer	Pacific blue eye	LC[1]	
Redigobius bikolanus	Speckled goby	LC[1]	
Redigobius chrysosoma	Spotfin goby	LC[1]	Caught in main channels
Scatophagus argus	Spotted scat	LC[1]	
Schismatogobius sp. A	Scaleless goby	LC[1]	
Selenotoca multifasciata	Striped scat	LC[1]	
Sicyopterus lagocephalus	Rabbithead cling-goby	LC[1]	
Sicyopterus sp.	Goby sp.	LC[1]	
Stenogobius psilosinionus	Teardrop Goby	LC[1]	Mostly estuarine but is also found in Tully River (possibly vagrant)
Stiphodon alleni	Allen's cling-goby	LC[1]	
Stiphodon sp. Cf alleni		LC[1]	Found in Cooper Creek and Noah Creek
Strongylura krefftii	Freshwater longtom	LC[1]	
Synclidopus hogani	Alf's fish	LC[1]	Found in the Daintree
Tandanus sp.		LC[1]	
Tandanus tandanus	Freshwater catfish	LC[1]	Translocated although there is a local species (new species based on genetics)
Toxotes chatareus	Sevenspot archerfish	LC[1]	
Toxotes jaculatrix	Banded archerfish	LC[1]	
Zenarchopterus buffonis	Northern river garfish	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.2 Reptile richness

There were 11 native reptile species identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. Table 6 lists the wetlands-dependant reptiles that were considered in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.3).

Table 6 Freshwater reptiles

This list was used to generate the values for the AquaBAMM measure (3.1.3).

Scientific Name	Common Name	Status	Comments
Crocodylus johnstoni	Australian freshwater crocodile	LC[1]	
Crocodylus porosus	Estuarine crocodile	V[1]	
Elseya dentata	Northern snapping turtle	LC[1]	
Elseya stirlingi	Johnstone river snapping turtle	LC[1]	
Emydura macquarii krefftii	Krefft's river turtle	LC[1]	
Enhydris polylepis	Macleay's water snake	LC[1]	
Eulamprus quoyii	Eastern water skink	LC[1]	
Liasis mackloti	Water python	LC[1]	
Physignathus lesueurii	Eastern water dragon	LC[1]	
Tropidechis carinatus		LC[1]	
Wollumbinia latisternum	Saw-shelled turtle	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.3 Waterbird richness

There were 28 native waterbird species identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. Table 7 lists the wetlands-dependant reptiles that were considered in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.4). These species were expert panel derived using WildNet and Queensland Museum records. Only those species that were considered to inhabit freshwater wetland environments for part or all of their natural life functions were included (Table 7).

Table 7 Native waterbirds

This list was used to generate the values of the AquaBAMM measure (3.1.4).

Scientific name	Common name	Status	Comments
Acrocephalus australis	Australian reed-warbler	LC[1]	
Acrocephalus orientalis	Oriental reed-warbler	LC[1]	
Amaurornis cinerea	White-browed crake	LC[1]	
Amaurornis moluccana	Pale-vented bush-hen	LC[1]	
Anas castanea	Chestnut teal	LC[1]	
Anas gracilis	Grey teal	LC[1]	
Anhinga melanogaster	Australasian darter	LC[1]	
Ardea intermedia	Intermediate egret	LC[1]	
Ardea modesta	Eastern great egret	LC[1]	
Ardea pacifica	White-necked heron	LC[1]	
Ardea sumatrana	Great-billed heron	LC[1]	
Aythya australis	Hardhead	LC[1]	

Scientific name	Common name	Status	Comments
Botaurus poiciloptilus	Australasian bittern	LC[1]	
Ceyx azureus	Azure kingfisher	LC[1]	
Ceyx pusilla	Little kingfisher	LC[1]	
Egretta garzetta	Little egret	LC[1]	
Egretta novaehollandiae	White-faced heron	LC[1]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Gallinula tenebrosa	Dusky moorhen	LC[1]	
Irediparra gallinacea	Comb-crested jacana	LC[1]	
Ixobrychus flavicollis	Black bittern	LC[1]	
Microcarbo melanoleucos	Little pied cormorant	LC[1]	
Nycticorax caledonicus	Nankeen night-heron	LC[1]	
Pelecanus conspicillatus	Australian pelican	LC[1]	
Phalacrocorax carbo	Great cormorant	LC[1]	
Phalacrocorax sulcirostris	Little black cormorant	LC[1]	
Phalacrocorax varius	Pied cormorant	LC[1]	
Porphyrio porphyrio	Purple swamphen	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.4 Frog richness

There were 17 species of amphibians identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. Table 8 lists frog species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.1 and 3.1.6).

Table 8 Native frog species

This list was used to generate the values of the AquaBAMM measures (3.1.1 and 3.1.6).

Scientific name	Common name	Status	Comments
Litoria genimaculata	Tapping green eyed treefrog	R[1]	
Litoria jungguy	Stony-creek frog	LC[1]	
Litoria lorica	Little waterfall frog	E[1,] CE[2]	
Litoria myola	Kuranda treefrog	LC[1]	
Litoria nannotis	Waterfall frog	E[1,2]	
Litoria nyakalensis	Mountain mistfrog	E[1,] CE[2]	
Litoria rheocola	Common mistfrog	E[1,2]	
Litoria sp. '*wilcoxii/ jungguy'*		LC[1]	
Litoria wilcoxii	Wilcox's stony-creek frog	LC[1]	
Litoria xanthomera	Orange thighed treefrog	LC[1]	
Mixophyes carbinensis		LC[1]	
Mixophyes coggeri		LC[1]	
Mixophyes schevilli		LC[1]	

Scientific name	Common name	Status	Comments
Mixophyes schevilli (spp. complex)		LC[1]	
Nyctimystes dayi	Australian lacelid	E[1,2]	
Taudactylus acutirostris	Sharp snouted dayfrog	E[1,] EX[2]	
Taudactylus rheophilus	Northern tinkerfrog	E[1,2]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (Ex – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

5.5 Mammal richness

There were three species of mammal identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. Table 9 lists mammal species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.7).

Table 9 Native mammals

This list was used to generate the values of the AquaBAMM measure (3.1.7)

Scientific name	Common name	Status	Comments
Ornithorhynchus anatinus	Platypus	LC[1]	
Myotis macropus	Large-footed myotis	LC[1]	
Hydromys chrysogaster	Water rat	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.6 Macroinvertebrate richness

There were five species of macroinvertebrates, identified in the riverine wetlands of the Wet Tropics section of the GBR catchment. Table 8 lists macroinvertebrate species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.2.1).

Table 10 Native macroinvertebrates

This list was used to generate the values of the AquaBAMM measure (3.2.1)

Scientific name	Common name	Status	Comments
Euastacus balanensis	Freshwater crayfish	LC[1]	
Euastacus fleckeri	Freshwater crayfish	LC[1]	
Euastacus robertsii	Freshwater crayfish	LC[1]	
Euastacus yigara	Freshwater crayfish	LC[1]	
Hypochrysops apollo apollo	Apollo jewel (Wet Tropics subsp.)	V[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

6 Exotic fauna

Eleven fish, one crustacean and seven vertebrate species were nominated by the panel (Table 11) as exotic fauna in riverine wetlands. The presence of aquatic exotic fauna species was recorded under 'Criterion 1 Naturalness (aquatic)' (1.1.1).

Table 11 Alien fauna

This list was used to generate the values of the AquaBAMM measure (1.1.1)

Scientific name	**Common name**	**Comments**
Amphilophus citrinellus	Midas cichlid, red devil	Established populations in north Queensland (Webb 2008).
Bos sp.	Cattle	
Bos taurus		
Cherax quadricarinatus	Redclaw crayfish	Translocated native found in the Barron, Herbert and upper Johnstone rivers, its impact fluctuates but is generally low.
Felis catus	Cat	
Gambusia holbrooki	Mosquitofish	Becoming less common in the region as it is now only found in pockets around Cairns, but big patches still persist on the Tablelands. It is also found in the Johnstone River catchment.
Haplochromis burtoni	Burton's haplochromis	Established populations in north Queensland (Webb 2008).
Lonchura punctulata	Nutmeg mannikin	Species is a significant problem as it excludes other finches from nesting sites and out competes native species.
Oreochromis mossambicus	Mozambique mouthbrooder	Widely distributed including the Barron River catchment and northern beaches area, Saltwater Creek, Lily Creek, creeks draining into upper Herbert River, Wild River and Wright Creek.
Poecilia latipinna	Sailfin molly	Used to be in Jumrum Creek, believed to be a threat but not widely established. Lesser threat than other livebearers in this group.
Poecilia reticulata	Guppy	Found virtually everywhere.
Rhinella marina	Cane toad	Roads and tracks in urban and dry areas Note: new taxonomic name for cane toad.
Salmo trutta	Brown trout	Not certain if they are still in the region. Potentially still in the Mossman River catchment. Species has a low impact.
Sturnus tristis	Indian miner	Nests around streamlines in cities and out of towns it uses any nesting hollow available. Has only minor impact by competing with native species. Tends to favour agricultural land but may invade wetland areas in the future, also found in Cairns central swamp.
Sus scrofa	Pig	
Tilapia mariae	Spotted tilapia	Found in the Johnstone, Mulgrave/Russell and Barron River catchments as well as at the northern beaches and Cairns inlet.
Trichogaster trichopterus	Three-spot gourami	Established populations in north Queensland (Webb 2008).
Xiphophorus helleri	Swordtail	Found virtually everywhere.
Xiphophorus maculatus	Platy	Species has a patchy distribution throughout the Mulgrave River but large numbers can be found in the Tully River catchment and it is also present at Kuranda.

- *recent records (>1975) and records with precision <2,000 m only*

7 Special features

The panel identified several riverine special features in the Wet Tropics section of the GBR catchment (Table 12). These were identified for their aquatic fauna values. Where special features nominated by the aquatic fauna expert panel were also considered to have additional values (e.g. flora, ecology) by the aquatic flora or wetland ecology expert panels, the special area were implemented as a wetland ecology special feature.

Each spatial unit that intersected with a particular ecosystem or feature in Table 12 was given a score equal to the conservation rating.

Table 12 Identified priority ecosystems and special features, and their values

Decisions listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for Criterion 6 Special features. All implemented special features were given a conservation rating of between 1 and 4 assigned by the panel.

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Lamb Range riverine wetlands	The majority of riverine wetland systems in this area have high diversity and abundance of rare and threatened frog taxa and associated habitats. Some streams along the dryer western edges of this range may also provide refugial habitat for rare and threatened frog species.	Barron	bn_r_fa _01	6.3.1	4
Daintree lowland creeks	The lowland creeks in the Daintree catchment contain significant fauna values with many rare and threatened species known to reside in this area. The streams contain excellent low altitude, refugial habitat for rare and threatened frogs and boast some of the best fish habitat in the Wet Tropics. The area has high fish diversity with many species being endemic to this region. The area also supports other endemic flora species in the areas up to 1,000 m above sea level.	Daintree	da_r_fa _01	6.3.1	4
Northern bank of Daintree/ Forest creek road area	The northern bank of the Daintree River contains good biodiversity and good fish habitat including an isolated population of McCullough's rainbow fish (*Melanotaenia maccullochi*) which is morphologically distinctive, endangered species of frogs, good cassowary (*Casuarius casuarius johnsonii*) habitat and is home for many other rare and threatened species.	Daintree	da_r_fa _02	6.3.1	4
Daintree river north of Daintree Village (near Creb Track crossing)	The Daintree River north of Daintree Village is a highly biodiverse area that experiences a tidal influence. The area provides good crocodile habitat and good spawning ground/ nursery area for various fish species.	Daintree	da_r_fa _03	6.3.1	4
Polly Creek	Polly Creek provides critical habitat for many species including the Cairns rainbowfish (*Cairnsichthys rhombosomoides*), gudgeons and goby species, cassowaries *Casuarius casuarius johnsonii)*, the lacelid frog (*Nyctimystes dayi*) and the common mistfrog (*Litoria rheocola*). Polly Creek is also the most intact creek in the region.	Johnstone	jo_r_fa_ 01	6.3.1	4
Utchee Creek	Utchee Creek is a type locality for *Melanotaenia utcheensis. M. utcheensis* which is endemic to the upper Johnstone River catchment.	Johnstone	jo_r_fa_ 02	6.3.1	3

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Mt Myrtle/Walter Hill Range	The Mt Myrtle and Walter Hill Ranges are lowland areas widely believed to be one of two different kinds of refugial areas for a major taxonomic assemblage of rare and threatened frog species in the Wet Tropics. The area provides an important corridor function allowing for the area to support a high abundance of rare and threatened frogs.	Johnstone	jo_r_fa_03	6.3.1 7.1.1	4
Upper Mossman basin	The Upper Mossman basin area is a biodiverse area that provides habitat for a range of cool temperate species including an endemic spiny crayfish left over from the last ice age and is only found above altitudes of 650 m. The area is habitat for unique faunal species and provides connectivity with the Carbine Tablelands.	Mossman	mo_r_fa_01	6.3.1 7.1.1	4
Malbon Thompson range	The creeks flowing off the eastern side of the Malbon Thompson Range provide habitat for two species of goby, endemic to the Wet Tropics (*Stiphodon allen* and *Stiphodon sp. nov.)* and the rarely encountered spotted flag-tail (*Kuhlia marginata*). The creeks flowing off the western side of the range provide habitat for the endemic Cairns rainbowfish (*Cairnsichthys rhombosomoides*) and disjunct populations of McCulloch's rainbowfish (*Melanotaenia maccullochi*) and spotted blue-eye (*Pseudomugil gertrudae*).	Mulgrave Russell	mr_r_fa_01	6.3.1	4
Harvey Creek	The Harvey Creek area boasts unique geomorphology and constant high stream flows. The catchment is reasonably steep so streams are more turbulent than most others in the region creating sandy benthic sediments. The area contains many large pools and riffle zones allowing for high fish diversity and the movement of marine vagrants into the lower reaches. The stream has high frog diversity and contains disjunct fish populations including wet tropic endemics such as Mulgrave river goby (*Glossogobius sp. D*). <u>Note:</u> This decision was not implemented as its extent is covered under a wetland ecology decision (mr_r_ec_06).	Mulgrave Russell	mr_r_fa_02	6.1.1 6.2.1 6.3.1	4
Fig Tree Creek, Fisheries Creek and Campbell Creek	The creeks in this area provide important habitat for many endemic, disjunct and threatened species. The area contains many disjunct fish species including genetically distinct populations of the Cairns rainbowfish (*Cairnsichthys rhombosomoides*). The riparian zone provides a critical wildlife corridor for faunal species such as cassowaries (*Casuarius casuarius johnsonii*) and threatened frog species (present on remnant areas higher than 80 m above sea level). The area has been highly impacted by surrounding land uses. <u>Note:</u> This decision was not implemented as its extent is covered under a wetland ecology decision (mr_r_ec_06).	Mulgrave Russell	mr_r_fa_03	6.3.1 7.1.1	4

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Lamb Range riverine wetlands	A large majority of riverine wetland systems in this area have a high diversity and abundance of rare and threatened frog taxa and habitat. Some streams along the dryer western edges of this range may also provide refugial habitat for rare and threatened frog species from causal factors of decline.	Mulgrave Russell	mr_r_fa_04	6.3.1	4
Mt Myrtle/Walter Hill Range	The Mt Myrtle and Walter Hill Ranges are lowland areas widely believed to be one of two different kinds of refugial areas for a major taxonomic assemblage of rare and threatened frog species in the Wet Tropics. The area provides an important corridor function allowing for the area to support a high abundance of rare and threatened frogs.	Tully	tu_r_fa_01	6.3.1 7.1.1	4

Attachments

Attachment A – GBR catchment study area

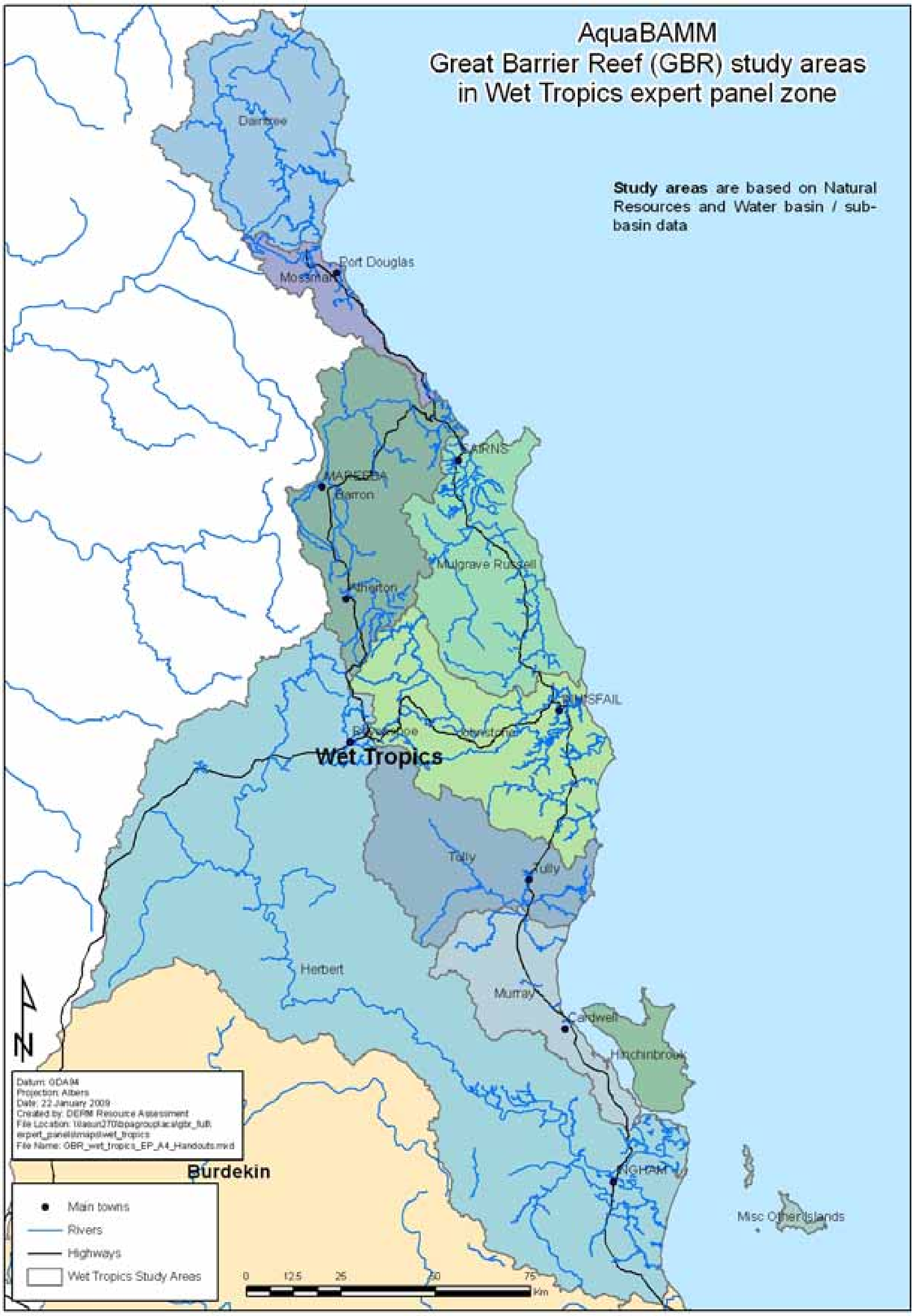

Figure 2 GBR catchment study area

Attachment B – Terms of reference (aquatic fauna expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic fauna

The aquatic fauna expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic fauna values.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on riverine and non-riverine threatened fauna species, habitat and localities
- provide advice on riverine and non-riverine priority fauna species, habitat and localities
- identify priority ecosystems or areas important for significant faunal communities or species
- provide advice on riverine and non-riverine ecosystem exotic fauna species localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a “starter set” for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 13 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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Attachment C GBR catchments ACA – Wetland ecology expert panel report (Wet Tropics region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Wetland ecology
Expert panel report

Wet Tropics region

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Tables

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
CS	Connectivity score
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FPR	Fish passage rating
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
ICS	Intrinsic connectivity score
NC Act	*Nature Conservation Act 1992*
RAMSAR	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the wetland ecology expert panel for the Wet Tropics region held in Cairns on Thursday 4 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the wetland ecology panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments are based on the Department of Environment and Resource Management basin/sub-basin data. The Wet Tropics study area largely corresponds to the Wet Tropics Natural Resource Management (NRM) region and contains the majority of the Wet Tropics World Heritage Area. In total the study area covers approximately 22,100 km^2 and lies across the majority of the Wet Tropics bioregion and a part of the Einasleigh Uplands bioregion to the west in the Upper Herbert and Upper Barron basins. It includes the nine basins shown in Figure 1, which comprise the coastal basins of the Daintree, Mossman, Barron, Mulgrave/Russell, Johnstone, Tully, Murray, and Herbert rivers and Hinchinbrook Island. Each of these is treated as an individual study area for the purpose of the AquaBAMM analyses.

As the name suggests the Wet Tropics is characterised by high rainfall largely due to the conspicuous topography. The major mountain masses exceed elevations of 1,000 m and all are granitic, although some have flanking acid volcanic and metamorphic rocks. Extensive

areas of basalt occur, particularly through the Atherton Tablelands, an extensive plateau between 600 m and 900 m that covers a large part of the upper Barron River catchment. The region contains a number of high peaks including the two highest mountains in Queensland, Mount Bartle Frere (1,622 m) and Mount Belenden Ker (1,593 m). The mountain ranges generally have steep precipitous mountain sides with deeply incised valleys. They run north to south, rising sharply near the coast and capture the moisture-laden air from the warm waters of the Coral Sea, resulting in generally high rainfall across the region. The most extensive lowlands are in the south of the study area, associated with the floodplains of the Tully and Herbert rivers, with extensive coastal freshwater and estuarine wetlands.

Mean annual rainfall for the Wet Tropics bioregion is above 1,500 mm, three times the continental average of below 500 mm, with several areas within the study area receiving much higher rainfall. Rainfall patterns are strongly seasonal with a distinct wet season occurring in the warmer months between December and April and although generally wet can vary substantially from year to year. Interannual variability is mainly driven by major rainfall events which commonly occur, associated with cyclones and low pressure depressions. These can flood large areas of the region resulting in huge volumes of water being discharged to the inshore waters of the Great Barrier Reef lagoon. For example, in the Herbert River total mean annual discharge is approximately 3.7 million megalitres and in the Johnstone and South Johnstone it is 3.23 million megalitres. The amount of rain also varies throughout the region due to topography and there is a distinct gradient to drier conditions from the western side of the ranges towards where the study area crosses into the Einasleigh Uplands bioregion. Rainfall is not recorded from the peak of Mount Bartle Frere, but at the summit of the adjacent Mount Belenden Ker records show an annual average rainfall of 8,312 mm, making it the wettest meteorological station in Australia. It also holds the record for the highest rainfall in a calendar year of 12,461 mm in 2000. On the lowlands the Daintree area and the area from Cairns south to Tully receives the highest rainfall with Babinda typically receiving rainfall in excess of 4,000 mm annually. In contrast, the western side of the study area, in the Upper Herbert and Upper Barron basins, on average, receives less than 800 mm annually.

The study area also has generally warm and uniform temperatures throughout the year. Typical daytime minimum and maximum temperatures range on the coast from 22ºC to 31ºC in summer and from 15ºC to 22ºC in winter. The tablelands and uplands are generally much cooler. On the western side of the study area temperatures vary slightly more and tend towards being hotter in summer.

As a consequence of the high rainfall, rainforest cover is extensive across the ranges and coastal lowlands and streams and wetlands are numerous and important features in the landscape. The consistent runoff results in most streams and many wetlands being perennial and they have been so for millions of years, in contrast to most other parts of Australia, including most of the tropical region. As a result the Wet Tropics has sustained a unique and diverse freshwater fauna and flora with many endemic species present.

The high degree of variation in rainfall, topography, combined with a complex evolutionary history has resulted in a diverse spectrum of forest types and plant and animal communities. The rainforests of the region which dominates the narrow, high rainfall coastal belt have been classified into 16 major structural types and 30 broad community types (Tracey and Webb, 1975; Tracey, 1982). In addition the rainforests are fringed and dissected by a range of sclerophyll forests and woodlands as well as wetlands including estuarine mangrove communities. Tall woodlands, open *Eucalyptus* forests and grasslands extend into the drier western parts of the study area in to the Einasleigh Upland bioregion.

Wetland types include an enormous number of low order, perennial or near perennial, streams descending the steep ranges. These join in to several major river systems that define the basins within the study area. The coastal lowland floodplains are generally narrow, with the most extensive lowlands occurring in the south of the study area associated with the floodplains of the Tully/Murray and the Herbert rivers. These areas contain complex systems of numerous interconnecting wetlands and extensive coastal estuarine areas. The Herbert floodplain receives the lowest rainfall of the coastal lowlands in the study area but can have the highest discharge from runoff in the upper catchment. Its floodplain is dominated by woodlands with extensive areas of grass and sedge swamps laying adjacent to dune systems and connected estuaries. This area also contains the Herbert River delta which is formed at the southern end of the Hinchinbrook Channel, with its extensive stands of mangrove forest. In the Tully/Murray floodplain (and areas to the north) rainfall is higher and the coastal vegetation is dominated by forest, rainforest and extensive wetland areas. Unfortunately many of the coastal wetlands throughout the study area have been lost or are now largely modified through drainage and reclamation works. Many of the remaining wetlands are also heavily impacted by clearing of riparian and fringing vegetation, infestation by weeds and by declines in water quality through runoff from adjacent agriculture. Fractured basalt and other fractured rock aquifers occur throughout the study area supporting unique fauna and flora. These aquifer systems are particularly significant in some of the areas within the drier parts of the study area in the Einasleigh Upland. Crater lakes are also a unique feature of the plateaus of the study area.

Approximately 35 per cent of the study area is covered by the Wet Tropics World Heritage Area, taking in most of the ranges and large areas of lowland rainforest. The World Heritage Area consists of extensive areas of National Park and other protected estate as well as areas of private land.   The major commercial land uses in the study area include extensive areas of lowlands, and some uplands, used for sugar cane production. Extensive areas in the lowlands are also used for banana production with a diverse range of other horticultural crops occurring throughout. On the fertile Atherton Tablelands dairy is a major industry along with a variety of horticulture and crops. Cattle grazing is a minor land use in the coastal lowlands but extensive cattle grazing is the major land use in the western part of the study area. The area was once heavily dependent on native forestry. However, this has declined with the protection of much of the native rainforest areas in the Wet Tropics World Heritage Area and in recent times forestry has depended on broad hectare softwood plantations on the Atherton Tablelands and the Cardwell area. Increasingly, other forestry plantations are being established on what was traditionally land used for sugar cane production.

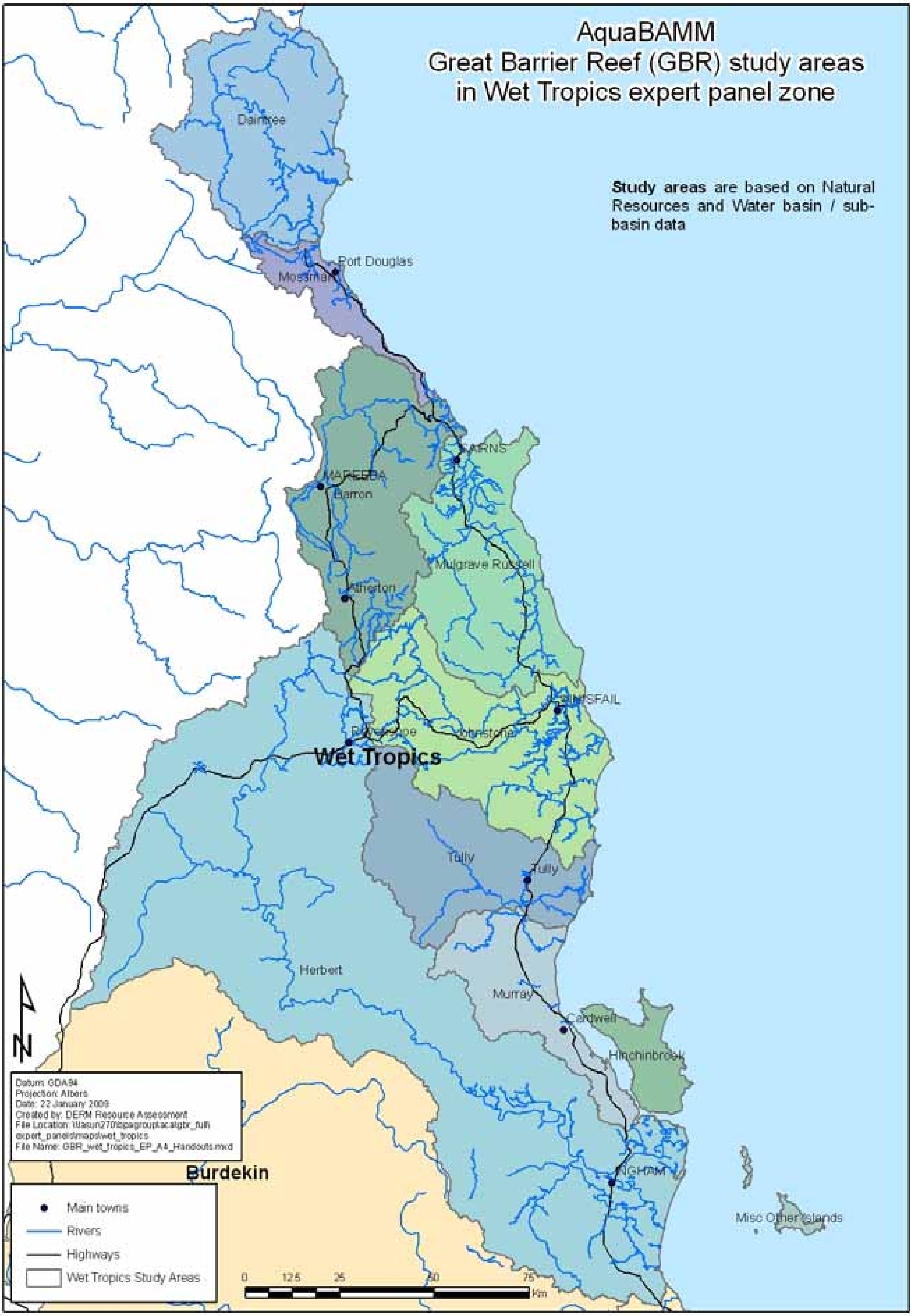

Figure 1 Wet Tropics section of the GBR catchment (incorporating nine individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of the persons listed in Table 1 who are familiar with non-riverine and riverine wetland ecology, including fish, macroinvertebrates, water quality, hydrology, geomorphology and vegetation, in the Wet Tropics section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Donna Audas	Project Manager – GBR Wetlands Coastal ecosystems & Water Quality, Great Barrier Reef Marine Park Authority	Coastal ecosystems, GIS and wetlands
Ant Backer	Senior Planning Officer, Department of Environment and Resource Management	Biodiversity planning and terrestrial ecology
Damien Burrows	Aquatic ecologist, Australian Centre for Tropical Freshwater Research, James Cook University	Aquatic ecology and water quality
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning – Aquatic ecology and water quality
Nick Cuff	Senior Botanist, Queensland Herbarium, Department of Environment and Resource Management	Botany and regional ecosystem assessment
Alf Hogan	Fisheries Scientist, Alf Hogan and Associates Fish Ecologists	Fish ecologist
Jeanette Kemp	Principal Botanist, Department of Environment and Resource Management	Native and exotic flora
Dominica Loong	Aquatic Ecologist, Australian Centre for Tropical Freshwater Research, James Cook University	Aquatic ecology and water quality
George Lukacs	Director, Australian Centre for Tropical Freshwater Research, James Cook University	Wetland ecology
Keith McDonald	Principal Technical Officer (threatened species), Department of Environment and Resource Management	Tropical ecology and conservation
Steve McDermott	Programme Leader – Wetlands, Waterways and Coastal Ecosystem, Terrain Natural Resource Management	Natural resource management and conservation planning
Tim Perry	Principal Ecologist, NRA Environmental Consultants	Native and exotic vegetation
Damon Sydes	Project Officer, Terrain Natural Resource Management	Natural resource management and conservation planning
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
Michael Trenerry	Team Leader (Regional Services), Department of Environment and Resource Management	Tropical ecology and conservation
Bruce Wannan	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Tropical flora and conservation planning

Selena Inglis and Heidi Millington provided administrative and technical support for the workshop, which was facilitated by Steven Howell.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Special features

The panel identified several riverine special features in the Wet Tropics section of the GBR catchment (Table 2). These were identified for their ecological values. Some special features nominated by either the aquatic flora and/or the aquatic fauna expert panels considered to have additional values (e.g. geomorphological or hydrological) were implemented as wetland ecology special features.

Each spatial unit that intersected with a particular ecosystem or feature in Table 2 was given a score equal to the conservation rating.

Table 2 Identified priority ecosystems and special features.

Decisions listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for Criterion 6 Special features. All implemented special features were given a conservation rating of between 1 and 4 assigned by the panel.

Special feature	**Values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Myola/ Kuranda contact zone	This area is the contact point between the southern and northern Wet Tropics bioregion where the rainforest and associated taxa have come back into contact following contraction events during the Pleistocene. It is a very important area for speciation and molecular evolution. The area contains endemic threatened fauna and flora.	Barron	bn_r_ec_01	6.3.1 7.1.1	4
Davies Creek, Closhey Creek, Emerald Creek & Emu Creek	The creeks in this area contain significant riparian values in a unique transition zone between dry and wet landscapes. The area has similar values to Flaggy Creek (including little modification) that is influenced by tannin inputs and significant refugial habitat for macrophyte species. The area encompasses significant habitat for endangered stream dwelling vertebrate species.	Barron	bn_r_ec_02	6.3.1	4

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Roaring Meg Falls to Bloomfield Falls	The Roaring Meg Falls is intact with very high biodiversity values. It encompasses significant stands of Trailing sundew (*Drosera prolifera*) found from Roaring Meg Creek, Mt Pieter Botte and Noah Creek through to Thornton Peak. Roaring Meg and Alexandra creeks have many significant rare and threatened species, some of which are endemic to those catchments (including *Hollandaea riparia* and *Diospyros* sp. (Baird LA). The upper reaches of Alexandra Creek have hanging *Melaleuca* swamps which contain Broad leafed banksia (*Banksia robur*). These communities are poorly known and are in need of surveying. In addition, the area contains species of fish which are unique from an evolutionary perspective, including the only tropic member of the percichthyidae (perch) family as well as a high diversity of endangered frogs and significant cultural values. Note: This decision was also included in the non-riverine ACA assessment (decision number da_nr_ec_02). See the Wet Tropics non-riverine report for more details.	Daintree	da_r_ec_01	6.2.1 6.3.1	4
Brown Creek wetlands south of Alexandra Range	The wetlands south of Alexandra Range identified in this decision are an interplay of tidal and freshwater wetlands containing a large complex of mangroves and freshwater wetland species. The site contains many threatened communities and species and provides an important function as a fish nursery area. Note: This decision was also included in the non-riverine ACA assessment (decision number da_nr_ec_04). See the Wet Tropics non-riverine report for more details.	Daintree	da_r_ec_02	6.3.1	4
Springs in upper Herbert tablelands at basalt rhyolite interface	This area, located between Herbert and Ravenshoe, represents important refugia in an otherwise dry area and maintains running groundwater from wet tropics to drier areas. The area supports threatened species and contains significant populations of *Aponogeton belosa*. Note: This was not implemented in this assessment as springs do not make up part of the wetlands base layer being used for the assessment.	Herbert	he_r_ec_01	6.3.1 6.4.1	

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Gunnawarra wetland aggregation	The Gunnawarra wetland aggregation boasts unique geomorphology including basalt intrusions. The area is home to stands of *Eucalyptus Corymbia* on plains and contains a high abundance of freshwater crocodiles (*Crocodylus johnstoni*). <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number he_nr_ec_02). See the Wet Tropics non-riverine report for more details. This decision includes measure values from he_r_ec_04 as these two decisions have been combined.	Herbert	he_r_ec_02	6.1.1 6.3.1 6.3.3	4
Basalt swamps, Undara area	The Basalt swamps, Undara area contains good connectivity, increased representativeness, high diversity and good integrity. It is important as wildlife refugia and is a centre of endemism, containing disjunct populations and high species richness many of which are at the limit of their geographical distribution. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number he_nr_ec_19). See the Wet Tropics non-riverine report for more details. This decision was combined with he_r_ec_02.	Herbert	he_r_ec_04	6.1.1 6.3.1 6.3.3	4
Herbert River Gorge and Blenco Falls	The Herbert River Gorge, Blenco Falls and Yamani Falls area are known to contain populations of the Waterfall frog (*Litoria nannotis*) and crocodiles. The Gorge is geomorophologically unique in the Wet Tropics. Other endangered frog species are also found at Blencoe Falls which is part of the Kirrama National Park.	Herbert	he_r_ec_05	6.3.1	4

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Hinchinbrook Island	Hinchinbrook Island is nationally and internationally recognised for its values. The island is covered by the Great Barrier Reef World Heritage Area, Hinchinbrook Island National Park and a Wild Rivers area. Additionally, the Missionary Bay Wetlands on the island are listed on the Directory of Important Wetlands. Hinchinbrook Island contains lush rainforests, rugged, misty and heath-covered mountains, sweeping sandy beaches, rocky headlands, paperbark and palm wetlands, mangrove-fringed shores and extensive open forests and woodlands. The mangrove forests on the island are some of the richest and most varied in Australia and are an important breeding ground for many marine animals. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number hi_nr_fl_01). See the Wet Tropics non-riverine report for more details.	Hinchinbrook	hi_r_ec_01	6.2.1 6.3.1 6.3.3	4
Streams entering from south Johnstone	The streams in this area are known to contain rare and threatened frogs as well as a good population of cassowaries (*Casuarius casuarius johnsonii)*. The area has similar values to the streams flowing into the Tully Gorge.	Johnstone	jo_r_ec_01	6.3.1	4
Mossman Gorge	Mossman Gorge represents floral refugia in a lowland area. The gorge contains lots of local endemics and is adjacent to one of the highest mountains in the area. The gorge has similar fauna values to the Carbine Tableland providing good Jungle perch (*Kuhlia rupestris*) habitat (which is on the restricted distribution list) and a large population of the Rough scaled snake (*Tropidechis carinatus*) above 100 m altitude. The gorge contains significant threatened species values generally.	Mossman	mo_r_ec_01	6.3.1	4
Mulgrave/ Russell headwaters	This area contains some of the most intact sections of streams in the central Wet Tropics that have been shown to retain a significantly high fish biodiversity, as well as high abundances of invertebrates and macrophytes species. This area has a better riparian zone than the more typically impacted stream systems. The area also has extremely high threatened vertebrate species richness.	Mulgrave Russell	mr_r_ec_01	6.3.1	4

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Eubenangee Swamp National Park	Eubenangee Swamp considered as being some of the best examples of riverine and non-riverine freshwater wetlands in the wet tropics region. The area contains significant floristic values found within sedgeland and grassland ecosystems in good condition and contains one of the few remaining areas of intact regional ecosystem 7.3.1. The area has good connectivity with the Russell River and the Wet Tropics World Heritage Area and provides good habitat for threatened species and various fish species. The area is currently subject to threatening processes, for example streams feeding the area are subject to threatening process which is thought to be impacting on the site. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number mr_nr_ec_02). See the Wet Tropics non-riverine report for more details.	Mulgrave Russell	mr_r_ec_ 02	6.3.1 7.1.1	4
Canal Creek	Canal Creek provides important connectivity between Wooroonooran National Park, Eubenangee Swamp National Park, Ella Bay National Park (Alice River) and Russell River National Park. <u>Note:</u> This decision was not implemented because it only scored a conservation rating of 1.	Mulgrave Russell	mr_r_ec_ 03	7.1.1	1
Upper section of Little Mulgrave River	The area around Little Mulgrave Forest Reserve is a section of relatively intact low altitude stream with high biodiversity values and good connectivity with surrounding protected areas. The area also contains good fish diversity.	Mulgrave Russell	mr_r_ec_ 04	6.3.1	3
Bahana Gorge and Creek	The entire Bahana Gorge and Creek area contains unique lowland third order stream habitat with unique biodiversity. The area, which is under threat from water extraction, boasts high fish diversity, numerous wet tropic endemics such as Mulgrave River Goby (*Glossogobius sp. D*), disjunct fish populations and high frog diversity. The gorge also contains unique vegetation. The gorge's geomorphology is important on a global scale, rapidly changing height from 1,500 m to 100 m.	Mulgrave Russell	mr_r_ec_ 05	6.3.1	4
Harvey Creek catchment	The Harvey Creek catchment is a good example of lowland rainforest with high fish and stream biodiversity, good pool and riffle sequences, good stream complexities and good connectivity. The area also contains many rare and threatened plant and animal species and is important for larval fish recruitment.	Mulgrave Russell	mr_r_ec_ 06	6.1.1 6.2.1 6.3.1	4

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Fig Tree Creek catchment	The Fig Tree Creek catchment is a good example of lowland rainforest with high fish and stream biodiversity, good pool and riffle sequences, good stream complexities and good connectivity. The area also contains manly threatened plant species and is important for larval fish recruitment.	Mulgrave Russell	mr_r_ec_07	6.1.1 6.3.1 7.1.1	4
Wetlands from Edmund Kennedy National Park to Murray Upper National Park	This area provides good connectivity between protected areas and good representation of endangered regional ecosystems including areas of Swamp paperbark (*Melaleuca quinquenervia*) and/or *Melaleuca cajuputi* closed forest to shrubland. The area also has significant threatened species values.	Murray	mu_r_ec_02	7.1.1	3
Tully/Hull lowlands	The wetlands of the Tully/Hull lowlands are within the biggest floodplain in the wet tropics and provide a good example of adventitious lowland streams, most of which are relatively intact. The wetlands in this area provide good general ecological resources and have a significant reef water quality protection function. The area consists of lowland fan palm and *Melaleuca* swamps close to the coast providing important habitat for crocodiles, cassowaries (*Casuarius casuarius johnsonii*) and numerous bird species. The area is the northern most limit of mahogany glider (*Petaurus gracilis*) habitat and is known to contain many endemic and disjunct wet tropics fish species, assisted by the provision of significant fish nursery areas. The area also contains significant indigenous values as well as commercial and recreational fishing values. <u>Note</u>: This decision straddles the Tully and Murray study areas and covers both riverine and non-riverine wetlands. The non-riverine component of this decision in the Murray study area is covered by decision number mu_nr_ec_04. The riverine and non-riverine components of this decision in the Tully study area are covered by decision numbers tu_r_ec_04 (this report) and tu_nr_ec_03 respectively. See the Wet Tropics non-riverine report for more details on non-riverine decisions.	Murray	mu_r_ec_03	6.2.1 6.3.1 7.5.1	4
Jara Creek	Jara Creek is the largest intact coastal rainforest on alluvium left. The area contains many threatened species including a good population of cassowary (*Casuarius casuarius johnsonii*) and spotted blue-eyes (*Pseudomugil gertrudae*). The creek has particularly high integrity as a lowland stream.	Tully	tu_r_ec_01	6.3.1	4
Davidson and Echo creeks	The Davidson and Echo creeks are isolated *Melaleuca* swamps with good intact headwaters.	Tully	tu_r_ec_02	6.4.1	3

Special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Tully/Hull lowlands	The wetlands of the Tully/Hull lowlands are within the biggest floodplain in the wet tropics and provide a good example of adventitious lowland streams, most of which are relatively intact. The wetlands in this area provide good general ecological resources and have a significant reef water quality protection function. The area consists of lowland fan palm and *Melaleuca* swamps close to the coast providing important habitat for crocodiles, cassowaries (*Casuarius casuarius johnsonii*) and numerous bird species. The area is the northern most limit of mahogany glider (*Petaurus gracilis*) habitat and is known to contain many endemic and disjunct wet tropics fish species, assisted by the provision of significant fish nursery areas. The area also contains significant indigenous values as well as commercial and recreational fishing values. <u>Note</u>: This decision straddles the Tully and Murray study areas and covers both riverine and non-riverine wetlands. The non-riverine component of this decision in the Tully study area is covered by decision number tu_nr_ec_03. The riverine and non-riverine components of this decision in the Murray study area are covered by decision numbers mu_r_ec_03 (this report) and mu_nr_ec_04 respectively. See the Wet Tropics non-riverine report for more details on non-riverine decisions.	Tully	tu_r_ec_03	6.2.1 6.3.1 7.5.1	4
Tully Gorge	The Tully Gorge contains high diversity and abundance of flora and fauna species including rare and threatened frog taxa. It provides important fish spawning habitat and supports populations of Tully River Tandanus species (undescribed). It is also important habitat for the Koombooloomba shrimp (*Macrobrachium koombooloomba*). Tully Gorge streams also have rare and threatened frog species.	Tully	tu_r_ec_04	6.3.1	4

4 Connectivity

The panel members were asked to develop and/or identify a set of principles that could be applied to determine relative connectivity scores of riverine spatial units within the GBR catchment and within the non-riverine wetlands. After some time discussing connectivity for non-riverine wetlands, the panel members agreed that connectivity Criterion 7 be turned off for the GBR Non-riverine ACA due to issues associated with its implementation (including method of implementation and resources). Hence, the following sections focus on implementing the connectivity measures for riverine wetlands. Discussion on non-riverine wetland connectivity is recorded here where relevant.

4.1 Importance of connectivity

There was broad agreement by the panel that the concept of connectivity is important, and it is directly or indirectly linked to most facets of aquatic ecology, geomorphology and water quality. The scientific literature reviewed for the AquaBAMM program reflects this view.

The ecological value of a particular reach of river is directly linked in quantity and quality to the movement both up and downstream (and between adjoining terrestrial lands) of resources such as water, sediment and debris and recruitment and distribution of species (Cullen 2003).

An inherent connectivity (or lack of connectivity in drier periods) is a significant feature of fresh waters. In arid-zone systems, and floodplains, the irregular flow regime and sporadic connectivity underpins the conservation of the instream and floodplain wetland biota such as the invertebrate assemblages (Sheldon *et al*. 2002).

Similarly, this relationship is evident for maintaining the health and productivity of end-of-river estuarine systems (Cullen 2003).

A largely unknown and unseen linkage occurs within the hyporheic zone between surface waters and groundwater ecosystems sustaining many endemic or relictual invertebrate fauna (Boulton *et al*. 2003).

4.2 Applying principles for measuring connectivity

The practicalities of measuring connectivity in a riverine environment are complex making general principles difficult to develop and implement. Connectivity in its broadest meaning incorporates hydrological processes (quantity and quality, temporal and spatial variability), organism dispersal (barriers) and disturbances from natural conditions. Connectivity can be bi-directional movements within a stream (e.g. fish passage), uni-directional contribution to a downstream spatial unit or special area, or lateral connectivity to floodplain wetlands or groundwater ecosystems. These aspects of connectivity combine to provide a matrix of competing and differing values from an ecological conservation viewpoint.

4.3 Fish Passage (riverine)

The principles for the fish passage connectivity rating (measure 7.1.2) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) were tabled at the wetland ecology expert panel workshop. It was agreed that this method would be implemented in the Wet Tropics section of the GBR catchment.

An agreed assumption is that barriers lower in the catchment have more impact on fish passage then those in upper reaches of the catchment. There was also recognition that each barrier can be rated according to its relative level of fish passage. The steps outlined below were used to calculate a connectivity score for each spatial unit.

Step 1: Each stream segment is scored for its intrinsic connectivity according to its stream order (1:100,000).

An intrinsic connectivity value for each stream segment can be calculated from a fish migration point of view. The higher the stream order, the higher its intrinsic connectivity score

for fish species. Table 3 provides the scoring system using the stream order of each stream segment.

Table 3 The intrinsic connectivity score for streams

Stream order was calculated using the buffered stream network at a scale of 1:100,000.

Stream order	Intrinsic connectivity score
1	1
2 & 3	2
4 & 5	3
>5	4

Step 2: Modify the intrinsic connectivity score using the fish passage rating for each barrier.

The former Department of Primary Industries and Fisheries (DPIF) rated the major instream barriers in the GBR catchment for their ability to allow fish passage both up and downstream based on the storage height at the spillway (Table 4). Only artificial barriers were considered for a fish passage rating. This fish passage rating is then subtracted from the intrinsic connectivity score to provide a connectivity score for each segment of stream within a spatial unit as shown below:

Connectivity score (CS) = Intrinsic connectivity score (ICS) – Fish passage rating (FPR)

For example, the ICS score for a river segment having a stream order of six would be four, and if a barrier exists on this river reach, its FPR score would be two; resulting in an overall CS score of two (measure 7.1.2) for the spatial unit (i.e., ICS – FPR = 4 – 2 = 2). Table 4 provides the calculation matrix for each combination using the rules outlined below.

Table 4 Calculation matrix for the Connectivity Score (7.1.2)

	Fish passage rating (FPR)			
Intrinsic connectivity score (ICS)	**No barrier present**	**1 Good**	**2 Moderate**	**3 Poor**
1 (Low)	1	1	1	1
2 (Medium)	2	1	1	1
3 (High)	3	2	1	1
4 (Very high)	4	3	2	1

Rules for calculating the connectivity score:

- the CS cannot be lower than 1
- a spatial unit's CS pertains to the highest stream order present in the unit
- where there is no barrier within a spatial unit, the ICS for the highest stream order is used as the CS.

These ratings were determined from expert opinion and were used to score the fish passage connectivity in the AquaBAMM measure (7.1.2).

The panel recognised that there can be issues with stream ordering and that in some areas the stream order would not be correct e.g. Eubenangee Swamp. This would mean that any spring fed areas would have a stream order of one, for example.

Floodplain areas were also identified as being problematic. For example, there would be areas where a stream that starts out of a wetland on a floodplain would have a stream order of 1. The DERM will continue to investigate the impact of using stream order across floodplains keeping in mind that there is the potential to bias the results by placing value on the larger systems and not the lesser systems. In floodplain areas there is also lateral connectivity.

The panel recommended that the stream order be a stratified order so that some streams that have high stream order (e.g. three) but have coastal connectivity should score high. Application of a fish barrier\stream order approach downstream was also considered.

The list of fish barriers used under measure 7.1.2 for the Wet Tropics region is not presented as part of this report however the full list can be obtained from the Department of Environment and Resource Management by forwarding an email to aquabamm@derm.qld.gov.au.

4.4 Connectivity between freshwater and estuarine wetlands

Connectivity between freshwater wetlands (riverine and non-riverine) and estuarine ecosystems was also recognised by the panel as being important. The panel members discussed several methods for assessing the lateral connectivity of freshwater and estuarine wetlands and agreed that anything that is connected hydrologically and/or biologically to estuarine areas should be given a higher connectivity rating.

The panel suggested assigning a three to an area with hydrological estuarine connectivity and a four to an area that has freshwater wetlands AND hydrological estuarine AND/OR biological connectivity. This approach is expected to be investigated during the implementation of future ACAs.

The panel also recommended that wetlands located a significant distance inland from estuarine areas, yet still have connectivity with estuarine ecosystems, should be given a higher value.

4.5 Connectivity of special features

The panel members were also asked to develop principles for scoring connectivity for special features such as waterfalls, macrophyte beds, significant instream habitats, and other areas or features identified through expert opinion. This question primarily relates to uni-directional connectivity, i.e. quantity or quality of flow to a downstream special feature.

The principles for assessing connectivity values for special features (measures 7.1.1, 7.2.1) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) was tabled at the panel workshop. The panel agreed that the “Model 4 Inverse exponential scoring of spatial units upstream” method could be implemented in the Wet Tropics section of the GBR catchment. This model is presented below:

Inverse exponential scoring of spatial units upstream:

> This model uses the spatial units rather than a distance to determine how they are scored. Every contributing spatial unit above a particular special feature was logarithmically scored with the spatial units immediately upstream of a special feature being scored a four, the next adjoining upstream spatial units received a score of two and the remainder above a special feature were scored a one. The spatial unit having the special feature located within it would not receive a score because it was already scored in Criterion 6. Where a spatial unit had more than one calculation (i.e. overlapping scores), the maximum value was incorporated.
>
> This model better reflects the importance of spatial units immediately above a special feature by applying a logarithmic threshold to scoring. It is also an efficient and practical application of a complex issue. A disadvantage of this model is that it treats all special features (e.g. macrophyte bed, geomorphological feature, hydrological feature) equally where there may be reasons to differentiate between them. Additionally, this approach does not recognise the importance of downstream connectivity. Also, this model can result in some variation of the real distances upstream and downstream of a special feature being scored.

The panel also recognised that there is some value that can be placed on downstream spatial units connected to special features. For example, some fish need to move downstream to breed. This approach was not applied in the assessment because further investigation is required to determine whether this model can be applied downstream based on the values in the Wet Tropics.

5 Modelled natural flows

Cullen (2003) proposed an Australian river classification based solely on flow extractions from rivers (Table 5). He argued that flow diversion is the most important threatening process, and one that is easily understood and managed. Cullen (2003) believed a flow classification could be useful in water planning in Australia. These flow extraction thresholds were used as thresholds for the AquaBAMM measure 1.4.2 “Percent natural flows – modelled flows remaining relative to predevelopment”. The results for measure 1.4.2 are depicted in Figure 5.

Table 5 Australian river classification

River class	Percent mean annual flow
Heritage river	>95%
Conservation river	85 – 95%
Sustainable working river	67 – 85%
Managed working river	<67%

The Department of Environment and Resource Management were able to interpret flow data for the Wet Tropics region of the GBR catchments and identify areas of modified hydrology. Through this exercise, the flow classes above represent only broad-scale trends with spatial boundaries between classes necessarily approximate. The percent natural flow class of the highest stream order within a spatial unit was assigned to all of the other streams within a spatial unit.

6 Stratification

Study area stratification for application to relevant measures of AquaBAMM is a user decision and is not mandatory for successful assessment. However, AquaBAMM makes provision for data to be stratified in any user-defined way that is determined to be ecologically appropriate. Stratification mitigates the effects of data averaging across large study areas, and is particularly important where ecological diversity and complexity is high. An example where stratification may be appropriate is fish diversity where fewer species inhabit the upland zone compared to lowland floodplains. For measure datasets where there is an equal probability of scoring across a range of values throughout the study area, stratification is unwarranted. To date, the use of strata in completed ACAs has been limited to 150 m above sea level (ASL) for coastal flowing catchments and 400 m ASL for catchments west of the Great Dividing Range in the Murray-Darling Basin.

Stratification was considered by the panel and it was recommended that the study areas be stratified by 100 m ASL. After further investigation post panel, and to maintain consistency with other ACAs, it was decided to stratify using 150 m ASL for all study areas in the Wet Tropics.

Spatial units above 150 m ASL were grouped together as “upland” for the purpose of measures calculation. Spatial units below 150 m ASL were grouped together as “lowland” for the purpose of measures calculation. Spatial units containing the 150 m ASL contour were allocated to one or other stratum according to the elevation of the majority of the spatial unit (e.g. “upland” where >50 per cent of the spatial unit’s area is >150 m ASL). When stratification is applied to the spatial units in an ACA, a separate set of measure thresholds is calculated for each stratum (refer Clayton *et al.* 2006).

7 Weighting of measures

The panel members and project officers that attended the nine workshops weighted the measures within each indicator. Measures were weighted according to their importance to an indicator and based on the following rules:

1. At least one measure within each indicator must be weighted 10, which is the highest weight.
2. Weight the other measures within each indicator compared to the weighting of 10 assigned in the first step.
3. It is okay to have different measures with the same weight (i.e. all measures could be weighted 10).
4. Some indicators only have one measure and have already been given a weighting of 10.
5. Don't weight a measure down because of the quality or lack of data for that measure.

The individual weights were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final weights it was decided to average the weights across all three expert panel zones within the Great Barrier Reef study area, rather than average the weights for each zone or study area.

The final weights for each measure were then applied in the AquaBAMM assessment (Table 6). The measure number in Table 6 relates to the hierarchical approach of the AquaBAMM method. The first number refers to a criterion and the second number to an indicator within a criterion followed by the individual measure number.

There are a number of different methods for eliciting expert information, however many of these can become very complicated and time intensive. The benefits of refining the weights through a more detailed method were considered minimal. The result from the approach adopted at the workshop was considered by the AquaBAMM development team to accurately reflect the expert panel's decisions.

Table 6 The average weights for each measure

Maximum score is 10; total number of participants was approximately 20.

Criteria & indicators	Measures		Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland	7.4
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	10
	1.1.3	Presence of exotic invertebrate fauna within the wetland	5.9
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	7.2
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition	10
	1.2.2	SIGNAL2 score (Max)	8.5
	1.2.3	AUSRIVAS[2] score – Edge (Min band)	7.8
	1.2.4	AUSRIVAS[2] score – Pool (Min band)	7.9
	1.2.9	AUSRIVAS[2] score – Riffle (Min band)	7.9
1.3 Habitat features modification	1.3.1	SOR[1] bank stability	5.6
	1.3.2	SOR[1] bed & bar stability	5.4
	1.3.3	SOR[1] aquatic habitat condition	8.1
	1.3.4	Presence/absence of dams/weirs within the wetland	8.1

Criteria & indicators	Measures		Weight
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)	7.3
	1.3.14	Aquatic habitat condition using acknowledged metric	7.5
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment	9.7
	1.4.7	WRP (Water Resource Plan) hydraulic habitat	9.7
	1.4.8	HEV (High Ecological Value) areas	9.7
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines.	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to pre-clearing extent within buffered riverine wetland or watercourses	9.8
	2.2.2	Total number of regional ecosystems relative to pre-clearing number of regional ecosystems within buffered riverine wetland or watercourses	7.6
	2.2.3	SOR[1] reach environs	6.7
	2.2.4	SOR[1] riparian vegetation condition	7.7
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	9.1
	2.3.2	% "grazing" land-use area	8.3
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	8.4
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)	8.8
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area	10
3 Diversity and richness			
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	8.9
	3.1.2	Richness of native fish	9.5
	3.1.3	Richness of native aquatic dependent reptiles	8.5
	3.1.4	Richness of native waterbirds	8.8
	3.1.5	Richness of native aquatic plants	9.6
	3.1.7	Richness of native aquatic dependent mammals	8.2
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa	9.2
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance	7.9
3.3 Habitat	3.3.1	SOR[1] channel diversity	8.3
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	9.0
	3.3.3	Richness of wetland types within the sub-catchment	9.2
3.4 Geomorphology	3.4.1	Richness of geomorphic features	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]	9.9
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]	9.9
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)	9.4
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	9.5
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)	8.7
	5.1.4	Habitat for significant numbers of waterbirds	8.1

Criteria & indicators	Measures		Weight
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	9.5
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc.	8.2
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	9.2
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. Spring fed stream, ephemeral stream, boggomoss)	10
7 Connectivity			
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6	9.6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit	9.4
7.1 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)	10
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

8 Ranking of indicators

The panel members and project officers that attended the nine workshops ranked the indicators within each criterion. Indicators were ranked according to their importance to a criterion and based on the following rules:

1. At least one indicator within each criterion must be ranked 1, which is the highest ranking.

2. Rank the other indicators within each criterion relative to the ranking of 1 assigned in the first step.

3. It’s okay to have different indicators with the same ranking (i.e. all indicators may be ranked 1).

4. Don't rank an indicator down because of the quality or lack of data for that indicator.

The individual rankings were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final rankings it was decided to average the ranks across all three expert panel zones within the GBR study area, rather than average the ranks for each zone or study area.

The final ranks for each indicator were then applied in the AquaBAMM assessment (Table 7).

Table 7 The average ranks for each indicator

Maximum rank is 1; total number of participants was approximately 20.

Indicator	Description	Rank
1 Naturalness aquatic		
1.1	Exotic flora/fauna	2
1.2	Aquatic communities/assemblages	1
1.3	Habitat features modification	2
1.4	Hydrological modification	1
1.5	Water quality	2
2 Naturalness catchment		
2.1	Exotic flora/fauna	2
2.2	Riparian disturbance	1
2.3	Catchment disturbance	1
2.4	Flow modification	2
3 Diversity and richness		
3.1	Species	1
3.2	Communities/assemblages	1
3.3	Habitat	1
3.4	Geomorphology	2
4 Threatened species and ecosystems		
4.1	Species	2
4.2	Communities/assemblages	1
5 Priority species and ecosystems		
5.1	Species	2
5.2	Ecosystems	1
6 Special features		
6.1	Geomorphic features	3
6.2	Ecological processes	2
6.3	Habitat	1
6.4	Hydrological	3

Indicator	Description	Rank
7 Connectivity		
7.1	Significant species or populations	1
7.2	Groundwater dependant ecosystems	1
7.3	Floodplain and wetland ecosystems	1
7.5	Estuarine and marine ecosystems	2

Attachments

Attachment A – GBR catchment study area

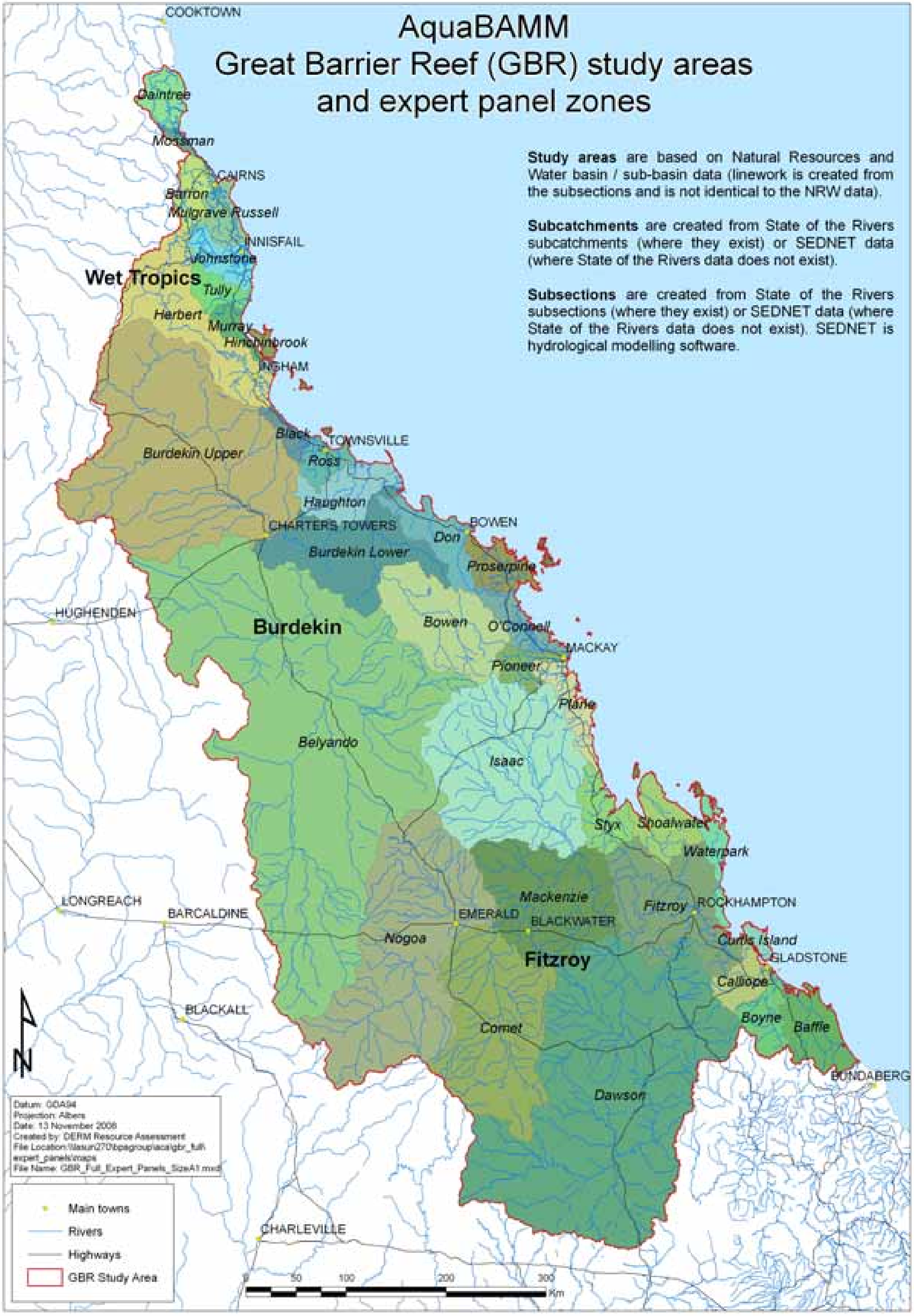

Figure 2 GBR catchment study area.

Attachment B – Terms of reference (wetland ecology expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Wetland ecology

The wetland ecology expert panel was established to provide expert advice based on experience and demonstrated scientific theory on natural ecological, geological or geo-morphological and hydrological processes, and issues of connectivity between aquatic systems within the riverine and non-riverine wetlands of the GBR. The panel consisted of professionals in fields of expertise relating to riverine and wetland ecology, water quality, geomorphology, fisheries and hydrological processes.

The tasks undertaken by the panel included, but without limitation, the following:

- identify areas of significant geomorphological, ecological or hydrological processes, or priority areas – special features
- provide advice on biodiversity ‘hot-spots’ or areas of particular significance for species or communities
- establish principles for applying the connectivity criterion (bi-directional, unidirectional and lateral directions) in the wetland ecosystems
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a "starter set" for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 8 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features.
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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Attachment D GBR catchments ACA – Aquatic flora expert panel report (Burdekin region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment

for the riverine wetlands of the

Great Barrier Reef catchment

Aquatic flora
Expert panel report

Burdekin region

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Tables

Figures

Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River, north of Cairns to Baffle Creek, south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic flora expert panel for the Burdekin region held in Townsville on Tuesday 18 November, 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments were based on the Department of Environment and Resource Management basin/sub-basin data. The Burdekin study area lies within the wet-dry tropics and includes the eight basins shown in Figure 1, as well as, the adjacent continental islands of the Palm Island group and Magnetic Island. This area takes in the coastal basins of the Black, Ross, Haughton, and Don rivers, and the sub-basins of the greater Burdekin River catchment; the Burdekin Lower, Burdekin Upper, Belyando and Bowen sub-basins. Apart from the inclusion of the Don Basin, the Burdekin study area largely corresponds to the Burdekin Dry Tropics Natural Resource Management (NRM) region and covers an area of approximately 140,000 km^2.

The area includes the Burdekin River catchment; Australia's largest in terms of peak discharge. It covers a diversity of landscapes crossing five bioregions: the Wet Tropics, the

Einasleigh Uplands, the Desert Uplands, the Brigalow Belt North, and a small section of the Central Queensland Coast bioregion on the southern edge. The physical environments include mountain ranges rising to 1,359 m at Mount McCartney in the Clarke Range to the south, 1,221 m at Mount Elliot near Townsville, 1,063 m at Mount Halifax in the Paluma Range to the north and 1,002 m at Mount Tabletop on the Great Dividing Range to the west. Other features include lower rock hills, coastal plains, floodplains, deltas, beach ridges and continental islands. Undulating plains with escarpments and dissected plateaus are found inland to the west. Vegetation types are equally diverse including tropical rainforest, vine thickets, forested swamps, drier woodlands, grassy plains, sedgelands, and coastal mangroves and saltpans.

The area has a tropical sub-humid climate with relatively high temperatures all year round and a pronounced wet and dry season with most rain falling in the warm, humid months of November through to April. Rainfall is highly variably across the region and influenced by monsoonal and cyclonic activity. There is a distinct gradient to drier conditions from the coast westward. Average annual rainfall varies through the area from above 3,000 mm in the coastal peaks of the Seaview and Paluma Ranges to the north, Mount Elliot near Townsville, and the Clarke Range to south, to below 500 mm in the south-west of the Belyando sub-basin. The spatial and seasonal variability and the high interannual variability of rainfall are an overriding characteristic of the study area that greatly influences the nature and distribution of its wetlands. Most streams and wetlands are subject to seasonal flows and are subject to irregular flooding. The exceptions to this are the perennial streams that rise in the high rainfall ranges and the wetlands fed by the large basalt aquifers in the Upper Burdekin sub-basin.

In general the Burdekin study area can be broadly divided into higher rainfall, more densely populated coastal areas with urban, industrial and irrigated agriculture land uses predominant and lower rainfall, sparsely populated inland areas used principally for rangeland grazing with some dryland agriculture and mining activity. There are several major water storages and large weirs located within the Burdekin study area, the largest being the Burdekin Falls Dam, which was completed in 1987 forming Lake Dalrymple, with a capacity of 1.86 million megalitres. Other major dams include the Ross River Dam, Paluma and Eungella dams.

The Ross basin is the most developed in the study area containing the regional city of Townsville. Many of the streams and wetlands in this basin are highly modified and impacted by water quality contamination and altered hydrology associated with urban development. Other major towns in the study area include Ayr and Home Hill to the south in the Lower Burdekin and Charters Towers in the Upper Burdekin.

The completion of the Burdekin Falls Dam and the subsequent development of the Burdekin-Haughton Water Supply Scheme (BHWSS) (previously known as the Burdekin River Irrigation Area (BRIA)) for intensive sugarcane production, has dramatically altered the environmental conditions of the streams and wetlands in the lower floodplain of the Haughton and Lower Burdekin basins. The Lower Burdekin is dominated by the Burdekin River delta, where the coastal plain widens and is prone to widespread flooding, with vast areas of wetlands. The Burdekin Delta and the floodplains and estuaries of the coastal rivers form the Townsville-Burdekin coastal wetland aggregation, one of the most extensive on the Australian east coast. This area includes the wetlands of Bowling Green Bay National Park listed under the international Ramsar Convention. Prior to development streams in this coastal plain, such as Barratta Creek, consisted of a series of clear or tannin-coloured seasonal in-stream and off-stream lagoons that connected across the floodplain during flood events. Flows were very variable between seasons and interannually. These systems have now been extensively modified. Flows to the streams and wetlands across this floodplain have been radically altered as a result of supplementation through the irrigation delivery system and by irrigation tail waters. This has removed the seasonality in much of the system and in combination with riparian disturbance and nutrient contamination has contributed to extensive weed infestation of wetlands by pasture grasses and aquatic weeds. These impacts have resulted in severe water quality degradation and altered ecology in the wetlands of this coastal plain and presented an enormous task to natural resource managers.

The Don Basin to the south of the Burdekin delta also contains extensive aggregations of coastal wetlands and estuaries. This area has remained one of the least developed along this coast due to relatively low rainfall and the unsuitability of soil types for large-scale irrigated agriculture, although horticulture, largely dependent on ground water, is common in some areas. Although, proposed developments associated with industrial developments at Abbott Point and the Water for Bowen water transfer scheme is likely to increase the pressure on coastal wetlands in this area.

The study area extends over 300 km westwards with the Upper Burdekin sub-basin draining the western side of the coastal ranges and the eastern side of the Great Dividing Range. This basin is contained almost entirely in the Einasleigh Uplands. The area contains a major basalt feature with highly productive black and red soils and numerous springs emanating from many locations that drive permanent flow and clear-water waterholes in many streams. This creates not only many significant waterbodies but a wide variety of wetland types. The Burdekin River channel, a large sand and gravel bed channel is another prominent feature. It consists of a small meandering low flow channel bordered by sand and gravel bars located within the high flow channel, with established riparian communities. Flow to this channel is almost perennial most years and comes from two sources: tributaries on the western slopes of the high rainfall coastal ranges; and the extensive basalt aquifers formed by the Toomba basalts flows.

The Belyando sub-basin covers a large part of the study area to the south west and includes the Cape-Campaspe, Belyando and Suttor River catchments. The source of the Belyando River in central western Queensland is almost 500 km from the mouth of the Burdekin River, and extends in to the black-soil grasslands of Central Queensland. The Belyando sub-basin contains two bioregions; the Desert Uplands in the west and the Brigalow Belt North bioregion to the east. The Belyando basin is the area that consistently receives the least rainfall in the study area, with streams and wetlands receiving ephemeral or intermittent flows. In contrast to the Burdekin River channel in the Upper Burdekin, the flow capacity of the main channels of the Cape-Campaspe, Belyando and Suttor River is relatively low resulting in braided (anastomosing) river channels with broad floodplains. The extent of water in the floodplain landscape is highly variable and strongly influenced by flood events which create large temporary wetlands and replenish several permanent waterholes that provide key refugia between flow events. Under flood conditions, flows are spread broadly across the floodplain.

The natural vegetation in the western part of the study area, away from the coast, largely consists of dry eucalypt and acacia savannah woodlands on typical infertile laterised soils and includes grasslands of perennial Mitchell and annual Flinders grasses to the west. Cattle grazing is widespread and a major industry in the inland areas. Land degradation, water quality contamination and erosion are major management problems. Consequently, the Burdekin River catchment has been identified as the biggest single source of sediment to the Great Barrier Reef lagoon and is targeted for improved management actions.

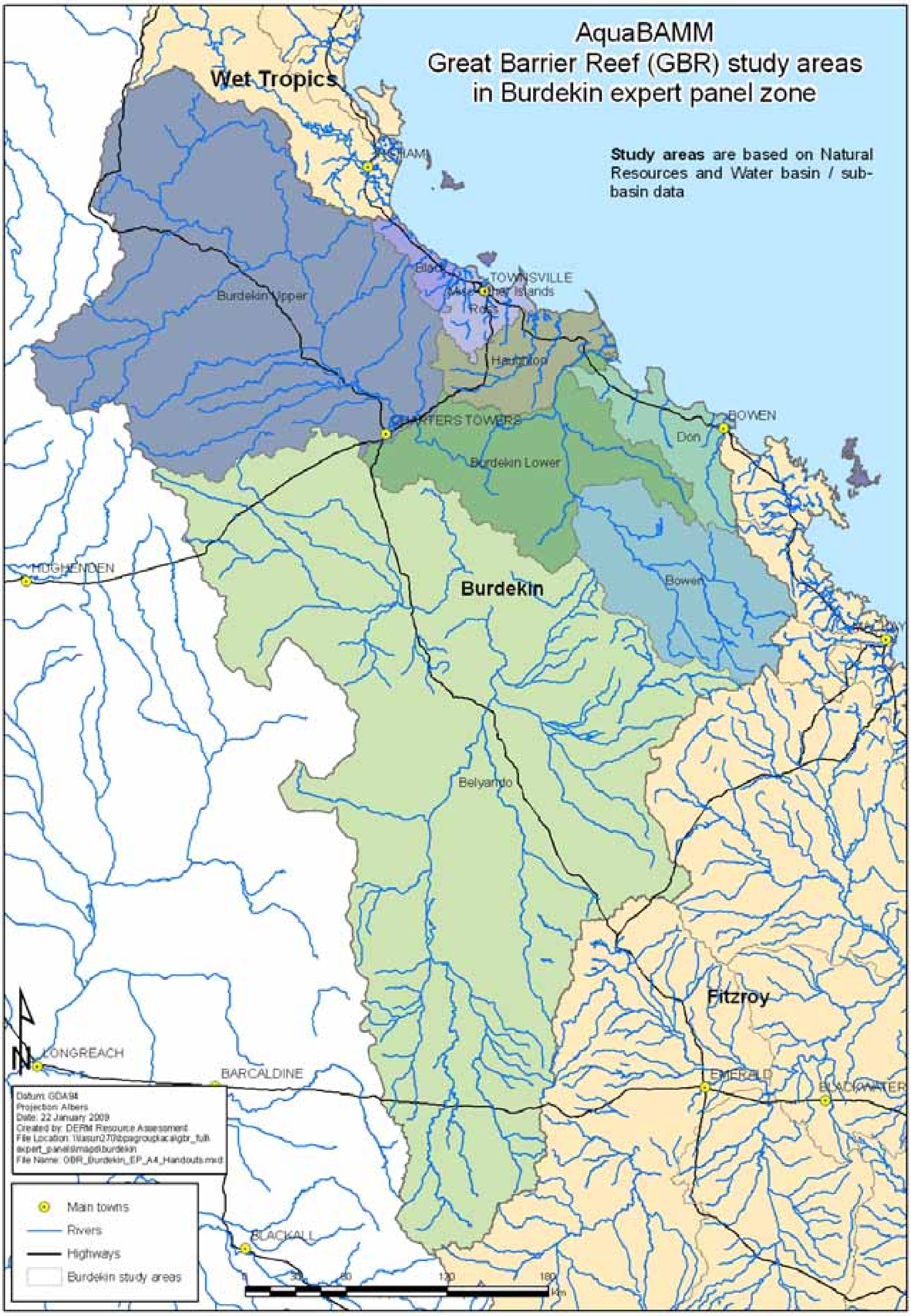

Figure 1 Burdekin section of the GBR catchment (incorporating eight individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of persons listed below in Table 1 who are familiar with aquatic flora in the Burdekin section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning, aquatic ecology and water quality
Nick Cuff	Senior Botanist, Queensland Herbarium, Department of Environment and Resource Management	Flora and regional ecosystems
Russell Cumming	Principal Botanist, Department of Environment and Resource Management	Native and exotic vegetation
John Dowe	Botanist, Australian Centre for Tropical Freshwater Research, James Cook University	Riparian vegetation
George Lukacs	Director, Australian Centre for Tropical Freshwater Research, James Cook University	Wetland ecology
Michaelie Pollard	Project Officer (aquatic ecology), Department of Environment and Resource Management	Aquatic ecology
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management

Selena Inglis and Heidi Millington provided administrative and technical support for the workshop which was facilitated by Darren Fielder.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened flora

The panel identified one 'rare' and one 'vulnerable' flora taxa in the Burdekin section of the GBR catchment as being primarily aquatic, semi-aquatic or riparian in habit (Table 2). Threatened taxa were excluded from this list if they did not correspond to one of these categories. This list of flora was used as the basis for identifying areas of significance for 'Criterion 4 Threatened species and ecosystems' (4.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present.

Table 2 Aquatic, semi-aquatic and riparian flora species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.2.

Scientific name	**Common name**	**Status**	**Habitat**	**Comments**
Eucalyptus raveretiana	Black ironbox	V[1]		Commonly found in the upper Bowen, Bogie and Broken rivers, stream dependent

- *recent records (>1950) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

4 Priority flora

The panel deliberated on all aquatic, semi-aquatic and riparian species within the GBR catchment to identify 'priority flora' (excluding the rare or threatened species listed in Table 2). The panel adopted a revised version of the earlier definition of a priority species from the Burnett River ACA: namely, a priority species must exhibit one or more of the following significant values:

1. It forms significant macrophyte beds (in shallow or deep water).
2. It is an important/critical food source.
3. It is important/critical habitat.
4. It is implicated in spawning or reproduction for other fauna and/or flora species.
5. It is at its distributional limit or is a disjunct population.
6. It provides stream bank or bed stabilisation or has soil-binding properties.
7. It is a small population and subject to threatening processes.

The panel identified nine riverine priority flora species (Table 3). These species were included in 'Criterion 5 Priority species and ecosystems' (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present.

Table 3 Identified priority flora species, and their significant values

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	Common name	Habitat	Comments
Ceratopteris thalictroides		Aquatic[4]	Indicator of better water quality systems.
Eucalyptus coolabah	Coolabah	Riparian[4]	Provides both important habitat and bank/bed stability.
Eucalyptus tereticornis			Provides good fish habitat.
Hydrilla verticillata	Hydrilla	Aquatic[4]	Small population subject to threatening processes.
Hymenachne acutigluma			Key indicator of waterfowl habitat value.
Leersia hexandra	Swamp rice grass	Aquatic[4]	Significant soil binding species providing bank stability.
Lomandra hystrix		Semi-aquatic[4]	Important for stream bank stability and provides habitat for terrestrial species. It is drought tolerant and its lifecycle is tied to the flood regime.
Melaleuca leucadendra	Broad-leaved tea-tree		Chanel dependant species. Provides important/critical habitat.
Vallisneria nana			Important in the Burdekin Dry Tropics as a food source, habitat for aquatic fauna and it sustains a diverse food web. It is dependent upon alluvial soils and is associated with threatened riparian and wetland ecosystems.

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

5 Species richness

Species richness (i.e. total number of species) was scored for aquatic-dependant flora, stratified using 150 m above sea level (ASL) for the Burdekin Lower and Haughton study areas and the Desert Uplands\Brigalow Belt bioregional boundary above the Burdekin Dam in the Belyando study area (see the Burdekin ecology expert panel report for more information on stratification).

The Burdekin section of the GBR catchment has 54 plants that are referred to in this report as 'aquatic-dependant' in riverine wetlands (Table 4). The datasets for these species were accessed from DERM corporate databases of WildNet and Herbrecs and from panel member records.

The panel defined 'aquatic-dependent flora' to mean:

> 'those species that are adapted to and dependant on living in wet conditions for at least part of their life cycle and found either within or immediately adjoining a non-riverine or riverine wetland'.

This definition of a wetland-dependent plant extends beyond the more traditional definition of submerged and floating aquatic plants to include plants inhabiting the littoral zone (waters edge) and plants that usually have 'wet feet' on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM indicator and measure of species richness: "Richness of wetland dependent plants" (3.1.5). The indicator is a measure of floristic richness of a particular spatial unit's aquatic environment, and hence, a broad definition better depicts the flora richness value at a given location.

Table 4 Wetland-dependent native flora species including priority species

This list was used to calculate an aquatic and riparian flora richness score (3.1.5), threatened flora species (4.1.2) and priority flora species (5.1.2).

Scientific name	Common name	Status	Habitat	Comments
Acacia salicina	Doolan	LC[1]		
Acacia stenophylla	Belalie	LC[1]	Riparian[4]	
Aponogeton queenslandicus		LC[1]	Aquatic[4]	
Casuarina cunninghamiana		LC[1]	Riparian[4]	
Casuarina cunninghamiana subsp. cunninghamiana		LC[1]		
Ceratopteris thalictroides		LC[1]	Aquatic[4]	Indicator of better water quality systems
Eleocharis acuta		LC[1]		
Eleocharis cylindrostachys		LC[1]	Semi-aquatic[4]	
Eriocaulon athertonense		LC[1]		Semi-aquatic species, some can be fully aquatic
Eucalyptus camaldulensis		LC[1]	Riparian[4]	Taxon identifies a priority ecosystem
Eucalyptus camaldulensis subsp. simulata		LC[1]		
Eucalyptus camaldulensis var. obtusa		LC[1]		

Scientific name	Common name	Status	Habitat	Comments
Eucalyptus camaldulensis x E. platyphylla		LC[1]		
Eucalyptus coolabah	Coolabah	LC[1]	Riparian[4]	
Eucalyptus raveretiana	Black ironbox	V[1,2]		Strictly riparian species
Eucalyptus tereticornis		LC[1]		Riparian species, wetland dependant in drier areas
Ficus racemosa		LC[1]		
Ficus racemosa var. racemosa		LC[1]		
Fimbristylis bisumbellata		LC[1]		Riparian species
Gonocarpus chinensis		LC[1]		Found on creek banks and seepage areas
Hibiscus tiliaceus	Cotton tree	LC[1]	Riparian[4]	Riparian tree
Hydrilla verticillata	Hydrilla	LC[1]	Aquatic[4]	
Hygrophila angustifolia		LC[1]		
Hymenachne acutigluma		LC[1]		Significant aquatic species
Leersia hexandra	Swamp rice grass	LC[1]	Aquatic[4]	Significant soil binding species providing bank stability
Leptospermum brachyandrum	Weeping tea-tree	LC[1]		Riparian species
Livistona decora		LC[1]		Present in swale wetlands and riparian areas
Lomandra hystrix		LC[1]	Semi-aquatic[4]	Riparian species
Lophostemon grandiflorus		LC[1]		Riparian species, wetland dependant in drier areas
Lophostemon grandiflorus subsp. riparius		LC[1]		Riparian species, wetland dependant in drier areas
Lophostemon suaveolens	Swamp box	LC[1]	Riparian[4]	Riparian species, wetland dependant in drier areas
Melaleuca bracteata	Black tea-tree	LC[1]		
Melaleuca dealbata	Swamp tea-tree	LC[1]		
Melaleuca fluviatilis		LC[1]	Riparian[4]	Riparian species
Melaleuca leucadendra	Broad-leaved tea-tree	LC[1]		
Melaleuca linariifolia	Snow-in summer	LC[1]	Riparian[4]	Riparian species
Melaleuca trichostachya		LC[1]	Riparian[4]	Riparian species
Melaleuca viminalis		LC[1]	Riparian[4]	
Millettia pinnata		LC[1]		Riparian tree
Myriophyllum verrucosum	Water milfoil	LC[1]	Aquatic[4]	
Nymphoides crenata	Wavy marshwort	LC[1]		
Nymphoides indica	Water snowflake	LC[1]	Aquatic[4]	
Spirodela punctata	Thin duckweed	LC[1]	Aquatic[4]	
Syzygium angophoroides		LC[1]		Riparian tree
Syzygium australe	Scrub cherry	LC[1]	Riparian[4]	Riparian tree
Syzygium oleosum	Blue cherry	LC[1]		Riparian tree

Scientific name	Common name	Status	Habitat	Comments
Syzygium tierneyanum	River cherry	LC[1]		Riparian tree
Terminalia sericocarpa	Damson	LC[1]		Riparian in the coastal plain
Triglochin procerum		LC[1]	Aquatic[4]	Restricted in distribution
Tristaniopsis exiliflora	Kanuka box	LC[1]		Strictly riparian species
Utricularia bifida		LC[1]	Aquatic[4]	
Utricularia caerulea	Blue bladderwort	LC[1]		
Utricularia uliginosa	Asian bladderwort	LC[1]		
Vallisneria nana		LC[1]	Aquatic[4]	Abundance thought to be reduced significantly within the region

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

6 Exotic flora

The panel recommended that only exotic plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a non-riverine landscape be included for the GBR ACA using AquaBAMM. Seventeen exotic plant taxa that are known to occur within the riverine wetlands in the Burdekin section of the GBR catchment were nominated by the panel (Table 5). The presence of aquatic and semi-aquatic flora species was recorded under ‘Criterion 1 Naturalness (aquatic)’ (1.1.2). Riparian exotic flora species were recorded under ‘Criterion 2 Naturalness (catchment)’ (2.1.1).

The degree of infestation and abundance of an exotic plant at a particular locality was acknowledged by the panel as being an important factor in determining the level of impact to a natural ecosystem. Where available, information and mapping of exotic species’ extent (sourced from the Department of Environment and Resource Management and regional bodies) were used instead of point records to flag the spatial units that have an exotic species present. Where only a point record is available for a location, then the record was used to identify the spatial units as having an exotic species present. Hence, an individual point record may or may not correspond to localities of dense weed infestations.

Table 5 Exotic flora species

This list was used to calculate the measures for 1.1.2 and 2.1.1 in the AquaBAMM assessment.

Scientific name	Common name	Habitat	Comments
Cabomba caroliniana var. caroliniana	Cabomba		
Centrosema molle			
Chromolaena odorata	Siam weed		
Cryptostegia grandiflora	Rubber vine		
Eichhornia crassipes	Water hyacinth	Aquatic[1]	Key species in terms of wetland condition indicator
Hymenachne amplexicaulis cv. Olive			Key species in terms of wetland condition indicator
Leucaena leucocephala subsp. glabrata	Leucaena		Invades riparian zones
Leucaena leucocephala subsp. leucocephala	Leucaena		Invades riparian zones
Macfadyena unguis-cati	Cat's claw creeper		Invades riparian zones
Megathyrsus maximus var. maximus	Guinea grass		In the absence of grazing it dominates the understorey of alluvial areas and generates fuel loads that destroy riparian ecosystems.
Myriophyllum aquaticum	Brazilian water milfoil		
Parkinsonia aculeata	Jerusalem thorn		Wetland, woody weed
Salvinia molesta	Salvinia		
Sphagneticola trilobata			Large populations occur along the Ross River.
Thunbergia grandiflora	Sky flower		Riparian vine species
Urochloa mutica		Semi-aquatic[1]	Considered a semi-aquatic exotic, not terrestrial. Key species as a wetland condition indicator.
Ziziphus mauritiana	Indian jujube		Widely spread, significantly impacts riparian zones, density important to transforming riparian zone

- *recent records (>1950) and records with precision <2,000 m only*

1. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

7 Priority ecosystems and special features

The panel identified several riverine priority ecosystems/special features in the Burdekin section of the GBR catchment (Table 6). These were identified for their aquatic and riparian flora values. Where special features nominated by the aquatic flora expert panel were also considered to have additional values (e.g. fauna, ecology) by the aquatic fauna or wetland ecology expert panels, the special area was implemented as a wetland ecology special area decision.

Each spatial unit that intersected with a particular ecosystem or feature in Table 6 was given a score equal to the conservation rating.

Table 6 Identified priority ecosystems and special features, and their values

Decisions listed by catchment. These features were intersected with the spatial units to identify the values for Criterion 6 Special features. All implemented special features were given a conservation rating of between one and four assigned by the panel.

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Belyando	be_r_fl_01	5.2.1	3
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Black	bk_r_fl_01	5.2.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Black	bk_r_fl_02	5.2.1	3
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 7.3.6	Rare (riparian) ecosystem	Black	bk_r_fl_03	5.2.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Bowen	bw_r_fl_01	5.2.1	3
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Burdekin Lower	bl_r_fl_01	5.2.1	3

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Burdekin Lower	bl_r_fl_02	5.2.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Don	do_r_fl_01	5.2.1	3
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Don	do_r_fl_02	5.2.1	4
Mt Elliott region	The riverine wetlands of the Mount Elliott Region contain unique geomorphologic features with unique floristic values that are under threat from weed invasion.	Haughton	ha_r_fl_01	6.1.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Haughton	ha_r_fl_02	5.2.1	3
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Haughton	ha_r_fl_03	5.2.1	4
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Misc Other Islands	oi_r_fl_02	5.2.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Misc Other Islands	oi_r_fl_03	5.2.1	3

Priority ecosystem/ special feature	**Values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Melaleuca dealbata ecosystems on old alluvials (including gilgai landforms and seasonal drainage depressions with or without *livistona decipiens*) – RE 11.3.12	Rare (riparian) ecosystem	Ross	ro_r_fl_01	5.2.1	4
Blue Gum on Alluvial Floodplains / Delta land system – RE 11.3.25	Rare (riparian) ecosystem	Ross	ro_r_fl_02	5.2.1	3
River redgum communities	These communities provide habitat for riparian fauna and contribute significantly to the supply of large woody debris in streams. Note: This decision was not implemented as its regional ecosystem type (RE 11.3.25) is covered under the 'Blue/Gum on Alluvial Floodplains/Delta land system' priority ecosystem decisions.	Various		5.2.1	4
Deepwater floodplain lagoons on distributary stream channels with 'blackwater' and native emergent species	Threatened aquatic ecosystem type declining in extent. Previously seasonally, these type of lagoons are now full of turbid water year round and under threat from invasion by Para grass (*Urochloa mutica*) and Guinea grass (*Megathyrsus maximus var. maximus*). Many emergent and submergent macrophyte communities have disappeared. Note: This decision has not been implemented in this assessment because further investigation into its implementation is required.	Various		5.2.1	4

Attachments

Attachment A – GBR catchment study area

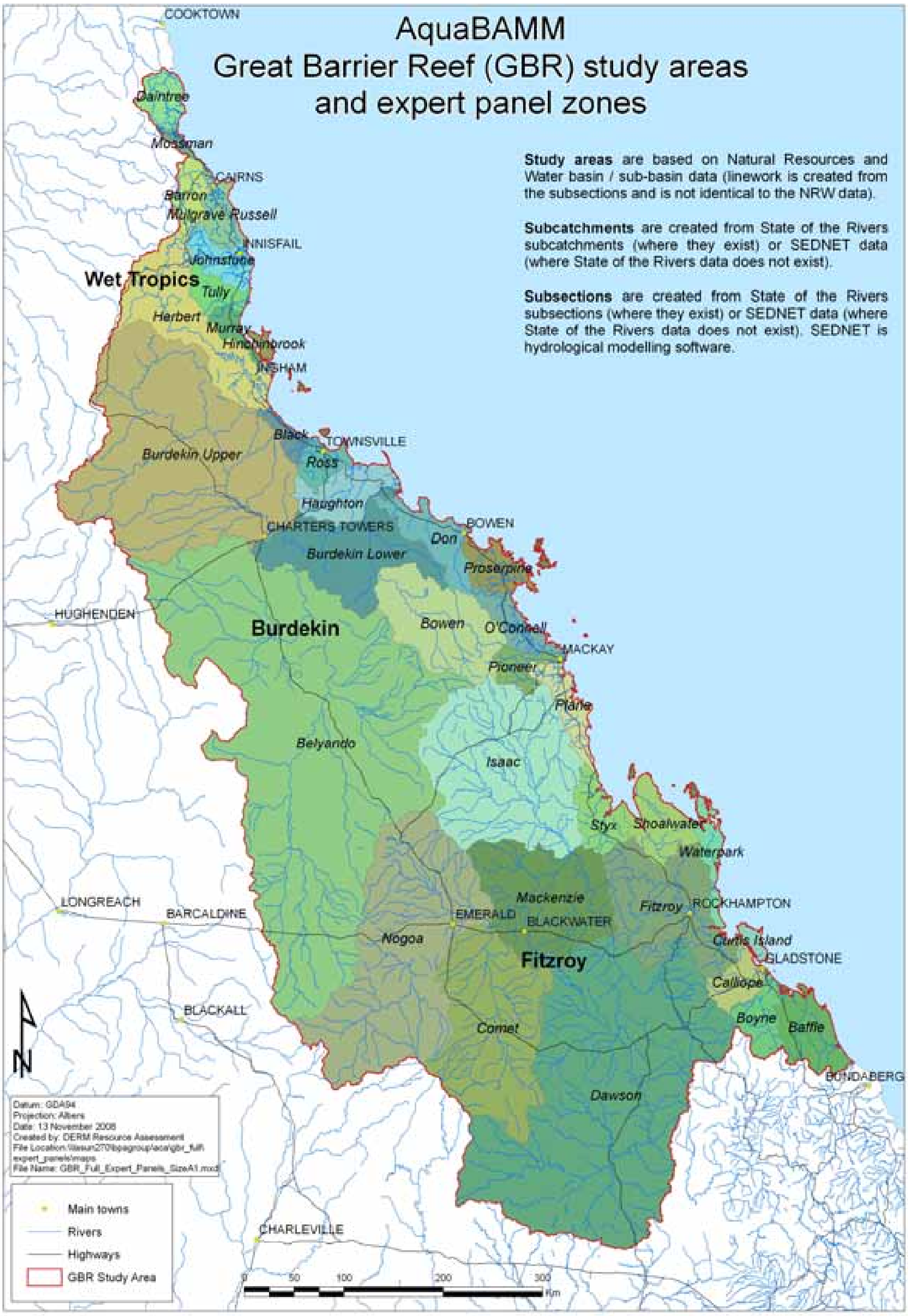

Figure 2 GBR catchment study area

Attachment B – Terms of reference (aquatic flora expert panel)

The terms of reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to gain information for a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic flora

The aquatic flora expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to both the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic flora and floristic communities.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on non-riverine and riverine ecosystem threatened flora species, habitat and localities
- provide advice on non-riverine and riverine ecosystem priority flora species, habitat and localities
- identify priority ecosystems or areas important for significant floral communities or species
- provide advice on non-riverine and riverine ecosystem exotic flora species, localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a “starter set” for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 7 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. Spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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DERM (In prep) *Biodiversity Planning Assessment, Einasleigh Uplands, Flora, Fauna and Landscape Expert Panel Report.* Department of Environment and Resource Management

Attachment E GBR catchments ACA – Aquatic fauna expert panel report (Burdekin region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Aquatic fauna
Expert panel report

Burdekin region

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	above sea level
BPA	Biodiversity Planning Assessment
CAMBA	China-Australia Migratory Birds Agreement
CMS	Convention of Migratory Species of Wild Animals
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
JAMBA	Japan-Australia Migratory Birds Agreement
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic fauna expert panel for the Burdekin region held in Townsville on Wednesday 19 November 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments were based on the Department of Environment and Resource Management basin/sub-basin data. The Burdekin study area lies within the wet-dry tropics and includes the eight basins shown in Figure 1, as well as, the adjacent continental islands of the Palm Island group and Magnetic Island. This area takes in the coastal basins of the Black, Ross, Haughton, and Don rivers, and the sub-basins of the greater Burdekin River catchment; the Burdekin Lower, Burdekin Upper, Belyando and Bowen sub-basins. Apart from the inclusion of the Don Basin, the Burdekin study area largely corresponds to the Burdekin Dry Tropics Natural Resource Management (NRM) region and covers an area of approximately 140,000 km^2.

The area includes the Burdekin River catchment; Australia's largest in terms of peak discharge.

It covers a diversity of landscapes crossing five bioregions: the Wet Tropics, the Einasleigh Uplands, the Desert Uplands, the Brigalow Belt North, and a small section of the Central

Queensland Coast bioregion on the southern edge. The physical environments include mountain ranges rising to 1,359 m at Mount McCartney in the Clarke Range to the south, 1,221 m at Mount Elliot near Townsville, 1,063 m at Mount Halifax in the Paluma Range to the north and 1,002 m at Mount Tabletop on the Great Dividing Range to the west. Other features include lower rock hills, coastal plains, floodplains, deltas, beach ridges and continental islands. Undulating plains with escarpments and dissected plateaus are found inland to the west. Vegetation types are equally diverse including tropical rainforest, vine thickets, forested swamps, drier woodlands, grassy plains, sedgelands, and coastal mangroves and saltpans.

The area has a tropical sub-humid climate with relatively high temperatures all year round and a pronounced wet and dry season with most rain falling in the warm, humid months of November through to April. Rainfall is highly variably across the region and influenced by monsoonal and cyclonic activity. There is a distinct gradient to drier conditions from the coast westward. Average annual rainfall varies through the area from above 3,000 mm in the coastal peaks of the Seaview and Paluma Ranges to the north, Mount Elliot near Townsville, and the Clarke Range to south, to below 500 mm in the south-west of the Belyando sub-basin. The spatial and seasonal variability and the high interannual variability of rainfall are an overriding characteristic of the study area that greatly influences the nature and distribution of its wetlands. Most streams and wetlands are subject to seasonal flows and are subject to irregular flooding. The exceptions to this are the perennial streams that rise in the high rainfall ranges and the wetlands fed by the large basalt aquifers in the Upper Burdekin sub-basin.

In general the Burdekin study area can be broadly divided into higher rainfall, more densely populated coastal areas with urban, industrial and irrigated agriculture land uses predominant and lower rainfall, sparsely populated inland areas used principally for rangeland grazing with some dryland agriculture and mining activity. There are several major water storages and large weirs located within the Burdekin study area, the largest being the Burdekin Falls Dam, which was completed in 1987 forming Lake Dalrymple, with a capacity of 1.86 million megalitres. Other major dams include the Ross River Dam, Paluma and Eungella dams.

The Ross basin is the most developed in the study area containing the regional city of Townsville. Many of the streams and wetlands in this basin are highly modified and impacted by water quality contamination and altered hydrology associated with urban development. Other major towns in the study area include Ayr and Home Hill to the south in the Lower Burdekin and Charters Towers in the Upper Burdekin.

The completion of the Burdekin Falls Dam and the subsequent development of the Burdekin-Haughton Water Supply Scheme (BHWSS) (previously known as the Burdekin River Irrigation Area (BRIA)) for intensive sugarcane production, has dramatically altered the environmental conditions of the streams and wetlands in the lower floodplain of the Haughton and Lower Burdekin basins. The Lower Burdekin is dominated by the Burdekin River delta, where the coastal plain widens and is prone to widespread flooding, with vast areas of wetlands. The Burdekin Delta and the floodplains and estuaries of the coastal rivers form the Townsville-Burdekin coastal wetland aggregation, one of the most extensive on the Australian east coast. This area includes the wetlands of Bowling Green Bay National Park listed under the international Ramsar Convention. Prior to development streams in this coastal plain, such as Barratta Creek, consisted of a series of clear or tannin-coloured seasonal in-stream and off-stream lagoons that connected across the floodplain during flood events. Flows were very variable between seasons and interannually. These systems have now been extensively modified. Flows to the streams and wetlands across this floodplain have been radically altered as a result of supplementation through the irrigation delivery system and by irrigation tail waters. This has removed the seasonality in much of the system and in combination with riparian disturbance and nutrient contamination has contributed to extensive weed infestation of wetlands by pasture grasses and aquatic weeds. These impacts have resulted in severe water quality degradation and altered ecology in the wetlands of this coastal plain and presented an enormous task to natural resource managers.

The Don Basin to the south of the Burdekin delta also contains extensive aggregations of coastal wetlands and estuaries. This area has remained one of the least developed along this coast due to relatively low rainfall and the unsuitability of soil types for large-scale irrigated agriculture, although horticulture, largely dependent on ground water, is common in some areas. Although, proposed developments associated with industrial developments at Abbott Point and the Water for Bowen water transfer scheme is likely to increase the pressure on coastal wetlands in this area.

The study area extends over 300 km westwards with the Upper Burdekin sub-basin draining the western side of the coastal ranges and the eastern side of the Great Dividing Range. This basin is contained almost entirely in the Einasleigh Uplands. The area contains a major basalt feature with highly productive black and red soils and numerous springs emanating from many locations that drive permanent flow and clear-water waterholes in many streams. This creates not only many significant waterbodies but a wide variety of wetland types. The Burdekin River channel, a large sand and gravel bed channel is another prominent feature. It consists of a small meandering low flow channel bordered by sand and gravel bars located within the high flow channel, with established riparian communities. Flow to this channel is almost perennial most years and comes from two sources: tributaries on the western slopes of the high rainfall coastal ranges; and the extensive basalt aquifers formed by the Toomba basalts flows.

The Belyando sub-basin covers a large part of the study area to the south west and includes the Cape-Campaspe, Belyando and Suttor River catchments. The source of the Belyando River in central western Queensland is almost 500 km from the mouth of the Burdekin River, and extends in to the black-soil grasslands of Central Queensland. The Belyando sub-basin contains two bioregions; the Desert Uplands in the west and the Brigalow Belt North bioregion to the east. The Belyando basin is the area that consistently receives the least rainfall in the study area, with streams and wetlands receiving ephemeral or intermittent flows. In contrast to the Burdekin River channel in the Upper Burdekin, the flow capacity of the main channels of the Cape-Campaspe, Belyando and Suttor River is relatively low resulting in braided (anastomosing) river channels with broad floodplains. The extent of water in the floodplain landscape is highly variable and strongly influenced by flood events which create large temporary wetlands and replenish several permanent waterholes that provide key refugia between flow events. Under flood conditions, flows are spread broadly across the floodplain.

The natural vegetation in the western part of the study area, away from the coast, largely consists of dry eucalypt and acacia savannah woodlands on typical infertile laterised soils and includes grasslands of perennial Mitchell and annual Flinders grasses to the west. Cattle grazing is widespread and a major industry in the inland areas. Land degradation, water quality contamination and erosion are major management problems. Consequently, the Burdekin River catchment has been identified as the biggest single source of sediment to the Great Barrier Reef lagoon and is targeted for improved management actions.

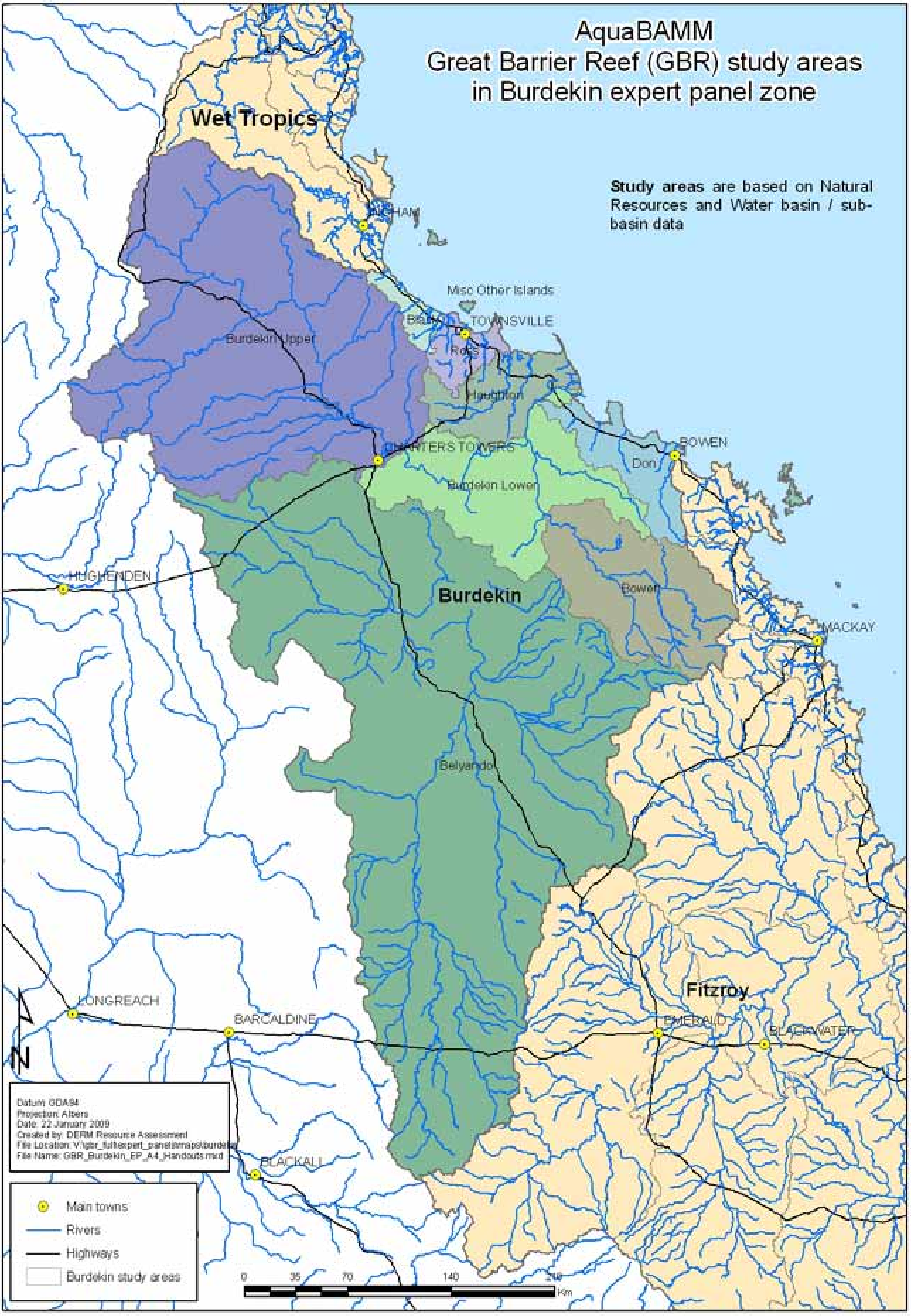

Figure 1 Burdekin section of the GBR catchment (incorporating eight individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of the persons listed in Table 1 who are familiar with aquatic fauna in the Burdekin section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Ant Backer	Senior Conservation Officer, Department of Environment and Resource Management	Biodiversity planning, terrestrial vertebrate ecology
Jason Carter	Business and Natural Resources Manager, Alluvium Consulting Pty Ltd	River and wetland management
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning, aquatic ecology and water quality
Mark Kelton	Senior Conservation Officer, Department of Environment and Resource Management	Geographic Information Systems (GIS) analyst
Michaelie Pollard	Project Officer (aquatic ecology), Department of Environment and Resource Management	Aquatic ecology
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
Alan Webb	Aquatic ecologist, Australian Centre for Tropical Freshwater Research, James Cook University	Aquatic ecology, exotic fish
Jo Winnieke	Regional Bird Observer and Author	Birds

Selena Inglis, Heidi Millington and Steven Howell provided administrative and technical support for the workshop which was facilitated by Darren Fielder.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened fauna

The panel identified eight 'rare', six 'vulnerable' and five 'endangered' fauna taxa in the riverine wetlands of the Burdekin section of the GBR catchment (Table 2). Only threatened taxa listed either on a schedule of the Queensland *Nature Conservation Act 1992* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and considered to be wetland dependent by the Panel were included in Table 2. This list of fauna was used as the basis for identifying areas of significance for 'Criterion 4 Threatened species and ecosystems' (4.1.1). A spatial unit with one or more of these species present was scored the highest category of four.

Table 2 Aquatic, semi-aquatic and riparian fauna species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.1.

Scientific name	**Common name**	**Status**	**Comments**
Adelotus brevis	Tusked frog	V[1]	
Crocodylus porosus	Estuarine crocodile	V[1]	
Denisonia maculata	Ornamental snake	V[1,2]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Eulamprus amplus		R[1]	Found in the Clark Range, restricted to boulders in streams.
Litoria genimaculata	Tapping green eyed treefrog	R[1]	
Litoria nannotis	Waterfall frog	E[1,2]	Suffered significant population decline during 1990's.
Litoria revelata	Whirring treefrog	R[1]	The Eungella population is one of three disjunct populations of conservation significance with potential poor taxonomic resolution.
Neochmia phaeton	Crimson finch	V[1]	
Nettapus coromandelianus	Cotton pygmy-goose	R[1]	
Nyctimystes dayi	Australian lacelid	E[1,2]	
Phyllurus gulbaru	Leaf-tailed gecko, Gulbaru gecko	E[1]	Significantly restricted distribution. Only found amongst in-stream boulders in splash zones and adjacent riparian areas.
Poephila cincta cincta	Black-throated finch (white-rumped subsp.)	V[1], E[2]	
Pristis microdon	Freshwater sawfish	V[2]	Rarely observed, historically recorded from floodplain and lower reaches. Has been recorded in Horseshoe Lagoon (Haughton). This species is dependent on estuarine ecosystems and expected to occur in estuarine reaches of the lower Burdekin, Burdekin Delta distributaries and Ross basins including the Bohle River although is possibly locally extinct.
Rheobatrachus vitellinus	Northern gastric brooding frog	E[1], Ex[2]	
Rostratula australis	Australian painted snipe	V[1,2]	
Tadorna radjah	Radjah shelduck	R[1]	
Taudactylus eungellensis	Eungella dayfrog	E[1,2]	
Taudactylus liemi	Eungella tinkerfrog	R[1]	
Varanus semiremex	Rusty monitor	R[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (Ex – Extinct, E – Endangered, V – Vulnerable)*

4 Priority fauna

The panel deliberated on all aquatic-dependent fauna species within the Burdekin section of the GBR catchment to identify ‘priority fauna’ (excluding the rare or threatened species listed in Table 2). The panel agreed to a definition of a priority species: namely, a priority species must exhibit one or more of the following significant values.

1. It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
2. It has experienced, or is suspected of experiencing, a serious population decline.
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
4. It is currently a small population and threatened by loss of habitat.
5. It is a significant disjunct population.
6. It is a migratory species (other than birds).
7. A significant proportion of the breeding population (>1 per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar Criterion 6 for waterbirds).

4.1 Priority species

The panel identified 19 riverine priority fauna species (Table 3). These species were included in Criterion 5 Priority species and ecosystems (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present. A spatial unit with one or more of these species present was scored the highest category four.

Table 3 Identified priority fauna species, and their significant values.

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	Common name	Comments
Ambassis agrammus	Sailfin glassfish	One of the less common glass perches. They are widely distributed in the lower reach floodplains, which are highly impacted by agriculture.
Anguilla obscura	Pacific shortfin eel	Presence of species indicates good habitat connectivity. Evidence suggests the population above Burdekin Dam is in decline. Populations are declining state-wide, due to over fishing and fish barriers. Species is now restricted to a small number of regions.
Anguilla reinhardtii	Longfin Eel	Presence of species indicates good habitat connectivity. Evidence suggests the population above Burdekin Dam is in decline. Populations are declining state-wide, due to over fishing and fish barriers. Species is now restricted to a small number of regions.
Chanos chanos	Milkfish	Historically occurred all the way up the Burdekin River catchment to the falls and across perennial floodplain water bodies. Species is dependent on good connectivity with estuarine ecosystems and therefore provides a good indicator of hydrological and habitat connectivity with estuaries. This species is only found in a few floodplain locations.
Elseya irwini	Irwin's turtle	Endemic to Burdekin basin.

Scientific name	Common name	Comments
Elops hawaiensis	Giant herring	Historically occurred in all accessible lower catchment floodplain and riverine habitats. Species is dependent on good connectivity with estuarine ecosystems and therefore provides a good indicator of hydrological and habitat connectivity with estuaries. This species is only found in a few floodplain locations.
Giurus margaritacea	Snakehead gudgeon	Highly migratory catadromous species thought to be an estuarine brackish breeder and therefore an indicator of coastal hydrological connectivity. Species has an intolerance to low dissolved oxygen levels and can indicate an anoxic reach that is still hydrologically connected.
Haliaeetus leucogaster	White-bellied sea-eagle	Nesting habitat has declined as a result of coastal development.
Kuhlia rupestris	Jungle perch	Species is suffering a decline in population and distribution as it is sensitive to water quality and riparian vegetation condition as well as being connectivity dependent. Historically this species was broad ranging, even to the Broken River but has now disappeared from the Haughton and Ross rivers above Applin weir although it still occurs in Stuart Creek and Alligator Creek above the weir.
Litoria wilcoxii		Significant taxonomic split from a single species into three separate species. Further knowledge is required on this species although it is believed to be geographically restricted.
Mogurnda adspersa	Southern purple spotted gudgeon	Declining populations and local extinctions. Sleepy cod (*Oxyeleotris lineolata*) and yellow belly (*Macquaria ambigua*) translocations to upper catchments are placing direct predation pressure on this species.
Neosilurus hyrtlii	Hyrtl's catfish, Hurtl's tandan	Priority just for the Ross River catchment as the Ross River is full of fish passage barriers and this species requires access to free flowing water. Population decline coincides with barramundi (*Lates calcarifer*) stocking; however, it is probably not predation but the limited access to free flowing water that is causing the decline.
Neosilurus mollespiculum	Softspine catfish	Endemic to Burdekin region with a patchy distribution in the Burdekin River catchment. Population potentially impacted since 1970s by translocated native Freshwater Catfish (*Tandanus tandanus)*.
Ophiocara porocephala	Spangled gudgeon	Largely a brackish species restricted in distribution and suffering from loss of habitat. Impoundments such as tidal bunds are of some concern.
Philypnodon grandiceps	Flathead gudgeon	Restricted in distribution.
Phyllurus gulbaru	Leaf-tailed gecko, Gulbaru gecko	Significantly restricted distribution. Only found amongst in-stream boulders in splash zones and adjacent riparian areas.
Pseudophryne raveni	Copper backed broodfrog	The Burdekin population may be a significant disjunct population.
Scortum parviceps	Smallhead grunter	Endemic to the Burdekin River catchment, this species has a patchy distribution within the catchment because of specific habitat requirements for example below Burdekin falls. One threat to its habitat is thought to be turbidity.

Scientific name	Common name	Comments
Strongylura krefftii	Freshwater longtom	Suffering declining populations and distribution, this species has disappeared from the Haughton and Ross rivers above Applin weir although it is still known occur in Stuart creek and Alligator creek above the weir. This species is a floodplain breeder and alienation of floodplain habitat physically or exposure to low dissolved oxygen is a concern.

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

4.2 Migratory species

In addition to the priority species identified above, the panel nominated migratory species listed under the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA) or the Convention on the Conservation of Migratory Species of Wild Animals (CMS) as priority fauna. Three migratory species known to occur in riverine wetlands (Table 4) were included in the AquaBAMM assessment in Criterion 5 Priority species and ecosystems (5.1.3). A spatial unit containing one species record scored a 3 and a 4 if more than one migratory species occurred within its boundary.

Table 4 A list of migratory species

This list was used to generate the values for the AquaBAMM measure (5.1.3). Sourced from Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) at:
http://www.environment.gov.au/biodiversity/migratory/waterbirds/index.html

Scientific name	Common name	Agreements/ conventions	Comments
Anas querquedula	Garganey	CAMBA[1], JAMBA[2]	
Ceyx azureus	Azure kingfisher		
Gallinago hardwickii	Latham's snipe	CAMBA[1], JAMBA[2], CMS[3]	

- *recent records (>1975) and records with precision <2000m only*

1 *China-Australia Migratory Birds Agreement (CAMBA)*
2 *Japan-Australia Migratory Birds Agreement (JAMBA)*
3 *Convention on the Conservation of Migratory Species of Wild Animals (CMS) otherwise know as the Bonn Convention*

5 Species richness

Species richness (i.e. total number of species) was scored for each class (amphibians – frogs, fish, reptiles, and birds – waterbirds) of fauna, stratified using 150 m above sea level (ASL) for the Burdekin Lower and Haughton study areas and the Desert Uplands\Brigalow Belt bioregional boundary above the Burdekin Dam in the Belyando study area (see the Burdekin wetland ecology expert panel report for more information on stratification). Stratifying the catchments is important to describe variability in richness. For example, fish richness is expected to be greater in the floodplain river channels than headwater streams which are smaller, with less food availability and unable to support high fish richness.

5.1 Fish richness

There were 49 native fish species identified in the riverine wetlands of the Burdekin section of the GBR catchments. A further 20 species were considered to be alien to the region and included some translocated species. Table 5 lists fish species that were used under the diversity and richness criterion (3.1.2).

Table 5 Native fish

This list was used to generate the values for the AquaBAMM measure (3.1.2).

Scientific name	Common name	Status	Comments
Ambassis agassizii	Agassiz's glassfish	LC[1]	Found in Ross River
Ambassis agrammus	Sailfin glassfish	LC[1]	One of less common glass perches. They are widely distributed in the lower reach floodplains, which are highly impacted by agriculture.
Amniataba percoides	Barred grunter	LC[1]	
Anguilla obscura	Pacific shortfin eel	LC[1]	Presence of species indicates good habitat connectivity. Evidence suggests the population above Burdekin Dam is in decline. Populations declining state-wide due to over fishing and fish barriers. This species is now restricted in a small number of regions.
Anguilla reinhardtii	Longfin eel	LC[1]	Presence of this species indicates good habitat connectivity. Evidence suggests the population above Burdekin Dam is in decline. Populations are currently declining state-wide due to over fishing and fish barriers. This species is now restricted in a small number of regions.
Arius graeffei	Blue catfish	LC[1]	
Arrhamphus sclerolepis	Snubnose garfish	LC[1]	Widely distributed but reduced in abundance in floodplain distributaries. This species may have separate freshwater and marine breeding populations or subspecies.
Awaous acritosus	Roman-nose goby	LC[1]	This species has been collected from Ross River and Rollingstone Creek/Black River basin. Its distribution has only been reported as being south of the Herbert River.
Carcharhinus leucas	Bull shark, river whaler shark	LC[1]	Impacted by fish passage barriers. Known to occur in the Lower Burdekin catchment below Clare Weir and Haughton River. Also thought to occur within the Ross River basin and Crystal Creek.

Scientific name	Common name	Status	Comments
Chanos chanos	Milkfish	LC[1]	Historically this fish occurred all the way up the Burdekin catchment to the falls and across perennial floodplain water bodies. The species is dependent on good connectivity with estuarine ecosystems and therefore provides a good indicator of hydrological and habitat connectivity with estuaries. This species is only found in a few floodplain locations.
Craterocephalus stercusmuscarum	Flyspecked hardyhead	LC[1]	
Elops hawaiensis	Giant herring	LC[1]	Historically occurred in all accessible lower catchment floodplain and riverine habitats. Species is dependent on good connectivity with estuarine ecosystems and therefore provides a good indicator of hydrological and habitat connectivity with estuaries. This species is only found in a few floodplain locations.
Gerres filamentosus	Threadfin silverbiddy	LC[1]	This species is widely distributed and dependent on estuaries despite being impacted by fish passage barriers which are preventing them from moving in to freshwaters ecosystems.
Gerres subfasciatus	Common silver biddy	LC[1]	
Giurus margaritacea	Snakehead gudgeon	LC[1]	Highly migratory catadromous species thought to be an estuarine brackish breeder and therefore an indicator of coastal hydrological connectivity. Species has an intolerance to low dissolved oxygen levels and can indicate an anoxic reach that is still hydrologically connected.
Glossamia aprion	Mouth almighty	LC[1]	
Glossogobius giurus	Tank goby, flathead goby	LC[1]	
Hephaestus fuliginosus	Sooty grunter	LC[1]	Species has been translocated to the Running River Gorge near Hidden Valley, high in the catchment. Investigations into the genetics of this species are being undertaken to determine previous distribution.
Herklotsichthys castelnaui	Southern sprat	LC[1]	Thought to breed in lower freshwater pools, collected in the Ross River.
Hypseleotris compressa	Empire gudgeon	LC[1]	
Hypseleotris galii	Firetail gudgeon	LC[1]	Has been caught in freshwater reach of Ross River.
Hypseleotris klunzingeri	Western carp gudgeon	LC[1]	
Hypseleotris sp. A midgleyi	Midgley's carp gudgeon	LC[1]	
Kuhlia rupestris	Jungle perch	LC[1]	Species is suffering a decline in population and distribution as it is sensitive to water quality and riparian vegetation condition as well as being connectivity dependent. Historically this species was broad ranging, even to the Broken River but has now disappeared from the Haughton and Ross rivers above Applin weir although it still occurs in Stuart Creek and Alligator Creek above the weir.

Scientific name	Common name	Status	Comments
Lates calcarifer	Barramundi	LC[1]	Widely stocked distribution on the floodplain but severely impacted by fish passage barriers and habitat quality. Its presence remains a legitimate indicator of floodplain habitat and ecosystem quality.
Leiopotherapon unicolor	Spangled perch	LC[1]	
Lutjanus argentimaculatus	Mangrove jack	LC[1]	Freshwater/marine species.
Megalops cyprinoides	Oxeye herring/tarpon	LC[1]	
Melanotaenia splendida splendida	Eastern rainbowfish	LC[1]	
Mogurnda adspersa	Southern purple-spotted gudgeon	LC[1]	Declining populations and local extinctions. Sleepy cod (*Oxyeleotris lineolata*) and yellow belly (*Macquaria ambigua*) translocations to upper catchments are placing direct predation pressure on this species.
Monodactylus argenteus	Diamondfish, silver batfish	LC[1]	Predominantly a marine vagrant commonly found in freshwater.
Mugil cephalus	Sea mullet	LC[1]	Impacted by fish passage barriers and floodplain habitat decline.
Nematalosa erebi	Bony bream	LC[1]	This species is intolerant to low dissolved oxygen levels. Its presence is indicative of good ecosystem function and primary productivity.
Neosilurus ater	Black catfish, butter jew, narrow-fronted tandan	LC[1]	
Neosilurus hyrtlii	Hyrtl's catfish, Hyrtl's tandan	LC[1]	This species requires access to free flowing water. The population decline coincides with barramundi (*Lates calcarifer*) stocking; however, it is probably not predation but the limited access to free flowing water that is causing the decline.
Neosilurus mollespiculum	Softspine catfish	LC[1]	
Notesthes robusta	Bullrout	LC[1]	Records in Wet Tropics and Gulf.
Ophiocara porocephala	Spangled gudgeon	LC[1]	Largely a brackish species restricted in distribution and suffering from loss of habitat. Impoundments such as tidal bunds are of some concern.
Oxyeleotris lineolata	Sleepy cod	LC[1]	Translocated above Burdekin falls.
Philypnodon grandiceps	Flathead gudgeon	LC[1]	
Porochilus rendahli	Rendahl's catfish	LC[1]	
Pristis microdon	Freshwater sawfish	V[2]	Rarely observed, historically recorded from floodplain and lower reaches. Has been recorded in Horseshoe Lagoon (Haughton). This species is dependent on estuarine ecosystems and expected to occur in estuarine reaches of the lower Burdekin, Burdekin Delta distributaries and Ross basins including the Bohle River although is possibly locally extinct.
Pseudomugil signifer	Pacific blue eye	LC[1]	
Redigobius bikolanus	Speckled goby	LC[1]	
Scatophagus argus	Spotted scat	LC[1]	

Scientific name	Common name	Status	Comments
Scortum parviceps	Smallhead grunter	LC[1]	This species has a restricted distribution endemic to the Burdekin basin and is therefore worthy of conservation value recognition.
Selenotoca multifasciata	Striped scat, banded scat	LC[1]	
Strongylura krefftii	Freshwater longtom	LC[1]	This species has undergone a major reduction in distribution and abundance in floodplain habitat due to impacts on habitat and water quality, therefore it provides good indicator of habitat quality.
Toxotes chatareus	Sevenspot archerfish	LC[1]	This species has undergone a major reduction in distribution and abundance in the floodplain habitat and is a good indicator of habitat quality.

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.2 Reptile richness

There were 19 native reptile species identified in the riverine wetlands of the Burdekin section of the GBR catchment. Table 6 lists the wetlands-dependant reptiles that were considered in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.3).

Table 6 Freshwater reptiles

This list was used to generate the values for the AquaBAMM measure (3.1.3).

Scientific name	Common name	Status	Comments
Carlia jarnoldae		LC[1]	Restricted to ephemeral streams, some perennial streams
Chelodina canni	Cann's longneck turtle	LC[1]	
Chelodina longicollis	Eastern snake-necked turtle	LC[1]	
Crocodylus johnstoni	Australian freshwater crocodile	LC[1]	
Crocodylus porosus	Estuarine crocodile	V[1]	
Denisonia maculata	Ornamental snake	V[1,2]	
Elseya irwini	Irwin's turtle	LC[1]	
Emydura macquarii krefftii	Krefft's river turtle	LC[1]	
Emydura macquarii macquarii	Murray turtle	LC[1]	
Eulamprus amplus		R[1]	Found in the Clark range, this species is restricted to boulders in streams
Eulamprus quoyii	Eastern water skink	LC[1]	
Hemiaspis signata	Black-bellied swamp snake	LC[1]	
Liasis mackloti	Water python	LC[1]	
Phyllurus gulbaru	Leaf-tailed gecko, gulbaru gecko	LC[1]	
Physignathus lesueurii	Eastern water dragon	LC[1]	
Stegonotus cucullatus	Slaty-grey snake	LC[1]	
Tropidonophis mairii	Freshwater snake	LC[1]	
Varanus semiremex	Rusty monitor	R[1]	
Wollumbinia latisternum	Saw-shelled turtle	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.3 Waterbird richness

There were 44 native waterbird species identified in the riverine wetlands of the Burdekin section of the GBR catchment. Table 7 lists the wetlands-dependant reptiles that were considered in the AquaBAMM under ‘Criterion 3 Diversity and richness’ (3.1.4). These species were expert panel derived using WildNet and Queensland Museum records. Only those species that were considered to inhabit freshwater wetland environments for part or all of their natural life functions were included (Table 7).

Table 7 Native waterbirds.

This list was used to generate the values of the AquaBAMM measure (3.1.4).

Scientific name	Common name	Status	Comments
Acrocephalus australis	Australian reed-warbler	LC[1]	
Amaurornis cinerea	White-browed crake	LC[1]	
Amaurornis moluccana	Pale-vented bush-hen	LC[1]	
Anas gracilis	Grey teal	LC[1]	
Anas querqueldula	Garganey	LC[1]	
Anhinga melanogaster	Australasian darter	LC[1]	
Ardea intermedia	Intermediate egret	LC[1]	
Ardea modesta	Eastern great egret	LC[1]	
Ardea pacifica	White-necked heron	LC[1]	
Aythya australis	Hardhead	LC[1]	
Butorides striata	Striated heron	LC[1]	
Ceyx azureus	Azure kingfisher	LC[1]	
Ceyx pusilla	Little kingfisher	LC[1]	
Chroicocephalus novaehollandiae	Silver gull	LC[1]	
Egretta garzetta	Little egret	LC[1]	
Egretta novaehollandiae	White-faced heron	LC[1]	
Elseyornis melanops	Black-fronted dotterel	LC[1]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Erythrogonys cinctus	Red-kneed dotterel	LC[1]	Not present in large numbers but are wetland dependant when present
Gallinago hardwickii	Latham's snipe	LC[1]	
Gallinula tenebrosa	Dusky moorhen	LC[1]	
Haliaeetus leucogaster	White-bellied sea-eagle	LC[1]	These species are known to occur in inland areas
Irediparra gallinacea	Comb-crested jacana	LC[1]	
Ixobrychus dubius	Australian little bittern	LC[1]	
Ixobrychus flavicollis	Black bittern	LC[1]	
Lonchura castaneothorax	Chestnut-breasted mannikin	LC[1]	
Microcarbo melanoleucos	Little pied cormorant	LC[1]	
Neochmia phaeton	Crimson finch	V[1]	
Nettapus coromandelianus	Cotton pygmy-goose	R[1]	
Nycticorax caledonicus	Nankeen night-heron	LC[1]	
Pandion cristatus	Eastern osprey	LC[1]	Species relies on fish and can be found in riparian areas
Pelecanus conspicillatus	Australian pelican	LC[1]	
Phalacrocorax carbo	Great cormorant	LC[1]	

Scientific name	Common name	Status	Comments
Phalacrocorax sulcirostris	Little black cormorant	LC[1]	
Phalacrocorax varius	Pied cormorant	LC[1]	
Platalea flavipes	Yellow-billed spoonbill	LC[1]	
Platalea regia	Royal spoonbill	LC[1]	
Poephila cincta	Black-throated finch	LC[1]	
Poephila cincta cincta	Black-throated finch (white-rumped subsp.)	V[1], E[2]	
Porphyrio porphyrio	Purple swamphen	LC[1]	
Ramsayornis modestus	Brown-backed honeyeater	LC[1]	Prefer to nest over water
Rostratula australis	Australian painted snipe	V[1,2]	
Tadorna radjah	Radjah shelduck	R[1]	
Vanellus miles	Masked lapwing	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.4 Frog richness

There were 27 species of amphibians identified in the riverine wetlands of the Burdekin section of the GBR catchment. Table 8 lists frog species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.1 and 3.1.6).

Table 8 Native frogs

This list was used to generate the values of the AquaBAMM measures (3.1.1 and 3.1.6).

Scientific name	Common name	Status	Comments
Adelotus brevis	Tusked frog	V[1]	
Hylarana daemeli	Australian woodfrog	LC[1]	
Limnodynastes peronii	Striped marshfrog	LC[1]	
Litoria caerulea	Common green treefrog	LC[1]	
Litoria chloris	Orange eyed treefrog	LC[1]	
Litoria fallax	Eastern sedgefrog	LC[1]	
Litoria genimaculata	Tapping green eyed treefrog	R[1]	
Litoria gracilenta	Graceful treefrog	LC[1]	
Litoria infrafrenata	White lipped treefrog	LC[1]	
Litoria microbelos	Javelin frog	LC[1]	
Litoria nannotis	Waterfall frog	E[1,2]	Suffered significant population decline during 1990's
Litoria nasuta	Striped rocketfrog	LC[1]	
Litoria revelata	Whirring treefrog	R[1]	Eungella population is one of three disjunct populations of conservation significance with potential poor taxonomic resolution
Litoria rothii	Northern laughing treefrog	LC[1]	
Litoria rubella	Ruddy treefrog	LC[1]	
Litoria wilcoxii		LC[1]	
Litoria xanthomera	Orange thighed treefrog	LC[1]	
Mixophyes coggeri		LC[1]	

Scientific name	Common name	Status	Comments
ixophyes fasciolatus	Great barred frog	LC[1]	
Nyctimystes dayi	Australian lacelid	E[1,2]	
Pseudophryne major	Great brown broodfrog	LC[1]	
Pseudophryne raveni	Copper backed broodfrog	LC[1]	
Rheobatrachus vitellinus	Northern gastric brooding frog	E[1], Ex[2]	
Taudactylus eungellensis	Eungella dayfrog	E[1,2]	
Taudactylus liemi	Eungella tinkerfrog	R[1]	
Uperoleia altissima	Tableland gungan	LC[1]	
Uperoleia fusca	Dusky gungan	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (Ex - Extinct, E – Endangered, V – Vulnerable)*

5.5 Mammal richness

There were three species of mammal identified in the riverine wetlands of the Burdekin section of the GBR catchment. Table 9 lists mammal species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.7).

Table 9 Native mammals

This list was used to generate the values of the AquaBAMM measure (3.1.7)

Scientific name	Common name	Status	Comments
Ornithorhynchus anatinus	Platypus	LC[1]	
Myotis macropus	Large-footed myotis	LC[1]	
Hydromys chrysogaster	Water rat	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*

5.6 Macroinvertebrate richness

There was one species of macroinvertebrate identified in the riverine wetlands of the Burdekin section of the GBR catchments. Table 10 lists macroinvertebrate species that were used in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.2.1).

Table 10 Native macroinvertebrates

This list was used to generate the values of the AquaBAMM measure (3.2.1)

Scientific name	Common name	Status	Comments
Telicota eurotas laconia	Northern sedge darter	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*

6 Exotic fauna

Twenty fish, one crustacean and one vertebrate species were nominated by the panel (Table 11) as exotic fauna in riverine wetlands. Some species identified by the panel were considered to only be exotic in certain areas of the Burdekin region despite being a native species. This was mainly due to translocations or introductions upstream of natural instream barriers. The presence of aquatic exotic fauna species was recorded under 'Criterion 1 Naturalness (aquatic)' (1.1.1).

Table 11 Alien fauna species

This list was used to generate the values of the AquaBAMM measure (1.1.1)

Scientific name	**Common name**	**Comments**
Aequidens rivulatus	Green terror	One off record from Ross River weirs in Townsville.
Amphilophus citrinellus	Midas cichlid, red devil	Breeding populations known to occur in the Ross River weirs in Townsville.
Archocentrus spilurus	Blue eye cichlid	One off report from sheep station lagoon.
Archocentrus nigrofasciatus	Convict cichlid	Several isolated reports from Townsville (note: genus has changed to *Amatitlania*).
Astronotus ocellatus	Oscar	Breeding population in the Ross River weirs in Townsville & other specimen from various parts in catchment.
Bos sp.	Cattle	Differential impacts, impacts particularly bad in rainforest areas. Certain pastoral holdings have cattle that are impacting on all wetlands in that holding.
Cherax quadricarinatus	Redclaw crayfish	Translocated species becoming a problem with observations in the Upper Ross River and Burdekin Dam (introduced). It is currently moving into tributaries of the Belyando and is thought to outcompete native crayfish.
Gambusia holbrooki	Mosquitofish	Preferred common name is now eastern gambusia.
Geophagus brasiliensis	Pearl cichlid	One off report from sheep station lagoon.
Haplochromis burtoni	Burton's haplochromis	Breeding population in the Ross River Weirs in Townsville, local dispersal occurring.
Hemichromis guttatus/bimaculatus	Jewel cichlid	Population known to occur in the Ross River.
Hephaestus fuliginosus	Sooty grunter	Considered to be an exotic in Running River Gorge and Broken River above and within Eungella Dam, where it is a predatory fish. It has been translocated to the Running River Gorge near Hidden Valley. Investigations into genetics are currently being undertaken to determine prior distribution.
Heros severus	Banded cichlid	One off from Ross River weirs in Townsville.
Lates calcarifer	Barramundi	Only considered to be an exotic above Burdekin falls due to translocation.
Oreochromis mossambicus	Mozambique mouthbrooder	Widely distributed in the Burdekin and Ross River catchments and rapidly spreading.
Oxyeleotris lineolata	Sleepy cod	Only considered to be an exotic above Burdekin Falls due to translocation.
Poecilia latipinna	Sailfin molly	Specimens recorded in Majors creek.
Poecilia reticulata	Guppy	
Thorichthys meeki	Firemouth cichlid	One off from Ross River weirs in Townsville.

Scientific name	Common name	Comments
Trichogaster trichopterus	Three-spot gourami	Found in sheep station creek, reports from lower Burdekin and Townsville weirs. This species is of major concern as it is rapidly spreading.
Xiphophorus helleri	Swordtail	Breeding populations of this species are mainly in Applin Weir in Townsville and other small creeks leading into Applin Weir.
Xiphophorus maculatus	Platy	

- *recent records (>1975) and records with precision <2,000 m only*

7 Special features

The panel identified one riverine special feature in the Burdekin section of the GBR catchment (Table 12). These were identified for their aquatic fauna values. Where special features nominated by the aquatic fauna expert panel were also considered to have additional values (e.g. flora, ecology) by the aquatic flora or wetland ecology expert panels, the special area were implemented as a wetland ecology special area.

Each spatial unit that intersected with a particular ecosystem or feature in Table 12 was given a score equal to the conservation rating.

Table 12 Identified priority ecosystems and special features, and their values

Decisions are listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for 'Criterion 6 Special features'. All implemented special features were given a conservation rating of between one and four assigned by the panel.

Special feature	**Values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Upper Burdekin/ Wairuna plateau	The Upper Burdekin/ Wairuna plateau contains a variety of instream wetlands including rapids, which provide spawning grounds for fish species such as the Sooty Grunter (*Hephaestus fuliginosus*), Black Catfish (*Neosilurus ater*) and the Small Headed Grunter (*Scortum parviceps*). Note: This decision is also a fauna decision in the Einasleigh Uplands Biodiversity Planning Assessment (eiu_fa_5).	Burdekin Upper	bp_r_fa_01	6.3.1 6.3.3 7.1.1	4

Attachments

Attachment A – GBR catchment study area

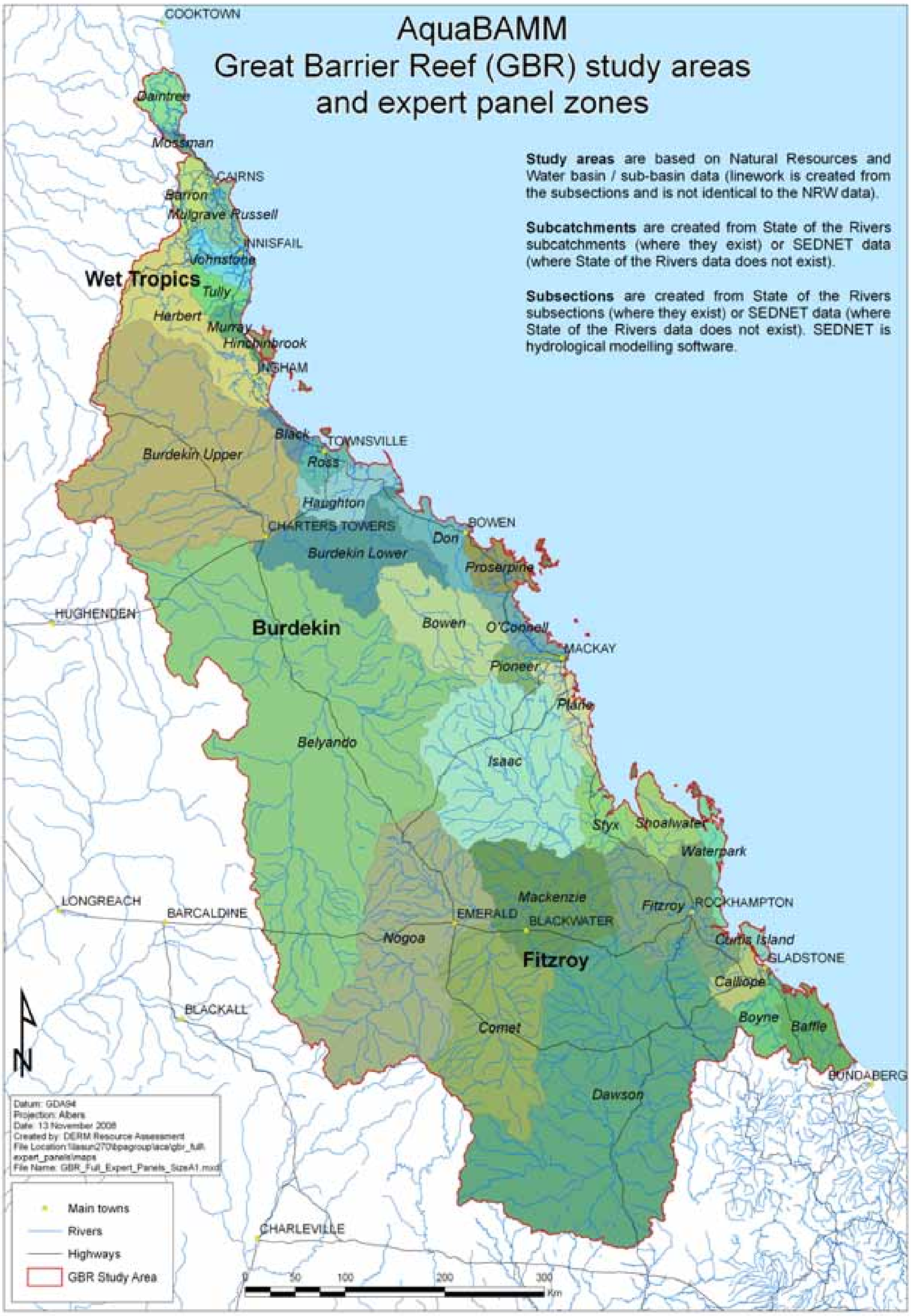

Figure 2 GBR catchment Study Area

Attachment B – Terms of reference (aquatic fauna expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to gain information for a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic fauna

The aquatic fauna expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic fauna values.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on riverine and non-riverine threatened fauna species, habitat and localities
- provide advice on riverine and non-riverine priority fauna species, habitat and localities
- identify priority ecosystems or areas important for significant faunal communities or species
- provide advice on riverine and non-riverine ecosystem exotic fauna species localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, Indicators and Measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a "starter set" for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of Indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 13 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features.
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. Spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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Attachment F GBR catchments ACA – Wetland ecology expert panel report (Burdekin region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Wetland ecology Expert panel report

Burdekin region

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
CS	Connectivity score
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FPR	Fish passage rating
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
ICS	Intrinsic connectivity score
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the data inputs.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. The AquaBAMM provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area—in this case, the GBR catchment.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the wetland ecology expert panel for the Burdekin region held in Townsville on Thursday 20 November 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the panel are provided in Attachment B.

2 Method

2.1 Study area

The study areas used to implement the AquaBAMM assessments were based on the Department of Environment and Resource Management basin/sub-basin data. The Burdekin study area lies within the wet-dry tropics and includes the eight basins shown in Figure 1, as well as, the adjacent continental islands of the Palm Island group and Magnetic Island. This area takes in the coastal basins of the Black, Ross, Haughton, and Don rivers, and the sub-basins of the greater Burdekin River catchment; the Burdekin Lower, Burdekin Upper, Belyando and Bowen sub-basins. Apart from the inclusion of the Don Basin, the Burdekin study area largely corresponds to the Burdekin Dry Tropics Natural Resource Management (NRM) region and covers an area of approximately 140,000 km^2.

The area includes the Burdekin River catchment; Australia's largest in terms of peak discharge. It covers a diversity of landscapes crossing five bioregions: the Wet Tropics, the Einasleigh Uplands, the Desert Uplands, the Brigalow Belt North, and a small section of the Central Queensland Coast bioregion on the southern edge. The physical environments include mountain ranges rising to 1,359 m at Mount McCartney in the Clarke Range to the south, 1,221 m at Mount Elliot near Townsville, 1,063 m at Mount Halifax in the Paluma Range to the north and 1,002 m at Mount Tabletop on the Great Dividing Range to the west. Other features include lower rock hills, coastal plains, floodplains, deltas, beach ridges and continental islands. Undulating plains with escarpments and dissected plateaus are found inland to the west. Vegetation types are equally diverse including tropical rainforest, vine thickets, forested swamps, drier woodlands, grassy plains, sedgelands, and coastal mangroves and saltpans.

The area has a tropical sub-humid climate with relatively high temperatures all year round and a pronounced wet and dry season with most rain falling in the warm, humid months of November through to April. Rainfall is highly variably across the region and influenced by monsoonal and cyclonic activity. There is a distinct gradient to drier conditions from the coast westward. Average annual rainfall varies through the area from above 3,000 mm in the coastal peaks of the Seaview and Paluma Ranges to the north, Mount Elliot near Townsville, and the Clarke Range to south, to below 500 mm in the south-west of the Belyando sub-basin. The spatial and seasonal variability and the high interannual variability of rainfall are an overriding characteristic of the study area that greatly influences the nature and distribution of its wetlands. Most streams and wetlands are subject to seasonal flows and are subject to irregular flooding. The exceptions to this are the perennial streams that rise in the high rainfall ranges and the wetlands fed by the large basalt aquifers in the Upper Burdekin sub-basin.

In general, the Burdekin study area can be broadly divided into higher rainfall, more densely populated coastal areas with urban, industrial and irrigated agriculture land uses predominant and lower rainfall, sparsely populated inland areas used principally for rangeland grazing with some dryland agriculture and mining activity. There are several major water storages and large weirs located within the Burdekin study area, the largest being the Burdekin Falls Dam, which was completed in 1987 forming Lake Dalrymple, with a capacity of 1.86 million megalitres. Other major dams include the Ross River Dam, Paluma and Eungella dams.

The Ross basin is the most developed in the study area containing the regional city of Townsville. Many of the streams and wetlands in this basin are highly modified and impacted by water quality contamination and altered hydrology associated with urban development. Other major towns in the study area include Ayr and Home Hill to the south in the Lower Burdekin and Charters Towers in the Upper Burdekin.

The completion of the Burdekin Falls Dam and the subsequent development of the Burdekin-Haughton Water Supply Scheme (BHWSS, previously known as the Burdekin River Irrigation Area (BRIA)) for intensive sugarcane production, has dramatically altered the environmental conditions of the streams and wetlands in the lower floodplain of the Haughton and Lower Burdekin basins. The Lower Burdekin is dominated by the Burdekin River delta, where the coastal plain widens and is prone to widespread flooding, with vast areas of wetlands. The Burdekin Delta and the floodplains and estuaries of the coastal rivers form the Townsville-Burdekin coastal wetland aggregation, one of the most extensive on the Australian east coast. This area includes the wetlands of Bowling Green Bay National Park listed under the international Ramsar Convention. Prior to development, streams in this coastal plain, such as Barratta Creek, consisted of a series of clear or tannin-coloured seasonal in-stream and off-stream lagoons that connected across the floodplain during flood events. Flows were very variable between seasons and interannually. These systems have now been extensively modified. Flows to the streams and wetlands across this floodplain have been radically altered as a result of supplementation through the irrigation delivery system and by irrigation tail waters. This has removed the seasonality in much of the system and in combination with riparian disturbance and nutrient contamination has contributed to extensive weed infestation of wetlands by pasture grasses and aquatic weeds. These impacts have resulted in severe water quality degradation and altered ecology in the wetlands of this coastal plain and presented an enormous task to natural resource managers.

The Don Basin to the south of the Burdekin delta also contains extensive aggregations of coastal wetlands and estuaries. This area has remained one of the least developed along this coast due to relatively low rainfall and the unsuitability of soil types for large-scale irrigated agriculture, although horticulture, largely dependent on ground water, is common in some areas. Although, proposed developments associated with industrial developments at Abbott

Point and the Water for Bowen water transfer scheme is likely to increase the pressure on coastal wetlands in this area.

The study area extends more than 300 km westwards, with the Upper Burdekin sub-basin draining the western side of the coastal ranges and the eastern side of the Great Dividing Range. This basin is contained almost entirely in the Einasleigh Uplands. The area contains a major basalt feature with highly productive black and red soils and numerous springs emanating from many locations that drive permanent flow and clear-water waterholes in many streams. This creates not only many significant waterbodies but a wide variety of wetland types. The Burdekin River channel, a large sand and gravel bed channel is another prominent feature. It consists of a small meandering low flow channel bordered by sand and gravel bars located within the high flow channel, with established riparian communities. Flow to this channel is almost perennial most years and comes from two sources: tributaries on the western slopes of the high rainfall coastal ranges; and the extensive basalt aquifers formed by the Toomba basalts flows.

The Belyando sub-basin covers a large part of the study area to the south west and includes the Cape-Campaspe, Belyando and Suttor River catchments. The source of the Belyando River in central western Queensland is almost 500 km from the mouth of the Burdekin River, and extends in to the black-soil grasslands of Central Queensland. The Belyando sub-basin contains two bioregions; the Desert Uplands in the west and the Brigalow Belt North bioregion to the east. The Belyando basin is the area that consistently receives the least rainfall in the study area, with streams and wetlands receiving ephemeral or intermittent flows. In contrast to the Burdekin River channel in the Upper Burdekin, the flow capacity of the main channels of the Cape-Campaspe, Belyando and Suttor River is relatively low resulting in braided (anastomosing) river channels with broad floodplains. The extent of water in the floodplain landscape is highly variable and strongly influenced by flood events which create large temporary wetlands and replenish several permanent waterholes that provide key refugia between flow events. Under flood conditions, flows are spread broadly across the floodplain.

The natural vegetation in the western part of the study area, away from the coast, largely consists of dry eucalypt and acacia savannah woodlands on typical infertile laterised soils and includes grasslands of perennial Mitchell and annual Flinders grasses to the west. Cattle grazing is widespread and a major industry in the inland areas. Land degradation, water quality contamination and erosion are major management problems. Consequently, the Burdekin River catchment has been identified as the biggest single source of sediment to the Great Barrier Reef lagoon and is targeted for improved management actions.

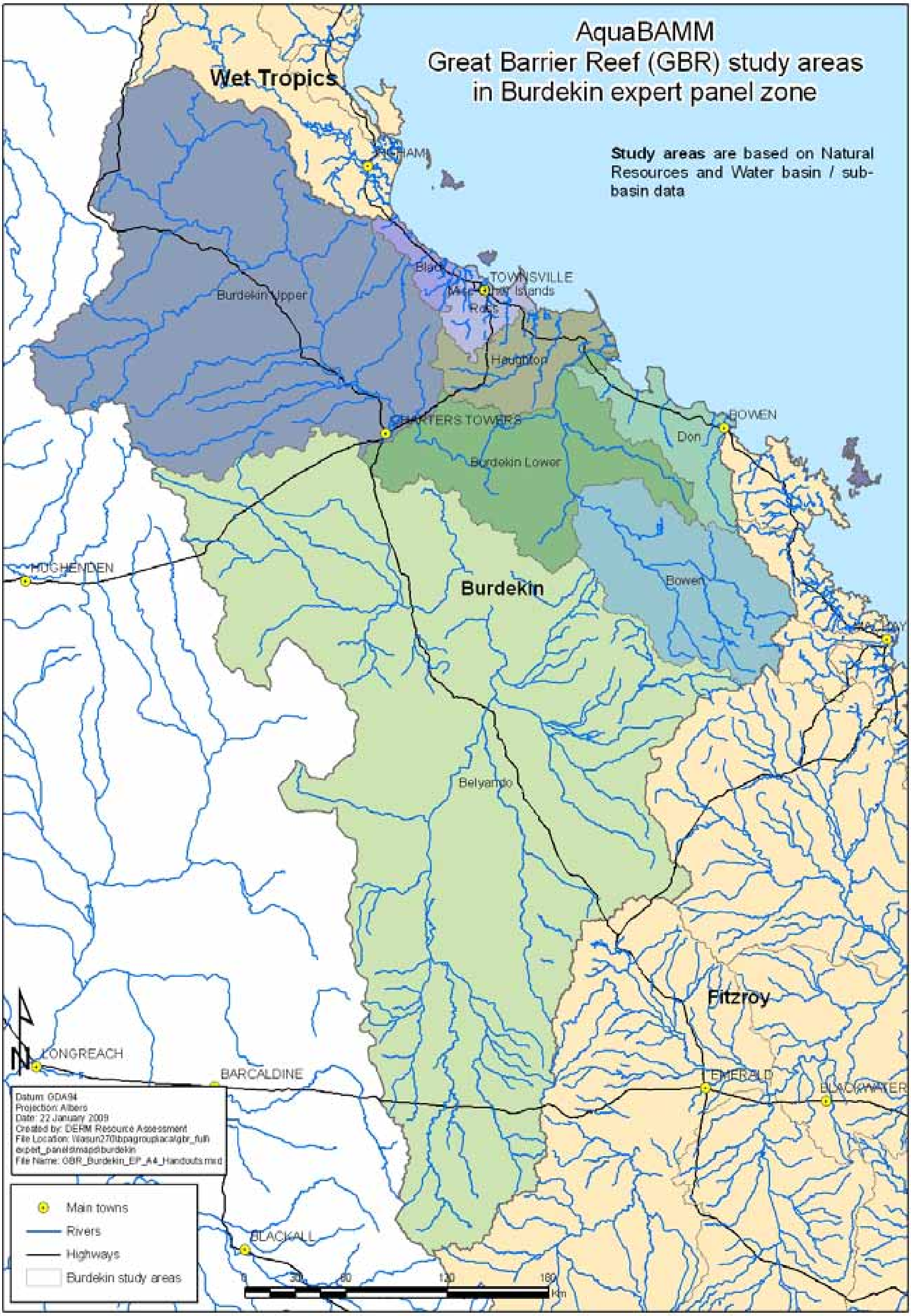

Figure 1 Burdekin section of the GBR catchment (incorporating eight individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of persons listed in Table 1 who are familiar with non-riverine and riverine wetland ecology, including fish, macroinvertebrates, water quality, hydrology, geomorphology and vegetation, in the Burdekin section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	**Position / Organisation**	**Expertise**
Donna Audas	Project Manager – GBR Wetlands Coastal ecosystems & Water Quality, Great Barrier Reef Marine Park Authority	Coastal ecosystems, GIS and wetlands
Anthony Backer	Senior Planning Officer, Department of Environment and Resource Management	Biodiversity planning and terrestrial ecology
Jon Brodie	Water Quality Scientist, Australian Centre for Tropical Freshwater Research, James Cook University	Water quality and catchment management
Barry Butler	Water Quality Scientist, Australian Centre for Freshwater Tropical Research, James Cook University	Aquatic ecology and water quality
Jason Carter	Business and Natural Resources Manager, Alluvium Consulting Pty Ltd	River and wetland management
Niall Connolly	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning – Aquatic ecology and water quality
Nick Cuff	Senior Botanist, Queensland Herbarium, Department of Environment and Resource Management	Aquatic flora and regional ecosystems
Carol Honchin	Project Manager – GBR Ecosystem Health, Great Barrier Reef Marine Park Authority	Marine ecosystem health and water quality
Brett King	Project Officer, Conservation Volunteers	Natural resource management and conservation
Dominica Loong	Aquatic Ecologist, Australian Centre for Tropical Freshwater Research, James Cook University	Aquatic ecology and water quality
Mal Lorimer	Principal Conservation Officer, Department of Environment and Resource Management	Biodiversity planning – land classification & soils
George Lukacs	Director, Australian Centre for Tropical Freshwater Research, James Cook University	Wetland ecology
Chris Manning	Total Water Cycle Coordinator, Townsville City Council	Water quality improvement and conservation planning
Tim Marsden	Senior Fisheries Biologist (Fishway), Department of Primary Industries and Fisheries	Fish and aquatic ecology
Gethin Morgan	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Biodiversity planning – landscape ecology
Diana O'Donnell	Programme Coordinator – Water, Burdekin Dry Tropics Natural Resource Management Group	Natural resource management and conservation planning
Tim Perry	Principal Ecologist, NRA Environmental Consultants	Native and exotic vegetation
Michaelie Pollard	Project Officer (aquatic ecology), Department of Environment and Resource Management	Aquatic ecology

Name	Position / Organisation	Expertise
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
Amber Webster	Senior Project Officer, Burdekin Dry Tropics Natural Resource Management Group	Wetland conservation
Carla Wegscheidl	Project Manager, Tide to Table – Burdekin Dry Tropics, OceanWatch Australia	Natural resource management and aquatic ecology
Adam West	Catchment Ecologist, Department of Primary Industries and Fisheries	Land use practices and influences

Selena Inglis and Heidi Millington provided administrative and technical support for the workshop which was facilitated by Steven Howell.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display the Burdekin River catchment and, where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. A draft report was circulated to panel members prior to the production of the final report.

3 Special features

The panel identified several riverine special features in the Burdekin section of the GBR catchment (Table 2). These were identified for their ecological values. Some special features nominated by either the aquatic flora and/or the aquatic fauna expert panels that were considered to have additional values (e.g. geomorphological or hydrological) were implemented as a wetland ecology special area.

Each spatial unit that intersected with a particular ecosystem or feature in Table 2 was given a score equal to the conservation rating.

Table 2 Identified priority ecosystems and special features

Decisions are listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for ‘Criterion 6 Special features’. All implemented special features were given a conservation rating of between 1 and 4 as assigned by the panel.

Priority ecosystem/ special feature	**Identified values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Belyando floodplain/ mistake creek	The Belyando floodplain contains large permanent billabong waterholes, thought to be naturally turbid as a result of tertiary clay sediments and saline influences from the substrate making it geologically unique. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number be_nr_ec_01). See the Burdekin non-riverine report for more details.	Belyando	be_r_ec_01	6.1.1	3
Lake Suttor	Lake Suttor provides important waterbird habitat for various species of pelican and duck. The area also has significant heritage values being the first cattle watering point in the Burdekin region.	Belyando	be_r_ec_02	5.1.4	3
Wentworth holding	The association between grassland (regional ecosystems 11.4.11 and 11.4.4) and wetlands (11.3.27) on ‘Wentworth’ is significant because of the distinct variation associated with geomorphology and other environmental variables. The wetlands on ‘Wentworth’ are not mapped as remnant. <u>Note</u>: This decision was also a landscape decision under the Brigalow Belt Biodiversity Planning Assessment (decision number – brbn_l_30). Values listed here are taken from that decision.	Belyando	be_r_ec_03	6.1.1 6.3.3	4
Creeks north of Leichhardt creek to Rollingstone including saltwater, lilypond and cassowary creeks.	The streams in this region are located at the southern extremes of the coastal wet tropics. The network boasts significant stands of remnant riparian vegetation and is highly connected from upland to lowland areas enabling a significant diversity of fish species. The integrity of these riverine systems is underpinned by the intactness of the intervening coastal plain woodland communities which include a host of palustrine wetlands. All of these coastal creeks also have perennial, granite bedrock hosted upper catchment reaches and lower reach coastal plain perennial pools which provide aquatic refugia in a seasonally dry environment.	Black	bk_r_ec_01	6.3.1 7.1.1	4

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Crystal creek/ Mutarnie Swamp	The Tributaries feeding Crystal Creek are high in ecological values. The area provides a good example of a relatively large lowland, perennial, boulder stream despite being altered by water extraction (~40 ML/day for Townsville water supply). The area contains good remnant riparian vegetation that connects the World Heritage area from the ranges to lowland coastal wetlands providing a significant wildlife corridor. This connectivity is also important for fish habitats connected to estuarine habitats, extensive coastal habitats and swale swamps. The area supports large populations of jungle perch (*Kuhlia rupestris*) and other catadromous species. Mutarnie Swamp is located on the north side of Crystal Creek just upstream of the Bruce Highway bridge. This has been formed by a meander cut off of lower Crystal Creek and connects with the tributary Bullocky Tom's Creek. This area provides a structurally complex habitat that includes wet palm forest and rainforest overstorey typical of high rainfall regions to the north. Large populations of snakeheaded gudgeons (*Giurus margaritacea*) have been reported within the backwaters of this billabong. This wetland was identified as a "Priority site" in a review of Thuringowa's Wetlands (Tait, 2006b).	Black	bk_r_ec_02	6.2.1 6.3.3 7.1.1 7.1.2	4
Patterson's Gorge	The special ecological processes that occur within the Patterson's Gorge area are unique in this region. The area provides extremely valuable fauna habitat areas. Additionally, the bed of the gorge has unique floristic assemblage and high biodiversity value. In the past, ecosystems typical of the Wet Tropics have expanded and contracted through this region. The area also contains perennial upper catchment bedrock hosted pools and jungle perch (*Kuhlia rupestris*) populations. Note: This decision straddles the Black and Burdekin Upper study areas. The Burdekin Upper component of this decision is covered by decision number bp_r_ec_03.	Black	bk_r_ec_03	6.1.1 6.3.1	4
Bluewater Creek	The streams in this region are located at the southern extremes of the coastal wet tropics that contain perennial, granite bedrock hosted pools in upper reaches. The network boasts significant stands of remnant riparian vegetation and is highly connected from upland to lowland areas enabling significant diversity of fish species. The area contains similar values to the creeks north of Leichhardt Creek.	Black	bk_r_ec_04	6.3.1 7.1.1	3

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Moongabulla	Moongabulla has significant threatened/listed species values, extensive examples of seasonally inundated woodlands in relatively good condition and is an intact remnant area of seasonal lowland palustrine wetlands in the southern Wet Tropics Bioregion, a vegetation type which has been heavily impacted elsewhere in the southern area of the bioregion. There is connectivity from the World Heritage Area ranges through to the riparian areas of Ollera and other creek systems. These palustrine wetlands are also thought to provide a filtering function for waters entering the Great Barrier Reef catchment. The area provides important intact habitat for the mahogany glider (*Petaurus gracilis*) and other rare and threatened species. The overall intactness of the heterogeneous coastal plain landscape mosaic, including its riverine, palustrine and marine wetlands, is a key value. Specific sites include Ant Plant Swamp, Ollera – Scrubby Creek Swamp, Ollera Creek Estuary and Swale Swamps (See Tait, 2006c for more information on these sites). <u>Note</u>: Although this site was added by the Wet Tropics Wetland Ecology Expert Panel, Moongabulla is in the Black catchment despite being part of the Wet Tropics bioregion.	Black	bk_r_ec_05	6.2.1 6.3.1 7.5.1	4
Dart Gorge	The Dart Gorge is a permanent waterhole with a good intact riparian zone important as a refuge for many wetland species.	Bowen	bw_r_ec_01	6.3.1	4
Urannah Creek	Urannah Creek contains intact riparian vegetation with good permanent flows fed from the Clark Range. The area also holds good aesthetic values and good water quality which supports a high diversity of fish species. The stream is important for providing good environmental flows to the Broken River downstream of the Eungella Dam.	Bowen	bw_r_ec_02	6.3.1 6.4.1	4
Back of Connors/ Clark Range	The creeks in the back of Connors/Clark Range contain distinct special ecological processes with extremely valuable fauna habitat areas. There are many threatened species in the area, the majority of which (if not all) are endemic to the Eungella/Clarke Range area.	Bowen	bw_r_ec_03	6.2.1 6.3.1	4
Glenroy Creek at junction with Burdekin River	Glenroy Creek is a permanently flowing stream containing intact riparian vegetation and significant bird habitat. The junction is important during flooding where the waters from two major river systems combine into a floodplain.	Burdekin Lower	bl_r_ec_01	6.3.1 6.4.1	4

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Junction of the Bogie River & Kirknie Creek	High conservation value wetlands including high integrity riparian forest and excellent water quality. The site has been selected as an area of high ecological value (HEV). The habitats, water quality and macrophytes community in this area is representative of what used to occur in the lower Burdekin River main channel prior to Burdekin Falls dam introduced perennial turbidity and flow regulation (refer to Blackman *et al* 2002 for more information). The area now provides significant habitat for estuarine crocodiles (*Crocodylus porosus*) and sub catchment refugia for communities representative of pre-regulation Burdekin main river channel.	Burdekin Lower	bl_r_ec _02	6.2.1 6.3.1 6.3.3 7.1.1	4
Cassidy Creek	This creek system is hydrologically modified by sustained discharges from the Burdekin – Haughton Water supply scheme in its upper reaches but these artificial flows contribute to the maintenance of a well structure riparian forest community and high value in stream habitats including channel hosted lagoons which support significant fish and bird populations. The value of this tributary system to catadromous fish such as barramundi (*Lates calcarifer*) within the Burdekin basin is accentuated because it joins the river system below Clare Weir, a major fish passage barrier.	Burdekin Lower	bl_r_ec _03	6.3.1	3
Lower Landers Creek	Site is hydrologically modified and receives a significant percentage of its flow from tailwater discharge from the Millaroo irrigation area however this is lower now. The perennial reaches support well developed riparian forest community and provide clear water sub catchment refugia for modified Burdekin main river channel.	Burdekin Lower	bl_r_ec _04	6.3.1	2
Upper Barratta Creek	The Upper Barratta Creek area provides good connectivity with a range of wetland types providing significant fish habitat areas and allowing for fish migration. Despite being supplemented by tailwaters and subject to encroachment by weeds (particularly Hymenachne), the creek contains good remnant riparian vegetation and is the best of its kind in the Haughton study area. The sites values are largely captured in the DIWA site listings for Barratta Channels Aggregation Qld 196 and the Jerona Aggregation Qld 201. A key feature of the palustrine wetlands in this area is the retention of thousands of hectares of floodplain vegetation, including riparian and back levee swamps, retained during the development of the Burdekin-Haughton Water Supply Scheme (see Tait and Veitch, 2007).	Burdekin Lower	bl_r_ec _05	6.3.1 7.1.1	3

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Kinnrara/ Valley of Lagoons	The Kinnrara/Valley of Lagoons aggregation contains riverine, lacustrine and palustrine wetlands in a complex continuous aggregation of spring fed, permanent and seasonal wetlands. The basalt soil system is listed as a significant wetland on the Directory of Important Wetlands (DIWA). The aggregation is large, unique and biologically rich constituting an outstanding geological phenomenon with high aesthetic value. It is a particularly good example of a wetland complex in the headwaters of the Burdekin River. The aggregation provides habitat for significant flora and fauna populations boasting rare and endangered regional ecosystems, good biomass production and high fish diversity and is on a flight migration route to the southwest of Cape York Peninsula. The site was also nominated as a special area in the Einasleigh Uplands Biodiversity Planning Assessment where values included were: * refugia and spawning area for *Macropus dorsalis*, sooty grunter (*Hephaestus fuliginosus*), small headed grunter (*Scortum parviceps*) and other species associated with lagoons; * international significance for cotton pygmy goose (*Nettapus coromandelianus*); and * significant vine thicket species. Note: This decision was also included in the non-riverine ACA assessment (decision number bp_nr_ec_01). See the Burdekin non-riverine report for more details.	Burdekin Upper	bp_r_ec_01	6.1.1 6.3.1 6.3.3 6.4.1 7.1.3	4
Upper Burdekin/ Wet Tropics	This area contains distinct special ecological processes providing extremely valuable fauna habitat areas. This area is biogeographically interesting in terms of rainforest streams with ‘inland’ drainage. There has also been a major reduction in populations of key top order predator Anguillid eels since the construction of the Burdekin Falls Dam.	Burdekin Upper	bp_r_ec_02	6.2.1 6.3.3	4
Patterson’s Gorge	The special ecological processes that occur within the Patterson’s Gorge area are unique in this region. The area provides extremely valuable fauna habitat areas. Additionally, the bed of the gorge has unique floristic assemblage and high biodiversity value. In the past, ecosystems typical of the Wet Tropics have expanded and contracted through this region. The area also contains perennial upper catchment bedrock hosted pools and jungle perch (*Kuhlia rupestris*) populations. Note: This decision straddles the Black and Burdekin Upper study areas. The Black component of this decision is covered by decision number bk_r_ec_03.	Burdekin Upper	bp_r_ec_03	6.1.1 6.3.1	4

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Keelbottom Creek, Star Creek, Little Star Creek and Running River	The creeks and rivers covered by this decision are granite based pool systems with moderate elevation located on the western side of the range. The streams are in a very high rainfall catchment area allowing many rainforest elements to occur in the riparian zone. These creeks provide the best examples of all the creeks of this type in the Burdekin Upper study area.	Burdekin Upper	bp_r_ec _04	6.2.1 6.3.1	4
Splitters Creek	The riverine and non-riverine wetlands of Splitters Creek contain a good diversity of flora species in an intact riparian zone such as *Potamogeton* and seasonal bulkuru (*Eleocharis dulcis*). The area also has good connectivity with estuarine areas providing good habitat for crocodiles and various species of bird and fish. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number do_nr_ec_03). See the Burdekin non-riverine report for more details.	Don	do_r_ec _01	6.3.1 7.5.1	4
Don River at Ida Creek junction	The Don River at Ida Creek junction is well known for its variability in seasonal and annual flows, observed as being permanently flowing in some years and dry in others. The river contains large macrophyte populations which are particularly prevalent in the wetter years as well as good water quality and habitats for significant flora species including *Eucalyptus raveretiana*.	Don	do_r_ec _02	6.3.1 6.4.1	4
Inkerman Station Lagoons	These lagoons occur in lower sub catchments/ billabongs of the Saltwater Creek system and are ‘off line’ from the flow augmentation where turbid nutrient rich river water is experienced by the rest of the system. They retain near natural water quality, blue gum dominated alluvial levees, native macrophyte and fish communities. Connectivity for catadromous fish is periodically impacted by anoxic weed infested reaches of lower Saltwater Creek.	Don	do_r_ec _03	6.2.1 6.3.1	3
Upper Reid River Gorge	The Upper Reid River Gorge boasts unique geomorphology and floristic values (including vine thickets) in a pristine condition retained within fire refugia. The area contains significant populations of red tailed rainbowfish *(Melanotaenia splendida splendida*). The area also has extensive perennial bedrock hosted pools and larger lagoons, gorges and tributary waterfalls. The catadromous fish community is affected by downstream passage barriers on the Haughton River system.	Haughton	ha_r_ec _01	6.1.1 6.3.1	4

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Upper Barratta Creek	The Upper Barratta Creek area provides good connectivity with a range of wetland types providing significant fish habitat areas and allowing for fish migration. Despite being supplemented by tailwaters and subject to encroachment by weeds (particularly Hymenachne), the creek contains good remnant riparian vegetation and is the best of its kind in the Haughton study area. The sites values are largely captured in the DIWA site listings for Barratta Channels Aggregation Qld 196 and the Jerona Aggregation Qld 201. A key feature of the palustrine wetlands in this area is the retention of thousands of hectares of floodplain vegetation, including riparian and back levee swamps, retained during the development of the Burdekin-Haughton Water Supply Scheme (see Tait and Veitch, 2007).	Haughton	ha_r_ec_02	6.3.1 7.1.1	3
Saint Margaret Creek	Saint Margaret Creek is a high-integrity perennial bedrock hosted upper catchment system within national park thereby containing good water quality and natural hydrology. The site has good intact riparian vegetation including lowland alluvial landform hosted reaches which are typically disturbed elsewhere in region from agricultural practices. Saint Margaret Creek has a unique rainforest community on its distil floodout delta. It adjoins the high value Cromarty wetland complex. Additionally, there are no fish passage barriers and therefore supports a thriving fish community including jungle perch (*Kuhlia rupestris*) as well as other catadromous species.	Haughton	ha_r_ec_03	5.2.1 6.2.1 6.3.1 6.4.1 7.1.1 7.1.2	4
Majors Creek	Majors Creek is a high-integrity perennial bedrock hosted upper catchment system within national park thereby containing good water quality and natural hydrology. The site has intact riparian vegetation including lowland reaches, but has more surrounding agricultural development than Saint Margaret Creek. It also has a major fish passage barrier downstream on the Haughton River thereby resulting in the loss of catadromous species, such as jungle perch (*Kuhlia rupestris*) from national park reaches.	Haughton	ha_r_ec_04	6.2.1 6.3.1 6.4.1	3
Horseshoe Lagoon and downstream palustrine swamp to Tidal Limit	This closed canopy Livistona palm dominated riparian forest provides good connectivity to natural, relatively large coastal floodplain lake and coastal Bulkuru sedge swamp. The area has waterfowl and fish habitat values including barramundi (*Lates calcarifer*) nursery values and estuarine crocodile (*Crocodylus porosus*) populations. Current management measures are ensuring fish passage from tidal areas to Horseshoe Lagoon. Note: This decision was also included in the non-riverine ACA assessment (decision number ha_nr_ec_04). See the Burdekin non-riverine report for more details. Note This decision was not implemented as its extent is covered under a wetland ecology decision (ha_r_ec_03).	Haughton	ha_r_ec_05	5.2.1 6.3.1 7.1.1	3

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Healy's Lagoon / Ironbark Ck	This deepwater lagoon system is a distributary of the Haughton River and is connected to the reed beds barramundi (*Lates calcarifer*) nursery swamps (part of the Cromarty wetlands) and is a high value habitat for catadromous fish. Although hydrologically modified by flow augmentation it retains blackwater (natural) water clarity and native macrophyte and riparian forest community including rainforest elements. The site also has a population of estuarine crocodiles (*Crocodylus porosus)* and via its connection through Ironbark Creek to the upper Haughton River provides a connectivity conduit for migratory fish past the fish passage barriers present in the lower Haughton River. It has been a site for revegetation and weed management initiatives.	Haughton	ha_r_ec _06	6.3.1 7.1.2	3
Glady's Lagoon	This is one of the largest examples of a Burdekin River back levee lagoon. The area is largely upstream of irrigation tailwater inputs thereby retaining natural hydrology, water quality, macrophyte communities, seasonally important waterbird habitat and retains a good freshwater fish community. Connectivity for catadromous fish is impacted by downstream road and irrigation infrastructure but barramundi (*Lates calcarifer*) are stocked into the system. It probably represents a prior channel of the Burdekin River and sits high in the Barratta Creek distributary system (See Tait and Veitch, 2007).	Haughton	ha_r_ec _07	6.2.1 6.3.1 6.3.3 6.4.1	3
Church's Lagoon Remnant – Sheep Station Creek	Church's Lagoon is a rare example of lower Burdekin Delta woodlands and riparian forests representative of alluvial landforms converted to agriculture. The area includes blue gum on levees and *Livistona/Nauclea* dominated riparian forest as well as two seasonal wetland basins and frontage to perennial Sheep Station Creek, areas important for woodland birds. The site is weed infested by Chinee apple (*Ziziphus mauritiana*) and exotic grasses though this is controlled by grazing based management which has limited and recovered some impacts (See Tait, 2005 a&b).	Haughton	ha_r_ec _08	5.2.1 6.3.3	2 .
Jack's Lagoon – Sheep Station Creek	Jack's Lagoon is one of the lower most deepwater lagoons on the regulated Sheep Station Creek system actively managed to keep it free of exotic floating aquatic weeds. The water is clearer than upstream sites due to filtering effects of upstream lagoons and vegetation reducing turbidity. The site contains a good native macrophyte community including *Nymphaea* lilies and is adjoined by crown land which retains good, rare examples of *Melaleuca dealbata* swamp forest (see Tait, 2005 a&b).	Haughton	ha_r_ec _09	6.3.1 6.3.3	3
Plantation Park – Plantation Creek	This site is on the outskirts of Ayr and retains one of the best examples of the gallery rainforest community and livistona palm forests that used to occur on the alluvial levees of Burdekin Delta distributary streams. The plantation creek channel running through the site is modified by flow augmentation.	Haughton	ha_r_ec _10	5.2.1	2

Priority ecosystem/ special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Collinsons Lagoon Complex	This site lies on the boundary between the Burdekin Delta and older floodplain (Barratta catchment) and possibly represents a prior (and infilled) channel system of the Burdekin River. The site is impacted by irrigation tail water inputs, aquatic and woody weeds and a hot fire regime but retains significant values including a *Melaleuca dealbata*, blue Gum, livistona dominated riparian forest representative of cleared Delta alluvial landforms. The area also contains a mix of palustrine and riverine wetlands including several isolated from tailwater inputs ensure the retention of a native macrophyte community (see Tait and Veitch, 2007).	Haughton	ha_r_ec_11	5.2.1 6.3.1 6.3.3	3
Stuart creek catchment	The Stuart Creek catchment is characterised by numerous valley areas often fed by permanent springs in the upper reaches and intact headwaters. Stuart Creek is the last seasonal stream with high connectivity to estuarine areas (see Tait, 2006a). The area contains gallery forest and the large pools located in the mid reaches of the creeks provide important habitat for numerous fish species. The relatively intact headwaters and rehabilitation efforts undertaken in the riparian zone maintain a naturally high diversity of threatened vertebrate species. The major barrier to fish passage in the mid reaches has recently been removed restoring access to deepwater lagoons for catadromous fish.	Ross	ro_r_ec_01	6.2.1 6.3.3 6.4.1 7.2.1 7.5.1	4
Alligator Creek	The Alligator Creek area is an active floodplain ecosystem that boasts a good diversity of wetland types with good connectivity with adjacent national parks. A barrage weir in the lower reaches presents connectivity impacts. The site is adjoined by one of the few stands of closed paperbark swamp forest in the Townsville region and has a large palustrine wetland complex on the floodplain created by artificial bunding.	Ross	ro_r_ec_02	6.4.1 7.5.1	4
Stuart Creek below Highway Lagoons	Despite cleared and weed infested riparian vegetation these perennial lagoons have high integrity in terms of water quality, hydrology, fish community and macrophyte community which includes the listed North Queensland lace plant (*Aponogeton bullosus*). The fish community is very diverse and includes a full compliment of catadromous and marine vagrant species including barramundi (*Lates calcarifer*) and mangrove jack (*Lutjanus argentimaculatus*). The macrophyte community is also very diverse and partially maintained by the seasonal hydrology and sustained grazing of para grass (*Urochloa mutica*) dominated margins. There is a full transitional zone to bulkuru sedge brackish and then mangrove lower reaches. The site seasonally supports large and diverse waterbird populations. This system is part of the sub catchment refugia of the broader Ross River basin provided by Stuart Creek.	Ross	ro_r_ec_03	6.2.1 6.3.1	3

4 Connectivity

The panel members were asked to develop and/or identify a set of principles that could be applied to determine relative connectivity scores of riverine spatial units within the GBR catchment and within the non-riverine wetlands. After some time discussing connectivity for non-riverine wetlands, the panel members agreed that connectivity Criterion 7 be turned off for the GBR Non-riverine ACA due to issues associated with its implementation (including method of implementation and resources). Hence, the following sections focus on implementing the connectivity measures for riverine wetlands. Discussion on non-riverine wetland connectivity is recorded here where relevant.

4.1 Importance of connectivity

There was broad agreement by the panel that the concept of connectivity is important, and it is directly or indirectly linked to most facets of aquatic ecology, geomorphology and water quality. The scientific literature reviewed for the AquaBAMM program reflects this view.

The ecological value of a particular reach of river is directly linked in quantity and quality to the movement both up and downstream (and between adjoining terrestrial lands) of resources such as water, sediment and debris and recruitment and distribution of species (Cullen 2003).

An inherent connectivity (or lack of connectivity in drier periods) is a significant feature of fresh waters. In arid-zone systems, and floodplains, the irregular flow regime and sporadic connectivity underpins the conservation of the instream and floodplain wetland biota such as the invertebrate assemblages (Sheldon *et al*. 2002).

Similarly, this relationship is evident for maintaining the health and productivity of end-of-river estuarine systems (Cullen 2003).

A largely unknown and unseen linkage occurs within the hyporheic zone between surface waters and groundwater ecosystems sustaining many endemic or relictual invertebrate fauna (Boulton *et al*. 2003).

4.2 Applying principles for measuring connectivity

The practicalities of measuring connectivity in a riverine environment are complex making general principles difficult to develop and implement. Connectivity in its broadest meaning incorporates hydrological processes (quantity and quality, temporal and spatial variability), organism dispersal (barriers) and disturbances from natural conditions. Connectivity can be bi-directional movements within a stream (e.g., fish passage), uni-directional contribution to a downstream spatial unit or special area, or lateral connectivity to floodplain wetlands or groundwater ecosystems. These aspects of connectivity combine to provide a matrix of competing and differing values from an ecological conservation viewpoint.

4.3 Fish passage (riverine)

The principles for the fish passage connectivity rating (measure 7.1.2) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) were tabled at the wetland ecology expert panel workshop. It was agreed that this method could be implemented in the Burdekin section of the GBR catchment.

An agreed assumption is that barriers lower in the catchment have more impact on fish passage then those in upper reaches of the catchment. There was also recognition that each barrier can be rated according to its relative level of fish passage. The steps outlined below were used to calculate a connectivity score for each spatial unit.

Step 1: Each stream segment is scored for its intrinsic connectivity according to its stream order (1:100,000)

An intrinsic connectivity value for each stream segment can be calculated from a fish migration point of view. The higher the stream order, the higher its intrinsic connectivity score

for fish species. Table 3 provides the scoring system using the stream order of each stream segment.

Table 3 The intrinsic connectivity score for streams

Stream order was calculated using the buffered stream network at a scale of 1:100,000.

Stream order	Intrinsic connectivity score
1	1
2 & 3	2
4 & 5	3
>5	4

Step 2: Modify the intrinsic connectivity score using the fish passage rating for each barrier.

The former Department of Primary Industries and Fisheries (DPIF) rated the major instream barriers in the GBR catchment for their ability to allow fish passage both up and downstream based on the storage height at the spillway (Table 5). Only artificial barriers were considered for a fish passage rating. This fish passage rating is then subtracted from the intrinsic connectivity score to provide a connectivity score for each segment of stream within a spatial unit as shown below:

Connectivity score (CS) = Intrinsic connectivity score (ICS) – Fish passage rating (FPR)

For example, the ICS score for a river segment having a stream order of six would be four, and if a barrier exists on this river reach, its FPR score would be two; resulting in an overall CS score of two (measure 7.1.2) for the spatial unit (i.e., ICS – FPR = 4 – 2 = 2). Table 4 provides the calculation matrix for each combination using the rules outlined below.

Table 4 Calculation matrix for the connectivity score (7.1.2).

	Fish passage rating (FPR)			
Intrinsic connectivity Score (ICS)	**No barrier Present**	**1 Good**	**2 Moderate**	**3 Poor**
1 (Low)	1	1	1	1
2 (Medium)	2	1	1	1
3 (High)	3	2	1	1
4 (Very high)	4	3	2	1

Rules for calculating the connectivity score:

- the CS cannot be lower than 1
- a spatial unit's CS pertains to the highest stream order present in the unit
- where there is no barrier within a spatial unit, the ICS for the highest stream order is used as the CS.

These ratings were used to score the fish passage connectivity in the AquaBAMM measure (7.1.2).

The panel recommended that flow rates available in this region be considered for integration with intrinsic connectivity scores through the use of flow duration curves from each IQQM site to determine how well it is connected. Although this approach has merit, it was not implemented in the ACA for the GBR catchment as further work is required prior to application.

Although the list of fish barriers used under measure 7.1.2 for the Burdekin region is too extensive to present as part of this report (> 1,000 barriers were listed), the full list can be obtained from the Department of Environment and Resource Management by forwarding an email to aquabamm@derm.qld.gov.au.

4.4 Connectivity between freshwater and estuarine wetlands

Connectivity between freshwater wetlands (riverine and non-riverine) and estuarine ecosystems was also recognised by the panel as being important. The panel members discussed several methods for assessing the lateral connectivity of freshwater and estuarine wetlands and agreed that anything that is connected hydrologically and/or biologically to estuarine areas should be given a higher connectivity rating.

The panel suggested assigning a three to an area with hydrological estuarine connectivity and a four to an area that has freshwater wetlands AND hydrological estuarine AND/OR biological connectivity. Although this approach has merit, it was not implemented as part of the ACA for the GBR catchment as further investigation is required prior to application. This approach is expected to be investigated during the implementation of future ACAs.

4.5 Connectivity of special features

The panel members were also asked to develop principles for scoring connectivity for special features such as waterfalls, macrophyte beds, significant instream habitats, and other areas or features identified through expert opinion. This question primarily relates to uni-directional connectivity, i.e. quantity or quality of flow to a downstream special feature.

The principles for assessing connectivity values for special features (measures 7.1.1, 7.2.1) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) was tabled at the panel workshop. The panel agreed that the “Model 4 Inverse exponential scoring of spatial units upstream” method could be implemented in the Burdekin section of the GBR catchment. This model is presented below.

Inverse exponential scoring of spatial units upstream:

> This model uses the spatial units rather than a distance to determine how they are scored. Every contributing spatial unit above a particular special feature was logarithmically scored with the spatial units immediately upstream of a special feature being scored a four, the next adjoining upstream spatial units received a score of two and the remainder above a special feature were scored a one. The spatial unit having the special feature located within it would not receive a score because it was already scored in Criterion 6. Where a spatial unit had more than one calculation (i.e. overlapping scores), the maximum value was incorporated.
>
> This model better reflects the importance of spatial units immediately above a special feature by applying a logarithmic threshold to scoring. It is also an efficient and practical application of a complex issue. A disadvantage of this model is that it treats all special features (e.g. macrophyte bed, geomorphological feature, hydrological feature) equally where there may be reasons to differentiate between them. Also, this model can result in some variation of the real distances upstream of a special feature being scored.

The panel recognised that waterways that feed into special features may either be beneficial or negative depending on the land use upstream or the presence of dams. However, for the majority of areas there was a positive benefit and the proposed model could be applied.

The Fitzroy and Wet Tropics wetland ecology expert panels also recognised that there is some value that can be placed on downstream spatial units connected to special features e.g. some fish need to move downstream to breed. This approach was not applied in the assessment because further investigation is required to determine whether this model can be applied downstream based on the values in the Burdekin.

5 Modelled natural flows

Cullen (2003) proposed an Australian river classification based solely on flow extractions from rivers (Table 5). He argued that flow diversion is the most important threatening process, and one that is easily understood and managed. Cullen (2003) believed a flow classification could be useful in water planning in Australia. These flow extraction thresholds were used as thresholds for the AquaBAMM measure 1.4.2 “Percent natural flows – modelled flows remaining relative to predevelopment”.

Table 5 Australian river classification

River class	Percent mean annual flow
Heritage river	>95%
Conservation river	85 – 95%
Sustainable working river	67 – 85%
Managed working river	<67%

The Department of Environment and Resource Management were able to interpret flow data for the Burdekin region of the GBR catchments and identify areas of modified hydrology. Through this exercise, the flow classes above represent only broad-scale trends with spatial boundaries between classes necessarily approximate. The percent natural flow class of the highest stream order within a spatial unit was assigned to all of the other streams within a spatial unit.

6 Stratification

Study area stratification for application to relevant Measures of AquaBAMM is a user decision and is not mandatory for successful assessment. However, AquaBAMM makes provision for data to be stratified in any user-defined way that is determined to be ecologically appropriate. Stratification mitigates the effects of data averaging across large study areas, and is particularly important where ecological diversity and complexity is high. An example where stratification may be appropriate is fish diversity where fewer species inhabit the upland zone compared to lowland floodplains. For measure datasets where there is an equal probability of scoring across a range of values throughout the study area, stratification is unwarranted. To date, the use of strata in completed ACAs has been limited to 150 m above sea level (ASL) for coastal flowing catchments and 400 m ASL for catchments west of the Great Dividing Range in the Murray-Darling Basin.

Stratification was considered by the Burdekin wetland ecology panel and the following stratification be applied in the respective catchments:

- Belyando – Desert Uplands/Brigalow Belt bioregion boundary in the western part of the subcatchment.
- Black – break of slope based on 150 m ASL.
- Bowen – eastern part of Desert Uplands/Brigalow Belt bioregion boundary.
- Burdekin lower – 150 m ASL.
- Burdekin upper – any subsections that adjoin the Wet Tropics bioregion.
- Haughton and Ross – break of slope based on 150 m ASL with Mt Stuart, The Pinnacles, Castle Hill and Cape Cleveland to be included in the lower stratification.

After further investigation post panel, to maintain consistency with other ACAs, and to reduce the complexity of the calculations it was decided to stratify using 150 m ASL for the Burdekin Lower and Haughton study areas and the Desert Uplands\Brigalow Belt bioregional boundary the Belyando study area. The panel noted that whilst the bioregional boundary is terrestrial, it does reflect relatively abrupt changes in aquatic diversity and richness.

Spatial units above 150 m ASL were grouped together as “upland” for the purpose of measures calculation. Spatial units below 150 m ASL were grouped together as “lowland” for the purpose of measures calculation. Spatial units containing the 150 m ASL contour were allocated to one or other stratum according to the elevation of the majority of the spatial unit (e.g. “upland” where more than 50 per cent of the spatial unit’s area is more than 150 m ASL). When stratification is applied to the spatial units in an ACA, a separate set of measure thresholds is calculated for each stratum (refer Clayton *et al.* 2006).

7 Weighting of measures

The panel members and project officers that attended the nine workshops weighted the measures within each indicator. Measures were weighted according to their importance to an indicator and based on the following rules:

1. At least one measure within each indicator must be weighted 10 which is the highest weight.

2. Weight the other measures within each indicator compared to the weighting of 10 assigned in the first step.

3. It is okay to have different measures with the same weight (i.e. all measures could be weighted 10).

4. Some indicators only have one measure and have already been given a weighting of 10.

5. Don't weight a measure down because of the quality or lack of data for that measure.

The individual weights were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final weights it was decided to average the weights across all three expert panel zones within the Great Barrier Reef study area, rather than average the weights for each zone or study area.

The final weights for each measure were then applied in the AquaBAMM assessment (Table 6). The measure number in Table 6 relates to the hierarchical approach of the AquaBAMM method. The first number refers to a criterion and the second number to an indicator within a criterion followed by the individual measure number.

There are a number of different methods for eliciting expert information, however many of these can become very complicated and time intensive. The benefits of refining the weights through a more detailed method were considered minimal. The result from the approach adopted at the workshop was considered by the AquaBAMM development team to accurately reflect the expert panel's decisions.

Table 6 The average weights for each measure.

Maximum score is 10; total number of participants was approximately 20.

Criteria & indicators	Measures		Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland	7.4
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	10
	1.1.3	Presence of exotic invertebrate fauna within the wetland	5.9
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	7.2
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition	10
	1.2.2	SIGNAL2 score (Max)	8.5
	1.2.3	AUSRIVAS[2] score – Edge (Min band)	7.8
	1.2.4	AUSRIVAS[2] score – Pool (Min band)	7.9
	1.2.9	AUSRIVAS[2] score – Riffle (Min band)	7.9
1.3 Habitat features modification	1.3.1	SOR[1] bank stability	5.6
	1.3.2	SOR[1] bed & bar stability	5.4
	1.3.3	SOR[1] aquatic habitat condition	8.1
	1.3.4	Presence/absence of dams/weirs within the wetland	8.1

Criteria & indicators	Measures		Weight
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)	7.3
	1.3.14	Aquatic habitat condition using acknowledged metric	7.5
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment	9.7
	1.4.7	WRP (Water Resource Plan) hydraulic habitat	9.7
	1.4.8	HEV (High Ecological Value) areas	9.7
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to pre-clearing extent within buffered riverine wetland or watercourses	9.8
	2.2.2	Total number of regional ecosystems relative to pre-clearing number of regional ecosystems within buffered riverine wetland or watercourses	7.6
	2.2.3	SOR[1] reach environs	6.7
	2.2.4	SOR[1] riparian vegetation condition	7.7
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	9.1
	2.3.2	% "grazing" land-use area	8.3
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	8.4
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)	8.8
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area	10
3 Diversity and richness			
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	8.9
	3.1.2	Richness of native fish	9.5
	3.1.3	Richness of native aquatic dependent reptiles	8.5
	3.1.4	Richness of native waterbirds	8.8
	3.1.5	Richness of native aquatic plants	9.6
	3.1.7	Richness of native aquatic dependent mammals	8.2
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa	9.2
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance	7.9
3.3 Habitat	3.3.1	SOR[1] channel diversity	8.3
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	9.0
	3.3.3	Richness of wetland types within the sub-catchment	9.2
3.4 Geomorphology	3.4.1	Richness of geomorphic features	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]	9.9
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]	9.9
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)	9.4
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	9.5
	5.1.3	Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)	8.7
	5.1.4	Habitat for significant numbers of waterbirds	8.1

Criteria & indicators	Measures		Weight
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10
6 Special features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	9.5
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc	8.2
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	9.2
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)	10
7 Connectivity			
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6	9.6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit	9.4
7.1 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)	10
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

8 Ranking of indicators

The panel members and project officers that attended the nine workshops ranked the indicators within each criterion. Indicators were ranked according to their importance to a criterion and based on the following rules:

1. At least one indicator within each criterion must be ranked 1 which is the highest ranking.
2. Rank the other indicators within each criterion relative to the ranking of 1 assigned in the first step.
3. It's okay to have different indicators with the same ranking (i.e. all indicators may be ranked 1).
4. Don't rank an indicator down because of the quality or lack of data for that indicator.

The individual rankings were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final rankings it was decided to average the ranks across all three expert panel zones within the GBR study area, rather than average the ranks for each zone or study area.

The final ranks for each indicator were then applied in the AquaBAMM assessment (Table 7).

Table 7 The average rank for each indicator

Maximum rank is 1; total number of participants was approximately 20.

Indicator	Description	Rank
1 Naturalness aquatic		
1.1	Exotic flora/fauna	2
1.2	Aquatic communities/ assemblages	1
1.3	Habitat features modification	2
1.4	Hydrological modification	1
1.5	Water quality	2
2 Naturalness catchment		
2.1	Exotic flora/fauna	2
2.2	Riparian disturbance	1
2.3	Catchment disturbance	1
2.4	Flow modification	2
3 Diversity and richness		
3.1	Species	1
3.2	Communities/ assemblages	1
3.3	Habitat	1
3.4	Geomorphology	2
4 Threatened species and ecosystems		
4.1	Species	2
4.2	Communities/ assemblages	1
5 Priority species and ecosystems		
5.1	Species	2
5.2	Ecosystems	1
6 Special features		
6.1	Geomorphic features	3
6.2	Ecological processes	2
6.3	Habitat	1
6.4	Hydrological	3

Indicator	Description	Rank
7 Connectivity		
7.1	Significant species or populations	1
7.2	Groundwater dependant ecosystems	1
7.3	Floodplain and wetland ecosystems	1
7.5	Estuarine and marine ecosystems	2

Attachments

Attachment A – GBR catchment study area

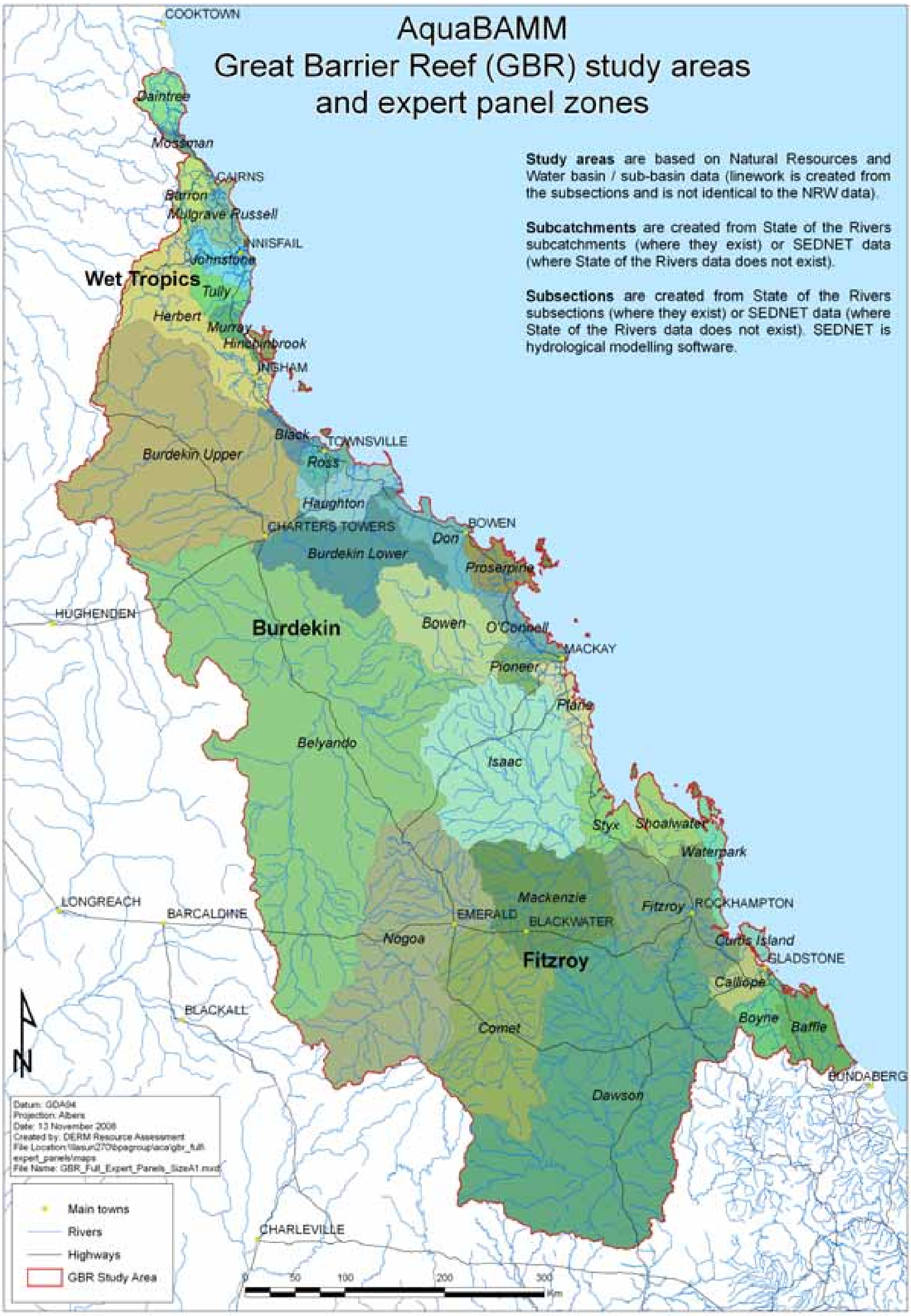

Figure 2 GBR catchment study area

Attachment B – Terms of reference (wetland ecology expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Wetland ecology

The wetland ecology expert panel was established to provide expert advice based on experience and demonstrated scientific theory on natural ecological, geological or geo-morphological and hydrological processes, and issues of connectivity between aquatic systems within the riverine and non-riverine wetlands of the GBR. The panel consisted of professionals in fields of expertise relating to riverine and wetland ecology, water quality, geomorphology, fisheries and hydrological processes.

The tasks undertaken by the panel included, but without limitation, the following:

- identify areas of significant geomorphological, ecological or hydrological processes, or priority areas – special features
- provide advice on biodiversity 'hot-spots' or areas of particular significance for species or communities
- establish principles for applying the connectivity criterion (bi-directional, unidirectional and lateral directions) in the wetland ecosystems
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a "starter set" for consideration in setting the assessment parameters for each ACA.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 8 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features.
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (Expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
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[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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Attachment G GBR catchments riverine ACA – Aquatic flora expert panel report (Fitzroy region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Aquatic flora
Expert panel report

Fitzroy region

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Tables

Figures

Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address ‘aquatic fauna’, ‘aquatic and riparian flora’ and ‘wetland ecology’ for some of the information.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. It provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic flora expert panel for the Fitzroy region held in Rockhampton on Tuesday 9 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the panel are provided in Attachment B.

2 Method

2.1 Study area

The Fitzroy section of the GBR catchment is a vast and extremely varied area. It ranges from the high rainfall, short, fast streams surrounded by rainforest on the Whitsunday coast to the slow, turbid, meandering floodplain streams of the Fitzroy catchment. It encompasses parts of three bioregions, supports Ramsar-listed wetlands and its waters impact on the southern and central GBR. It includes iconic sandstone gorges in places like the Carnarvon Ranges to perched lakes in the upper Comet sub-catchment to world-recognised wetland complexes such as the Goorganga Plains as well as waterfalls, cascades and torrents in the rainforests of the Whitsundays.

The Fitzroy catchment itself is the largest eastward flowing system in Australia and only exceeded by the Murray-Darling system Australia wide. The area includes two catchments (Waterpark Creek and Repulse Creek) that are almost entirely surrounded by protected areas while in contrast some catchments are highly modified with a number of rivers heavily regulated by dams, weirs and irrigation development.

The climate of the area is also highly variable. It ranges from distinctly tropical in the north to subtropical in the south. Rainfall is distinctly seasonal with a pronounced wet season from December to March but the amount of rain that falls is amongst the most variable in the world. Between 1976 and 2008, wet season flow to the mouth of the Fitzroy varied from around 349, 677 megalitres to 22,903,390 megalitres. Much of the aquatic ecology of the area is driven by variable boom and bust cycles and is consequently amongst the most resilient anywhere.

The largest land use in terms of area is cattle grazing, however extensive cropping and intensive cultivation of sugar cane is also very important. The area also contributes a huge quantity of coal that is vital to the Queensland and Australian economy.

It is not possible to adequately give an overview of such a vast and varied area, so a brief description of the 17 catchment areas is provided in Attachment C. This attachment should be considered when interpreting the contents of this report.

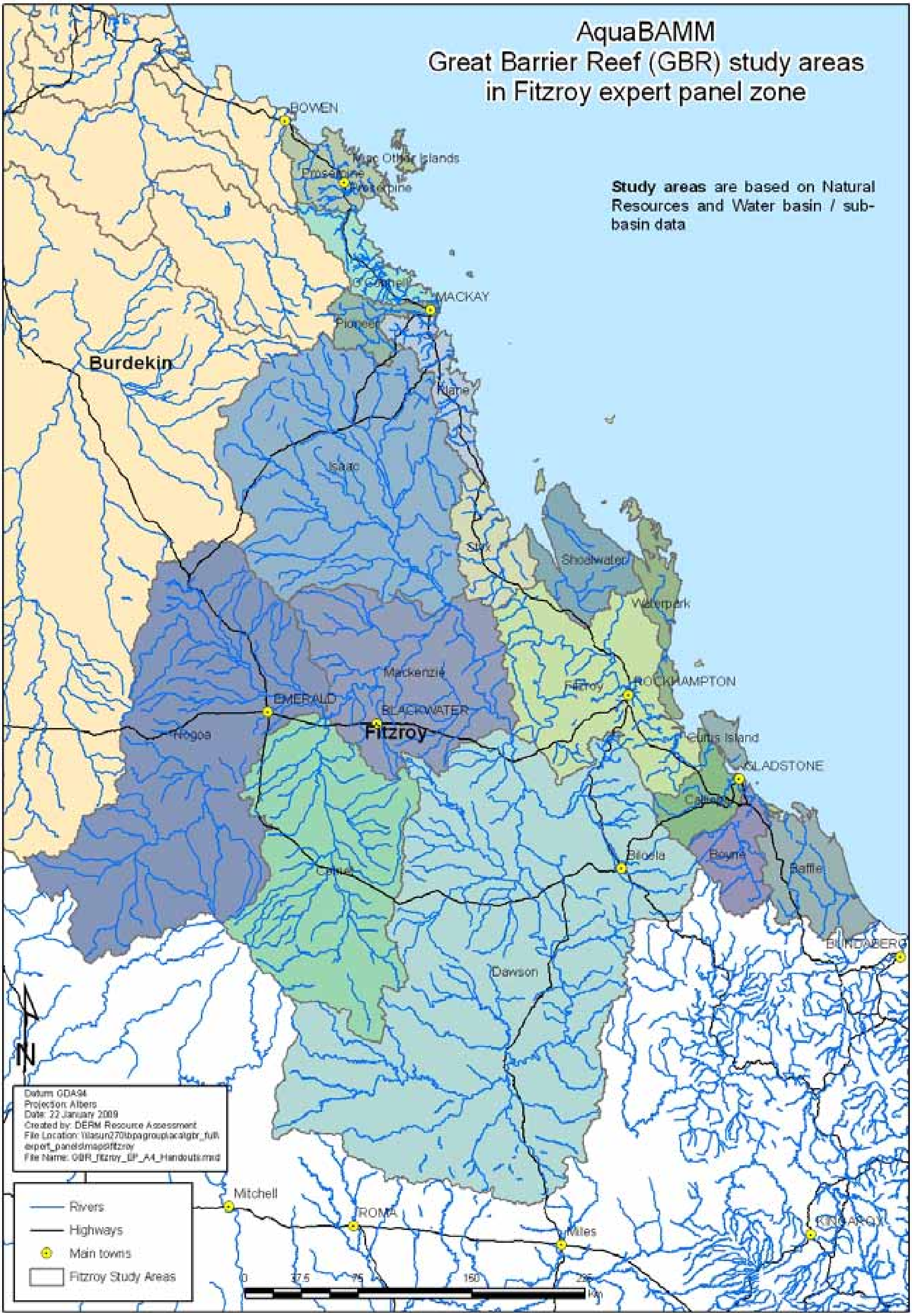

Figure 1 Fitzroy section of the GBR catchment (incorporating 17 individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised of invited persons (Table 1) familiar with aquatic flora in the Fitzroy section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	**Position / organisation**	**Expertise**
Jeanette Kemp	Principal Botanist, Department of Environment and Resource Management	Native and exotic flora
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
John McCabe	Senior Extension Officer, Nature Refuges, Department of Environment and Resource Management	Waterbirds, flora, and landscape restoration
John Platten	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Biodiversity planning, aquatic ecology and water quality
Joy Brusch	Senior Botanist, Department of Environment and Resource Management	Tropical flora
Leo Duivenvoorden	Senior Lecturer/ Researcher, Central Queensland University	Aquatic and semi-aquatic plants
Nick Cuff	Senior Botanist, Queensland Herbarium, Department of Environment and Resource Management	Botany and regional ecosystem assessment
Rhonda Melzer	Team Leader, Conservation Management Branch, Department of Environment and Resource Management	Botany and terrestrial ecology
Steve Elson	Principal Planning Officer, Department of Environment and Resource Management	Biodiversity planning

Selena Inglis and Heidi Millington provided administrative and technical support for the workshop, which was facilitated by Steven Howell.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened flora

The panel identified three 'rare' and two 'vulnerable' flora taxa in the Fitzroy section of the GBR catchment as being primarily aquatic, semi-aquatic or riparian in habit (Table 2). Threatened taxa were excluded from this list if they did not correspond to one of these categories. This list of flora was used as the basis for identifying areas of significance for 'Criterion 4 Threatened species and ecosystems' (4.1.2). Point records were used to identify the spatial units having that species present.

Table 2 Aquatic, semi-aquatic and riparian flora species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.2.

Scientific name	**Common name**	**Status**	**Habitat**	**Comments**
Eleocharis blakeana		R[1]		Found mainly in Brigalow gilgais
Eucalyptus raveretiana	Black ironbox	V[1,2]		Grows only on the banks of creeks between the high bank and low bank.
Livistona nitida		R[1]		
Neoroepera buxifolia		V[1,2]		

- *recent records (>1950) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

4 Priority flora

The panel deliberated on all aquatic, semi-aquatic and riparian species within the GBR catchment to identify ‘priority flora’ (excluding the rare or threatened species listed in Table 2). The panel adopted a revised version of the earlier definition of a priority species from the Burnett River ACA: namely, a priority species must exhibit one or more of the following significant values:

1. It forms significant macrophyte beds (in shallow or deep water).
2. It is an important/critical food source.
3. It is important/critical habitat.
4. It is implicated in spawning or reproduction for other fauna and/or flora species.
5. It is at its distributional limit or is a disjunct population.
6. It provides stream bank or bed stabilisation or has soil-binding properties.
7. It is a small population and subject to threatening processes.

The panel identified 26 riverine priority flora species (Table 3). These species were included in ‘Criterion 5 Priority species and ecosystems’ (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present.

Table 3 Identified priority flora species and their significant values

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	Common name	Habitat	Comments
Casuarina cunninghamiana			One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Casuarina cunninghamiana subsp. cunninghamiana	Sheoak	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Eucalyptus camaldulensis		Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Eucalyptus coolabah	Coolabah	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Eucalyptus tereticornis			One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Lomandra hystrix		Semi-aquatic[4]	Provides important habitat and source of food for fauna species. Helps maintain water quality via bank stabilisation and water filtering.
Lomandra longifolia		Semi-aquatic[4]	Forms significant macrophytes beds providing important habitat and food for fauna species. Helps maintain water quality via bank stabilisation and water filtering.

Scientific name	Common name	Habitat	Comments
Melaleuca bracteata	Black tea-tree	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Melaleuca fluviatilis		Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Melaleuca leucadendra	Broad-leaved tea-tree		One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Melaleuca linariifolia	Snow-in summer	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Melaleuca quinquenervia	Swamp paperbark	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Melaleuca viminalis	Callistemon	Riparian[3]	One of the canopy dominants in regional ecosystem 11.3.25 that contributes to structural complexity. It provides important habitat and source of food for fauna species.
Muehlenbeckia florulenta	Lignum	Riparian[3]	Forms significant macrophyte beds providing important habitat and source of food for fauna species
Myriophyllum simulans			Forms significant macrophyte beds providing important habitat and source of food for fauna species
Myriophyllum verrucosum	Water milfoil	Aquatic[4]	Forms significant macrophyte beds providing important habitat and source of food for fauna species
Najas tenuifolia	Water nymph	Aquatic[4]	Forms significant macrophyte beds providing important habitat and source of food for fauna species
Nelumbo nucifera	Pink waterlily		Forms significant macrophyte beds providing important habitat and source of food for fauna species
Nymphaea gigantea		Aquatic[4]	Forms significant macrophyte beds
Nymphoides exiliflora			Forms significant macrophyte beds providing critical habitat and source of food for threatened fauna species
Nymphoides indica	Water snowflake	Aquatic[4]	Forms significant macrophyte beds providing critical habitat and source of food for threatened fauna species
Ottelia alismoides			Forms significant macrophyte beds providing critical habitat and source of food for threatened fauna species
Paspalum distichum	Water couch	Semi-aquatic[4]	Forms significant macrophyte beds providing important habitat and source of food for fauna species. Also plays a soil binding and stabilisation role.
Phragmites australis	Common reed	Aquatic[4]	Forms significant macrophyte beds providing important habitat including spawning grounds for fauna. Also plays a soil binding and stabilisation role.

Scientific name	Common name	Habitat	Comments
Typha orientalis	Broad-leaved cumbungi		Forms significant macrophyte beds providing important habitat including spawning grounds for fauna. Also plays a soil binding and stabilisation role.
Vallisneria nana		Aquatic[4]	Forms significant macrophyte beds

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

5 Species richness

Species richness (i.e. total number of species) was scored for aquatic-dependant flora, stratified using 150 m above seal level (ASL) for the Baffle study area. See the Fitzroy ecology expert panel report for more information on stratification.

The Fitzroy section of the GBR catchment has 167 plants that are referred to in this report as 'aquatic-dependant' in riverine wetlands (Table 4). The datasets for these species were accessed from the DERM corporate databases of WildNet and Herbrecs and from panel member records.

The panel defined 'aquatic-dependent flora' to mean:

> *'those species that are adapted to and dependant on living in wet conditions for at least part of their life cycle and found either within or immediately adjoining a non-riverine or riverine wetland'.*

This definition of a wetland-dependent plant extends beyond the more traditional definition of submerged and floating aquatic plants to include plants inhabiting the littoral zone (waters edge) and plants that usually have 'wet feet' on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM indicator and measure of species richness: 'Richness of wetland dependent plants' (3.1.5). The indicator is a measure of floristic richness of a particular spatial unit's aquatic environment, and hence, a broad definition better depicts the flora richness value at a given location.

Table 4 Wetland-dependent native flora species, including priority species

This list was used to calculate an aquatic and riparian flora richness score (3.1.5), threatened flora species (4.1.2) and priority flora species (5.1.2).

Scientific name	Common name	Status	Habitat	Comments
Angophora floribunda	Rough-barked apple	LC[1]		Bank stabilisation
Aponogeton queenslandicus		LC[1]		
Baumea articulata	Jointed twigrush	LC[1]		Important habitat
Baumea juncea	Bare twigrush	LC[1]		Important habitat
Baumea planifolia		LC[1]		Important habitat
Blyxa aubertii		LC[1]	Aquatic[4]	Macrophyte beds
Blyxa octandra		LC[1]		Macrophyte beds
Bolboschoenus fluviatilis		LC[1]		Important habitat
Bulbochaete kwangtungensis		LC[1]		Macrophyte beds
Bulbochaete polyandria		LC[1]		Macrophyte beds
Carex breviculmis		LC[1]		Important habitat
Carex brunnea		LC[1]		Important habitat
Carex declinata		LC[1]		Important habitat
Carex fascicularis	Tassel sedge	LC[1]		Important habitat
Carex gaudichaudiana		LC[1]		Important habitat
Carex inversa	Knob sedge	LC[1]		Important habitat
Carex lobolepis		LC[1]		Important habitat
Carex polyantha		LC[1]		Important habitat

Scientific name	Common name	Status	Habitat	Comments
Casuarina cunninghamiana		LC[1]		Important to structural complexity
Casuarina cunninghamiana subsp. cunninghamiana		LC[1]		Bank stability
Caustis flexuosa		LC[1]		Important habitat
Caustis pentandra	Thick twistrush	LC[1]		Important habitat
Caustis recurvata		LC[1]		Important habitat
Caustis sp. (Robinson Gorge P.I.Forster+ PIF11256)		LC[1]		Important habitat
Chara fibrosa		LC[1]		Macrophyte beds
Chara vulgaris		LC[1]		Macrophyte beds
Cladophora glomerata		LC[1]		Macrophyte beds
Coleochaete irregularis		LC[1]		Macrophyte beds
Corymbia tessellaris	Moreton Bay ash	LC[1]		Bank stabilisation
Cyperus alterniflorus		LC[1]		Important habitat
Cyperus bifax	Western nutgrass	LC[1]		Important habitat
Cyperus bowmannii		LC[1]		Important habitat
Cyperus castaneus		LC[1]		Important habitat
Cyperus concinnus		LC[1]		Important habitat
Cyperus conicus var. conicus		LC[1]		Important habitat
Cyperus cyperinus		LC[1]		Important habitat
Cyperus cyperoides		LC[1]	Semi-aquatic[4]	Important habitat
Cyperus dietrichiae		LC[1]		Important habitat
Cyperus dietrichiae var. brevibracteatus		LC[1]		Important habitat
Cyperus dietrichiae var. dietrichiae		LC[1]		Important habitat
Cyperus distans		LC[1]	Semi-aquatic[4]	Important habitat
Cyperus exaltatus	Tall flatsedge	LC[1]	Semi-aquatic[4]	Important habitat
Cyperus fulvus		LC[1]		Important habitat
Cyperus gilesii		LC[1]		Important habitat
Cyperus gunnii		LC[1]		Important habitat
Cyperus gunnii subsp. gunnii		LC[1]		Important habitat
Cyperus haspan		LC[1]	Semi-aquatic[4]	Important habitat
Cyperus laevigatus		LC[1]		Important habitat
Cyperus laevis		LC[1]		Important habitat
Cyperus leiocaulon		LC[1]		Important habitat
Cyperus mirus		LC[1]		Important habitat
Cyperus nervulosus		LC[1]		Important habitat
Cyperus perangustus		LC[1]		Important habitat

Scientific name	Common name	Status	Habitat	Comments
Cyperus polystachyos		LC[1]	Semi-aquatic[4]	Important habitat
Cyperus polystachyos var. polystachyos		LC[1]		Important habitat
Cyperus pulchellus		LC[1]		Important habitat
Cyperus pygmaeus	Dwarf sedge	LC[1]		Important habitat
Cyperus sculptus		LC[1]		Important habitat
Cyperus sphaeroideus		LC[1]		Important habitat
Cyperus tetracarpus		LC[1]		Important habitat
Cyperus tetraphyllus		LC[1]		Important habitat
Cyperus victoriensis		LC[1]		Important habitat
Desmococcus viridis		LC[1]		Macrophyte beds
Eleocharis acuta		LC[1]		Important habitat
Eleocharis blakeana		R[1]		Found mainly in Brigalow gilgais
Eleocharis cylindrostachys		LC[1]	Semi-aquatic[4]	Important habitat
Eucalyptus camaldulensis		LC[1]	Riparian[3]	Bank stabilisation
Eucalyptus camaldulensis var. camaldulensis		LC[1]		Bank stabilisation
Eucalyptus coolabah	Coolabah	LC[1]	Riparian[3]	Bank stabilisation (need records)
Eucalyptus raveretiana	Black ironbox	V[1,2]		Bank stabilisation small threatened population
Eucalyptus tereticornis		LC[1]		Bank stabilisation
Fimbristylis bisumbellata		LC[1]		Important habitat
Fimbristylis depauperata		LC[1]		Important habitat
Fimbristylis dichotoma	Common fringe-rush	LC[1]		Important habitat
Fimbristylis oxystachya		LC[1]		Important habitat
Gahnia aspera		LC[1]		Important habitat
Gloeocystis		LC[1]		Macrophyte beds
Hydrilla verticillata	Hydrilla	LC[1]	Aquatic[4]	Macrophyte beds
Hymenachne acutigluma		LC[1]		Small population
Isolepis cernua	Nodding club rush	LC[1]		Important habitat
Isolepis inundata	Swamp club rush	LC[1]		Important habitat
Lepilaena australis		LC[1]		Macrophyte beds
Lepironia articulata		LC[1]		Important habitat
Livistona nitida		R[1]		
Livistona spp.	Livistona palms			
Lomandra confertifolia subsp. pallida		LC[1]	Semi-aquatic[4]	Bank stability
Lomandra hystrix		LC[1]	Semi-aquatic[4]	Bank stability
Lomandra longifolia		LC[1]	Semi-aquatic[4]	Bank stability

Scientific name	Common name	Status	Habitat	Comments
Lomandra multiflora		LC[1]	Semi-aquatic[4]	Bank stability
Melaleuca bracteata	Black tea-tree	LC[1]	Riparian[3]	Important for structural complexity
Melaleuca fluviatilis		LC[1]	Riparian[3]	Important for structural complexity
Melaleuca leucadendra	Broad-leaved tea-tree	LC[1]		Important for structural complexity
Melaleuca linariifolia	Snow-in summer	LC[1]	Riparian[3]	Important for structural complexity
Melaleuca quinquenervia	Swamp paperbark	LC[1]	Riparian[3]	Important for structural complexity
Melaleuca viminalis		LC[1]	Riparian[3]	Bank stability
Muehlenbeckia florulenta	Lignum	LC[1]	Riparian[3]	Macrophyte beds
Myriophyllum gracile var. gracile		LC[1]		Macrophyte beds
Myriophyllum gracile var. lineare		LC[1]		Macrophyte beds
Myriophyllum muricatum		LC[1]		Macrophyte beds
Myriophyllum simulans		LC[1]		Macrophyte beds
Myriophyllum variifolium		LC[1]		Macrophyte beds
Myriophyllum verrucosum	Water milfoil	LC[1]	Aquatic[4]	Macrophyte beds
Najas tenuifolia	Water nymph	LC[1]	Aquatic[4]	Macrophyte beds
Nauclea orientalis	Leichhardt tree	LC[1]		
Nelumbo nucifera	Pink waterlily	LC[1]		Macrophyte beds
Neoroepera buxifolia		V[1,2]		
Nitella cristata		LC[1]		Macrophyte beds
Nitella penicillata		LC[1]		Macrophyte beds
Nitella pseudoflabellata		LC[1]		Macrophyte beds
Nitella tasmanica		LC[1]		Macrophyte beds
Nymphaea gigantea		LC[1]	Aquatic[4]	Macrophyte beds
Nymphoides crenata	Wavy marshwort	LC[1]		Macrophyte beds
Nymphoides indica	Water snowflake	LC[1]	Aquatic[4]	Macrophyte beds
Oedogonium itzigsohnii		LC[1]		Macrophyte beds
Oedogonium rufescens				
Oedogonium tapeinosporum		LC[1]		Macrophyte beds
Ottelia alismoides		LC[1]		Macrophyte beds
Ottelia ovalifolia	Swamp lily	LC[1]	Aquatic[4]	Macrophyte beds
Paspalum distichum	Water couch	LC[1]	Semi-aquatic[4]	
Phragmites australis	Common reed	LC[1]	Aquatic[4]	Macrophyte beds
Potamogeton crispus	Curly pondweed	LC[1]	Aquatic[4]	Macrophyte beds

Scientific name	Common name	Status	Habitat	Comments
Potamogeton pectinatus	Fennel pondweed	LC[1]		Macrophyte beds
Potamogeton tepperi		LC[1]		Macrophyte beds
Potamogeton tricarinatus	Floating pondweed	LC[1]	Aquatic[4]	Macrophyte beds
Pseudendoclonium		LC[1]		Macrophyte beds
Rhizoclonium implexum		LC[1]		Macrophyte beds
Rhizoclonium tortuosum		LC[1]		Macrophyte beds
Rhynchospora brownii	Beak rush	LC[1]		Important habitat
Rhynchospora corymbosa		LC[1]		Important habitat
Rhynchospora heterochaeta		LC[1]		Important habitat
Rhynchospora rubra		LC[1]		Important habitat
Schoenoplectus lateriflorus		LC[1]		Important habitat
Schoenoplectus litoralis		LC[1]		Important habitat
Schoenoplectus mucronatus		LC[1]		Important habitat
Schoenoplectus validus		LC[1]		Important habitat
Schoenus apogon var. apogon		LC[1]		Important habitat
Schoenus brevifolius		LC[1]		Important habitat
Schoenus falcatus		LC[1]		Important habitat
Schoenus kennyi		LC[1]		Important habitat
Schoenus lepidosperma subsp. pachylepis		LC[1]		Important habitat
Schoenus maschalinus		LC[1]		Important habitat
Schoenus vaginatus		LC[1]		Important habitat
Scleria brownii		LC[1]		Important habitat
Scleria mackaviensis		LC[1]		Important habitat
Scleria sphacelata		LC[1]		Important habitat
Sparganium subglobosum	Floating bur-reed	LC[1]		Important habitat
Syzygium australe	Scrub cherry	LC[1]	Riparian[3]	
Terminalia sericocarpa	Damson	LC[1]		
Tetraria capillaris		LC[1]		Important habitat
Trentepohlia abietina		LC[1]		Macrophyte beds
Trentepohlia abietina var. tenue		LC[1]		Macrophyte beds
Trentepohlia arborum		LC[1]		Macrophyte beds
Trentepohlia bossei var. brevicellulis		LC[1]		Macrophyte beds
Trentepohlia bossei var. samoensis		LC[1]		Macrophyte beds
Trentepohlia effusa		LC[1]		Macrophyte beds

Scientific name	Common name	Status	Habitat	Comments
Trentepohlia odorata		LC[1]		Macrophyte beds
Trentepohlia odorata var. compacta		LC[1]		Macrophyte beds
Trentepohlia peruana		LC[1]		Macrophyte beds
Trentepohlia rigidula		LC[1]		Macrophyte beds
Typha orientalis	Broad-leaved cumbungi	LC[1]		Macrophyte beds
Typha domingensis		LC[1]	Aquatic[4]	Important habitat
Utricularia bifida		LC[1]	Aquatic[4]	Macrophyte beds
Utricularia caerulea	Blue bladderwort	LC[1]		Macrophyte beds
Utricularia dichotoma	Fairy aprons	LC[1]	Aquatic[4]	Macrophyte beds
Utricularia uliginosa	Asian bladderwort	LC[1]		Macrophyte beds
Vallisneria nana		LC[1]	Aquatic[4]	Macrophyte beds
Waterhousea floribunda	Weeping lilypilly	LC[1]	Riparian[3]	
Zygogonium ericetorum		LC[1]		Macrophyte beds

- *recent records (>1950) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*
3. *Queensland Herbarium list of wetland species (contact Bruce Wilson)*
4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

6 Exotic flora

The panel recommended that only exotic plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a riverine landscape be included for the GBR ACA using AquaBAMM. Ninety-one (91) plant taxa that are known to occur within the riverine wetlands in the Fitzroy section of the GBR catchment were nominated by the panel (Table 5). The presence of aquatic and semi-aquatic flora species were recorded under criterion 1 naturalness (aquatic) (1.1.2). Riparian exotic flora species were recorded under criterion 2 naturalness (catchment) (2.1.1).

The degree of infestation and abundance of an exotic plant at a particular locality was acknowledged by the panel as being an important factor in determining the level of impact to a natural ecosystem. Where available, information and mapping of exotic species' extent (sourced from the Department of Environment and Resource Management and regional bodies) were used instead of point records to flag the spatial units that have an exotic species present. Where only a point record is available for a location, then the record was used to identify the spatial units as having an exotic species present. Hence, an individual point record may or may not correspond to localities of dense weed infestations.

Table 5 Exotic flora species

This list was used to calculate the measures for 1.1.2 and 2.1.1 in the AquaBAMM assessment.

Scientific name	Common name	Habitat	Comments
Arundo donax			May have a high impact especially in ungrazed areas as it thrives on sandy soils like those for example along Moore's Creek.
Baccharis halimifolia	Groundsel bush		Limited in this region where it is mainly a pest on the edge of Melaleuca swamps. It also occurs near Granite Creek and is prevalent adjacent the mangroves near Eurimbula.
Cyperus involucratus			It is a problem in small streams with particularly bad infestations near Gladstone.
Echinochloa polystachya cv. Amity	Aleman grass		A deep water ponded pasture species that builds up causing significant problems particularly in impoundments with no significant flow. It also invades streams and outcompetes water lilies. It is a major threat in very specific locations for example the Fitzroy River barrage.
Eichhornia crassipes	Water hyacinth	Aquatic[4]	Key species in terms of wetland condition indicator.
Hymenachne amplexicaulis cv. Olive			Significant weed that outcompetes native species.
Mimosa pigra		Riparian[3]	Significant weed but very limited distribution within the region. Main occurrence is at Peter Faust Dam where it is being dealt with. May become a significant threat in the future.
Myriophyllum aquaticum	Brazilian water milfoil		Limited in this region but should be flagged as becoming a potential future problem as it becomes a threat when deliberately introduced.
Pennisetum alopecuroides	Swamp foxtail		Still being distributed as a nursery plant. It is posing a significant threat to one ecosystem in the Connors Range (8.3.13).

Scientific name	Common name	Habitat	Comments
Pistia stratiotes	Water lettuce		Major problem particularly in slow moving backwaters and around weirs.
Salvinia molesta	Salvinia		A problem particularly in dry times as it builds up significantly.
Urochloa mutica	Para grass	Semi-aquatic[4]	Coastal weed that can create ponded pastures. In the absence of grazing it smothers wetlands reducing the diversity of birds and fish.
Acacia nilotica	Prickly acacia		
Agave americana			
Agave americana var. americana			
Agave americana var. americana cv. Marginata			
Agave sisalana	Sisal hemp		
Agave vivipara var. vivipara			
Anredera cordifolia	Madeira vine		
Aristolochia elegans	Calico-flower		Impacts on the birdwing butterfly (*Ornithoptera priamus*).
Asystasia gangetica subsp. gangetica			Found growing in gravely creek beds.
Bryophyllum delagoense			
Bryophyllum pinnatum	Resurrection plant		Infestations in Marlborough Creek.
Caesalpinia decapetala	Wait-a-while		Thrives in wet places occurring along Granite Creek.
Cardiospermum grandiflorum	Heart seed vine		
Cardiospermum halicacabum			
Cardiospermum halicacabum var. halicacabum			
Cascabela thevetia	Yellow oleander		Infestations are becoming a problem.
Catharanthus roseus	Pink periwinkle		No significant impact observed yet. However may become a problem in the future.
Cryptostegia grandiflora	Rubber vine		Presence can be used as an indicator of poor condition.
Duranta erecta	Duranta		
Eugenia uniflora	Brazilian cherry tree		Mainly found in urban areas.
Furcraea foetida			
Gmelina elliptica	Badhara bush		
Haematoxylum campechianum	Logwood tree		Highly invasive of some ecosystems around Mackay and across the Fitzroy River floodplain.
Harrisia martini			
Harrisia pomanensis			
Harrisia tortuosa			

Scientific name	Common name	Habitat	Comments
Ipomoea cairica			
Ipomoea indica	Blue morning-glory		
Jatropha gossypiifolia			Highly invasive, declared weed, widespread around Styx River catchment and Alton Downs.
Lantana camara			
Lantana camara cv. Gol Gol			
Lantana montevidensis	Creeping lantana		
Leonotis nepetifolia	Lions tail		
Leucaena leucocephala			
Leucaena leucocephala subsp. glabrata			
Leucaena leucocephala subsp. leucocephala			
Lippia alba var. alba			
Macfadyena unguis-cati	Cat's claw creeper		Significant weed of coastal areas.
Macroptilium atropurpureum	Siratro		Smothers native plants growing on creek banks.
Macrotyloma axillare var. axillare			Has potential to become a weed.
Macrotyloma uniflorum			Has potential to become a weed.
Macrotyloma uniflorum var. stenocarpum			Has potential to become a weed.
Macrotyloma uniflorum var. uniflorum			Has potential to become a weed.
Mangifera indica	Mango		Has become a problem around Mackay.
Megathyrsus maximus			This species generates significant fuel loads that can carry hot fires which cause damage to native ecosystems.
Megathyrsus maximus var. coloratus			This species generates significant fuel loads that can carry hot fires which cause damage to native ecosystems.
Megathyrsus maximus var. maximus			This species generates significant fuel loads that can carry hot fires which cause damage to native ecosystems.
Megathyrsus maximus var. maximus cv. Hamil			This species generates significant fuel loads that can carry hot fires which cause damage to native ecosystems.
Megathyrsus maximus var. pubiglumis			This species generates significant fuel loads that can carry hot fires which cause damage to native ecosystems.
Opuntia aurantiaca	Tiger pear		
Opuntia leucotricha			
Opuntia streptacantha	Cardona pear		
Opuntia stricta			

Scientific name	Common name	Habitat	Comments
Opuntia tomentosa	Velvety tree pear		
Parkinsonia aculeata	Jerusalem thorn		
Parthenium hysterophorus	Parthenium weed		
Pennisetum ciliare	Buffel grass		
Pinus caribaea	Caribbean pine		
Pinus elliottii	Slash pine		
Praxelis clematidea			
Prosopis glandulosa var. glandulosa			
Prosopis pallida			
Psidium guajava	Guava		
Psidium guineense	Cherry guava		
Ricinus communis	Castor oil bush		Grows in beds and banks of streams, and may possibly be wetland dependant.
Rivina humilis			Inhibits regeneration of native species particularly in scrub areas.
Schinus terebinthifolius	Broad leaved pepper		
Senna occidentalis	Coffee senna		
Sorghum halepense	Johnson grass		
Sphagneticola trilobata			Thrives around urban areas.
Synedrellopsis grisebachii			Problem weed in the Boyne and Calliope River catchments.
Syzygium cumini			Started to occur on floodplains.
Tecoma stans	Tecoma		
Tecoma stans var. stans			
Tecoma stans var. velutina			
Thunbergia grandiflora	Sky flower		
Thunbergia laurifolia			
Xanthium occidentale	Noogoora burr		
Ziziphus mauritiana	Indian jujube		

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4. *Clayton, P.C., Fielder, D.F., Howell, S. and Hill, C.J. 2006. Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool with trial application in the Burnett River catchment. Queensland Environmental Protection Agency, Brisbane.*

7 Priority ecosystems and special features

The panel identified several riverine priority ecosystems/special features in the Fitzroy section of the GBR catchment (Table 6). These were identified for their aquatic and riparian flora values. Where special features nominated by the aquatic flora expert panel were also considered to have additional values (e.g. fauna, ecology) by the aquatic fauna or wetland ecology expert panels, the area was implemented as a wetland ecology special feature.

Each spatial unit that intersected with a particular ecosystem or feature in Table 6 was given a score equal to the conservation rating.

Table 6 Identified priority ecosystems and special features and their values.

Decisions listed by catchment. These features were intersected with the spatial units to identify the values for Criterion 6 Special features. All implemented special features were given a conservation rating of between 1 and 4 assigned by the panel.

Priority ecosystem/ special feature	**Values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Ribbon weed (*Vallisneria nana*) beds	There are few areas of extensive ribbon weed in the Baffle Creek catchment (Andrew McDougall pers. comm. Dec 2006).	Baffle	ba_r_fl_02	6.3.1	4
Regional ecosystem 12.3.7	Regional ecosystem 12.3.7 is the southeast Queensland bioregion equivalent of 11.3.25 and 8.3.3. That is, it is one of the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*) providing important habitat for many fauna species.	Baffle	ba_r_fl_03	5.2.1	4
Koolkooroom Creek	Koolkooroom Creek is habitat for a number of rare and threatened species including *Cycas megacarpa, Fontainea venosa, Sophora fraseri (*brush sophora)*, Macropteranthes leiocaulis, Atalaya rigida, Senna acclinis* and *Alyxia sharpei.*	Boyne	bo_r_fl_01	6.3.1	4
Creeks draining from Castle Tower granites (Many Peaks Range including the eastern Boyne River)	Contained mostly within National Park this area is in good condition and contains rare, threatened and endemic species. Note: This decision straddles the Boyne and Baffle study areas. The Baffle component of this decision is covered by decision number ba_r_fl_01.	Boyne	bo_r_fl_02	6.3.1	3
Regional ecosystem 12.3.7	Regional ecosystem 12.3.7 is the southeast Queensland bioregion equivalent of 11.3.25 and 8.3.3. That is, it is one of the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*) providing important habitat for many fauna species.	Boyne	bo_r_fl_03	5.2.1	4

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Creeks flowing off Mt Larcom	Cherry Creek contains rare and threatened species including *Actephila sessilifolia, Atalaya rigida, Cupaniopsis shirleyana* and also has patches of rainforest dominated by Mueller's redheart (*Dissiliaria muelleri*). Mueller's redheart (*Dissiliaria muelleri*) is not currently listed as rare or threatened but has a very restricted distribution. The vegetation along these creeks is part of a large remnant area that contains significant patches of dry rainforest as well as the rocky outcrops of Mt Larcom that are habitat to rare and endemic species. This area was previously a national park proposal and is currently under threat from industrial development and lack of appropriate ecological management.	Calliope	ca_r_fl_01	6.3.1	3
Regional ecosystem 12.3.7	Regional ecosystem 12.3.7 is the southeast Queensland bioregion equivalent of 11.3.25 and 8.3.3. That is, it is one of the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*) providing important habitat for many fauna species.	Calliope	ca_r_fl_02	5.2.1	4
Blackdown Tableland	The entire sandstone tableland area including the creeks flowing through and from it are habitat for numerous endemic, rare and threatened species as well as containing significant indigenous cultural values including rock art sites. Planet Creek is particularly high in all of these values including the section on Planet Downs south of Blackdown National Park. The area is fairly dry and highly phosphorous deficient. Also an important habitat for frogs. <u>Note</u>: This decision straddles the Comet and Dawson study areas. The Dawson component of this decision is covered by decision number dn_r_fl_01.	Comet	ct_r_fl_01	6.3.1	4
Regional ecosystem 12.3.7	Regional ecosystem 12.3.7 is the southeast Queensland bioregion equivalent of 11.3.25 and 8.3.3. That is, it is one of the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*) providing important habitat for many fauna species.	Curtis Island	ci_r_fl_01	5.2.1	4

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Blackdown Tableland	The entire sandstone tableland area including the creeks flowing through and from it are habitat for numerous endemic, rare and threatened species as well as containing significant indigenous cultural values including rock art sites. Planet Creek is particularly high in all of these values including the section on Planet Downs south of Blackdown National Park. The area is fairly dry and highly phosphorous deficient. Also an important habitat for frogs. Note: This decision straddles the Comet and Dawson study areas. The Comet component of this decision is covered by decision number dct_r_fl_01.	Dawson	dn_r_fl_01	6.3.1	4
Melaleuca Creek & Goodedulla National Park	This area is one of the best examples of black ironbox (*Eucalyptus raveretiana*) habitat in the region	Fitzroy	fi_r_fl_01	6.3.1	4
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Fitzroy	fi_r_fl_02	5.2.1	4
Regional ecosystem 11.3.38	This regional ecosystem is a serpentinite ecosystem known to contain a number of rare and threatened species.	Fitzroy	fi_r_fl_03	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Fitzroy	fi_r_fl_04	5.2.1	4
Denison Creek	Prime habitat for black ironbox (*Eucalyptus raveretiana*).	Isaac	is_r_fl_01	6.3.1	4
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Isaac	is_r_fl_03	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Isaac	is_r_fl_04	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Misc other islands	oi_r_fl_01	5.2.1	4
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	O'Connell	oc_r_fl_01	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	O'Connell	oc_r_fl_02	5.2.1	4

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Blacks Creek below the Dam	This area has an abundance of black ironbox (*Eucalyptus raveretiana*) which is in good condition with minimal disturbance and only lightly grazing. It has also been identified as a High Environmental Value (HEV) catchment.	Pioneer	pi_r_fl_01	6.3.1 6.3.3	3
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Pioneer	pi_r_fl_02	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species	Pioneer	pi_r_fl_03	5.2.1	4
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Plane	pl_r_fl_01	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species	Plane	pl_r_fl_02	5.2.1	4
Quandong Creek	This area has an abundance of black ironbox (*Eucalyptus raveretiana*) which is in good condition with minimal disturbance and only lightly grazing. It has also been identified as a High Environmental Value (HEV) catchment.	Proserpine	pr_r_fl_01	6.3.1 6.3.3	3
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Proserpine	pr_r_fl_02	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Proserpine	pr_r_fl_03	5.2.1	4
Raspberry Creek	This stream contains alluvial rainforest classified as regional ecosystem 11.3.11 which is under threat from fire and guinea grass (*Megathyrsus maximus var. maximus*) invasion.	Shoalwater	sh_r_fl_01	6.3.1	3
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Shoalwater	sh_r_fl_02	5.2.1	4
Regional ecosystem 11.3.38	This regional ecosystem is a serpentinite ecosystem known to contain a number of rare and threatened species.	Shoalwater	sh_r_fl_03	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Shoalwater	sh_r_fl_04	5.2.1	4

Priority ecosystem/ special feature	Values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Styx	st_r_fl_01	5.2.1	4
Regional ecosystems 11.3.25a & 8.3.3	These threatened regional ecosystems are the only ecosystems where you can find black ironbox (*Eucalyptus raveretiana*). These ecosystems provide important habitat for many fauna species.	Waterpark	wa_r_fl_01	5.2.1	4
Regional ecosystem 8.3.1	This regional ecosystem provides habitat for a number of rare and threatened species.	Waterpark	wa_r_fl_02	5.2.1	4

Attachments

Attachment A – GBR catchment study area

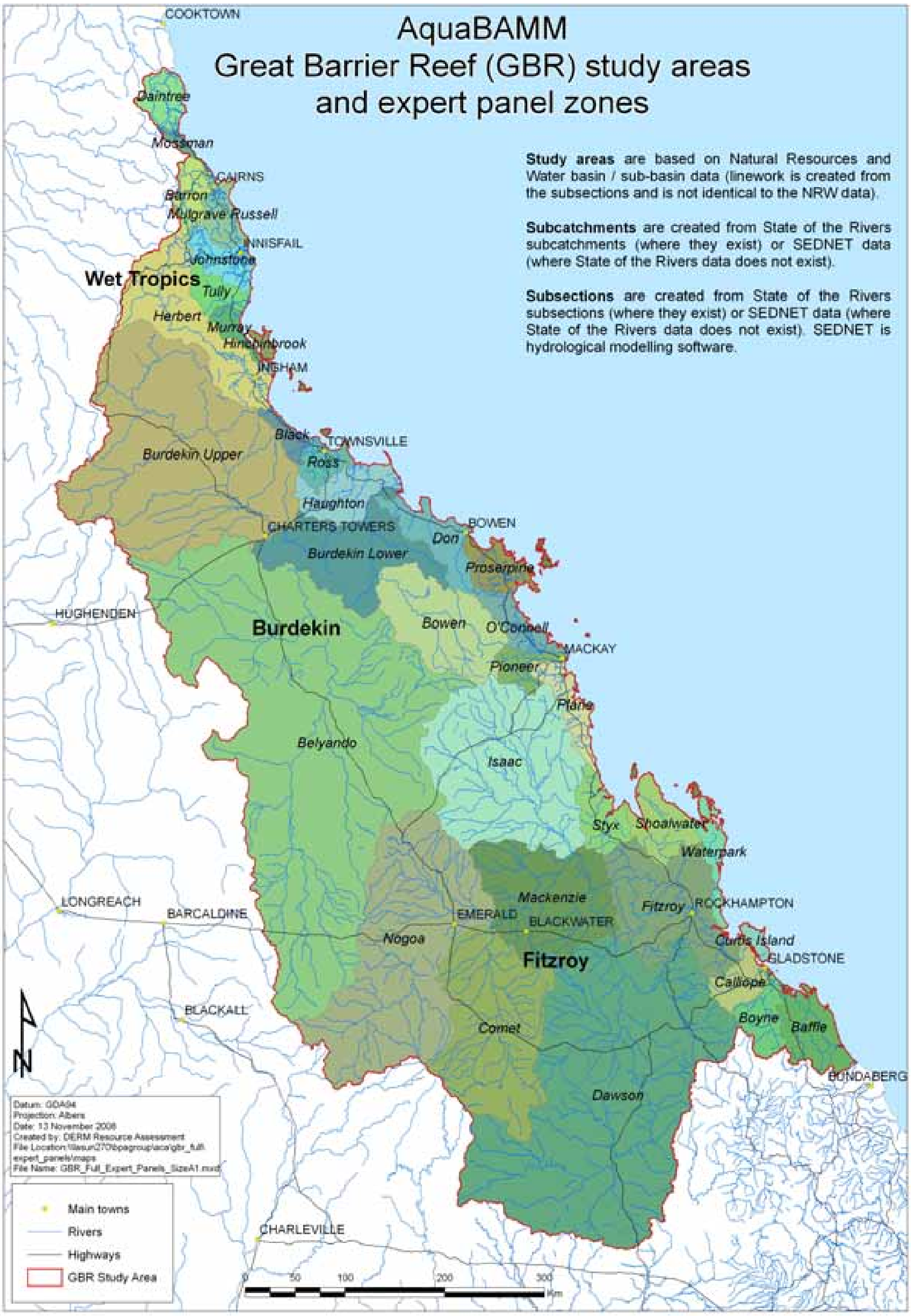

Figure 2 GBR catchment study area

Attachment B – Terms of reference (aquatic flora expert panel)

The terms of reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to inform a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic flora

The aquatic flora expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to both the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic flora and floristic communities.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on non-riverine and riverine ecosystem threatened flora species, habitat and localities
- provide advice on non-riverine and riverine ecosystem priority flora species, habitat and localities
- identify priority ecosystems or areas important for significant floral communities or species
- provide advice on non-riverine and riverine ecosystem exotic flora species, localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Fitzroy catchment descriptions

Boyne catchment

The Boyne catchment is found to the south of Gladstone and includes the townships of Nagoorin, Ubobo, Boyne Island, Tannum Sands and Benaraby. The Boyne River and its tributaries are the major streams in the area. The Boyne is highly regulated by the large Awoonga Dam that supplies water to Gladstone and to the power station on Callide Creek in the Dawson catchment to the west. The headwaters of the Boyne drain from Kroombit Tops, Castletower, Bulberin and Dawes national parks and these upper reaches are surrounded by high ecological value (HEV) habitat. The Boyne catchment is largely within the South-east Queensland (SEQ) bioregion.

Calliope catchment

The Calliope catchment is located to the north and west of Gladstone. Most of the catchment is within the Brigalow Belt (BRB) bioregion. It includes the Calliope and its tributaries and some small coastal creeks such as Boat and Manduran creeks. The Calliope River is one of few east coast rivers that are not regulated by a dam or weir and good ecological connectivity is maintained from its source to its estuary. Its freshwater reaches are relatively natural. However, its estuary flows through several major industrial sites including a power station that releases cooling water into its lower reaches.

Most of the catchments' freshwaters are surrounded by grazing lands. Townships within the catchment include Gladstone, Calliope and Mount Larcom.

Comet catchment

The Comet sub-catchment of the Fitzroy is located west of the Great Dividing Range largely to the south and east of Emerald. Townships in the sub-catchment include Rolleston, Springsure and Comet. The major river system is the Comet and its tributaries such as Orion and Humboldt creeks.

This sub-catchment originates in the Carnarvon and Expedition Ranges and flows across a relatively flat floodplain into the Mackenzie River. The catchment is flatter and the streams less steep than any others in the Fitzroy catchment.

The catchment has a number of levees and water harvesting infrastructure and the Comet Weir is found near its confluence with the Mackenzie. Several large perched lakes including Lake Nugga Nugga occur in its headwaters. The major industry of the sub-catchment is grazing but significant coal mines and cropping also occur in the sub-catchment.

Curtis Island

The Curtis Island catchment contains few freshwater streams but has significant non-riverine wetlands. These are of particular value in that they generally have good connectivity to estuarine systems. Most of the catchment's wetlands are surrounded by grazing lands or are within the Curtis Island National Park and Curtis Island Conservation Park.

Dawson catchment

The Dawson sub-catchment is the largest of the Fitzroy sub-catchments. Its sources include the Carnarvon Range to the south, the Expedition Range and Blackdown Tableland to the west and the Kroombit and Mount Morgan ranges to the east. The Dawson has several major tributaries including the Don and Dee rivers, Callide, Mimosa, Palm Tree, Juandah, Eurombah and Injune creeks.

Townships within the sub-catchment include Injune, Wandoan, Taroom, Theodore, Moura, Baralaba, Biloela, Mount Morgan and Duaringa. There is extensive grazing throughout the catchment as well as irrigated and dry-land cropping. There are several large coal mines and coal seam methane gas production is a significant and growing land use in the area that impacts on water flows.

The Dawson sub-catchment has dams and weirs including the Glebe, Orange Creek, Gyranda, Theodore, Moura and Neville Hewitt weirs on the Dawson and Kroombit and Callide dams on the Callide Creek system. There are also dams on the Dee River near Mount Morgan to provide water for the township and others to contain contaminated water runoff from the Mount Morgan Mine tailings. Water is also flood harvested from the Dawson into offstream storage at Moura. Water is also pumped over the range from the Awoonga Dam on the Boyne River into Callide Dam.

The Dawson Valley tends to be relatively flat and the river frequently splits into anabranches and oxbow lakes in some places. The river intersects a number of sandstone gorges, notably the Nathan Gorge near Taroom and has complex groundwater links that produce unusual mound springs in some areas.

Most of the flows in the Dawson occur in summer but its southern catchments may also receive significant winter rains in some years.

Fitzroy Sub-catchment

The Fitzroy sub-catchment receives its waters from the Mackenzie and Dawson rivers. It also receives significant inflows from Marlborough, Neerkol and Alligator creeks. The area also includes smaller Fitzroy delta streams including Raglan Creek.

In terms of area, grazing is the predominant land use. However there are industrial developments close to the river including two large meatworks and the Stanwell Power Station. The Fitzroy River estuary flows through the city of Rockhampton and the townships of Marlborough, Yaamba, Westwood, Bajool and Raglan.

The Fitzroy is highly regulated as a result of upstream dams and weirs, Eden Bann Weir and the Fitzroy Barrage that prevents tidal saltwaters from moving upstream. Eden Bann Weir provides water for Stanwell Power Station and the barrage provides water for Rockhampton and the Capricorn Coast. Raglan Creek is an almost perennial stream that flows into the Fitzroy Delta.

There are several large offstream wetlands through the Fitzroy Delta including Woolwash, Yeppen, Frogmore, Crescent, Nankin, Serpentine and Gracemere lagoons.

Isaac catchment

The Isaac-Connors sub-catchment of the Fitzroy is located west of the Great Dividing Range roughly from west of Sarina to west of Marlborough. Townships in the sub-catchment include Nebo and Moranbah.

This sub-catchment provides most of the flow that reaches the Fitzroy Estuary. This is particularly so of the Connors River whose tributaries originate in the wet Clarke Connors Range to the west of Mackay and Sarina. The western side receives much less rain than the rest of the catchment and consequently flows in the upper Isaac River are much smaller. The lower Isaac and Connors rivers become split into complex multi-channels and anabranches that can become separated lagoons during the dry season.

Grazing is the predominant land use in the catchment but there are several coal mines particularly to the west. This catchment is currently less regulated than any of the other Fitzroy sub-catchments with only small dams occurring in the upper Isaac River e.g. Burton Gorge Dam. There are significant quantities of water pumped from the Burdekin catchment into the catchment to supply the needs of coal mining.

The Dipperu National Park (scientific) is the only park within the Isaac Connors sub-catchment.

Mackenzie catchment

The Mackenzie sub-catchment of the Fitzroy receives flows from the Nogoa, Comet and Isaac rivers. The catchment extends downstream to the confluence with the Dawson River after which it becomes the Fitzroy. Townships in the sub-catchment include Middlemount, Blackwater and Dingo.

Grazing is the predominant land use in the catchment but there are coal mines, and irrigated and dry-land cropping are also important. The catchment is highly regulated with flows being controlled through Bingegang, Bedford and Tartrus weirs as well as a number of water harvesting operations.

Most of the upper catchment flows through a single channel. However, at the confluence with the Isaac River, the river has several large floodplain waterholes such as Lake Mary on its floodplain that may become river channels during floods.

There is one National Park—Taunton National Park—and several state forests within the sub-catchment.

Nogoa catchment

The Nogoa sub-catchment of the Fitzroy is located west of the Great Dividing Range largely to the west of Emerald. Townships in the sub-catchment include Emerald, Rubyvale, Sapphire, Clermont and Capella. The major river system is the Nogoa and its tributaries such as Theresa and Crinum creeks.

This sub-catchment originates between Carnarvon Range and Clermont and shares its origins with the Burdekin, Burnett and Murray-Darling systems. It is totally landlocked and flows into the Mackenzie River system. Grazing is the predominant land use in the catchment but there are coal mines and cropping is important in the Emerald irrigation area. The catchment is highly regulated downstream of the large Fairbairn Dam near Emerald with several small weirs and the Theresa Creek Dam also regulating flows.

There is one national park—Carnarvon National Park—at the south-western corner of the subcatchment and large state forests such as Kettle and Fairbairn .

O’Connell catchment

The O’Connell catchment is located to the south of Proserpine and north of Mackay. It forms part of the Central Queensland Coast bioregion.

Despite its name, this catchment is actually comprised of small coastal catchments including the Andromache, and O’Connell rivers and smaller creeks such as Murray, Constant and Blackrock creeks.

Townships in the area include Bloomsbury, Calen, Kuttabul and Seaforth. The major industries of the area include tourism, cane growing, cattle grazing and fishing.

The O'Connell catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters across a highly modified coastal plain extensively developed for sugar cane growing.

Pioneer catchment

The Pioneer catchment is located on the east coast flowing through the city of Mackay. It forms part of the Central Queensland Coast bioregion.

This catchment includes the Pioneer River and its tributaries such as Cattle, Finch Hatton Teemburra, Blacks and Black Waterhole creeks. The Pioneer River is highly regulated with a major dam (Teemburra Dam) and a series of weirs (Marian, Mirani and Dumbleton). Water is also diverted through a series of creeks to be utilised in the Pioneer Valley Irrigation Scheme and also pumped to the nearby Kinchant Dam which is the major storage for the Eton Irrigation Scheme in the Plane Creek catchment.

The headwaters of the catchment rise in high conservation value rainforest and then flow across a highly modified coastal plain through the city of Mackay.

Townships in the area include Mackay, Marian, Mirani and Pinnacle. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. Most of the headwaters of the Pioneer rise in national parks, such as the Eungella National Park, or state forest (including Crediton State Forest).

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Plane catchment

The Plane catchment is located on the east coast of Queensland, to the south of Mackay. It forms part of the Central Queensland Coast bioregion. Despite its name, this 'catchment' is actually comprised of small coastal catchments including Bakers, Sandy, Alligator, Plane, Rocky Dam, Marion, Carmilla, West Hill and Clairview creeks.

Townships within the catchment include Sarina, Koumala, Carmila and Clairview. The northern streams form part of the Eton Irrigation Scheme supplying water for irrigated cane growing. Water from the Pioneer River is flood harvested and transferred into these streams in part through the large offstream storage Kinchant Dam. Plane Creek has a series of small weirs regulating its flows. Streams tend to be less regulated and modified in the southern parts of the catchment.

The Plane catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters. In the north they flow across a highly modified coastal plain extensively developed for sugar cane growing.

Southern streams largely rise in state forests such as the West Hill and Kelvin State Forest. Cape Palmerston National Park is found on the coast within the catchment.

Proserpine catchment

The Proserpine catchment is located on the east coast, to the south of Bowen and north of Mackay. It forms part of the Central Queensland Coast bioregion.

Despite its name, this 'catchment' is actually comprised of small coastal catchments including the Proserpine and Gregory rivers and smaller creeks such as Repulse Creek. It also includes the world-recognised wetlands of Goorganga Plain. Streams in the area tend to be short and fast flowing, usually with headwaters in rainforest.

Repulse Creek is one of few streams almost entirely enclosed in a protected area (predominantly Conway National Park). In contrast, the Proserpine River is highly regulated with a major storage (Peter Faust Dam) in its headwaters. Water is released from this dam through a series of stream diversions to facilitate irrigated sugar cane growing.

Townships in the area include Proserpine, Airlie Beach, Dingo Beach and Midge Point. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. There are also major national parks including the Whitsunday Islands and Conway National Park.

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Shoalwater catchment

The Shoalwater catchment is located to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It is largely bounded by the western coast of Shoalwater Bay and the shores of Stanage Bay. It includes the small streams flowing into Stanage Bay such as Herbert and Wadallah creeks. It includes the settlement of Stanage Bay.

There are extensive non-riverine wetlands in the vicinity of the Torilla Plains and Glenprairie to the east and west of Stanage Bay. The major modification to local water regime is the construction of extensive levees to stop saltwater intrusion. These have modified a number of estuarine wetlands to become extensive freshwater palustrine areas.

The Shoalwater catchment has a tropical to subtropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep fast streams to the north and the long slow flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north.

Styx River catchment

The Styx catchment is located on the east coast of Queensland, to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt North bioregion. The major streams in this small catchment are the Styx River and St Lawrence Creek. Locations within the catchment include St Lawrence and Ogmore. St Lawrence Creek is regulated by a small weir.

The Styx catchment has a tropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep, fast, streams to the north and the long, slow-flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north. The highly dispersive soils of the area make the streams naturally more turbid.

The major industries in the area are cattle grazing and fishing with some horticulture and plantation forestry in the north.

Two small state forests (Glencoe and Mt Buffalo) and a small conservation park (Newport) exist in the catchment.

Waterpark catchment

The Waterpark catchment is located to the north-east of Rockhampton. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It includes the Shoalwater Bay Military Training Area south to the mouth of the Fitzroy River. The northern section from the mouth of Waterpark Creek is one of the least disturbed catchment areas in Queensland with only infrequent use in relatively small areas. It is closely managed as part of the Shoalwater Bay Military Training Area, the Byfield National Park and Byfield State Forest with limited access and largely natural remnant vegetation.

The largest stream in the area is Waterpark Creek, which rises from sand dunes in the north and flows south and then east into Corio Bay almost exclusively through protected areas. Its water quality and source from within sand dunes makes it unique within the Fitzroy study area. Within Shoalwater Bay, there are several small streams including Shoalwater Creek and a large wetland complex (Dismal Swamp) but no large rivers. Further south creeks such as Coorooman Creek have much more disturbed catchments. The acid Wallum wetlands of the Dismal Swamp area are very unusual within the central Fitzroy area.

The area includes the townships of Yeppoon, Emu Park and Keppel Sands.

Attachment D – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a 'starter set' for consideration in setting the assessment parameters for each assessment.

AquaBAMM does not allow criteria change, addition or deletion. It does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, generally modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 7 CIM list for the GBR catchment.

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – Riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Per cent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

References

Clayton, P.D., Fielder, D.P., Barratt, P.J. and Hill, C.J. (2008). Aquatic Conservation Assessments (ACA), using AquaBAMM, for freshwater wetlands of the Baffle Creek catchment. Published by the Environmental Protection Agency, Brisbane.

Attachment H GBR catchments ACA – Aquatic fauna expert panel report (Fitzroy region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment for the riverine wetlands of the Great Barrier Reef catchment

Aquatic fauna
Expert panel report

Fitzroy region

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
CAMBA	China-Australia Migratory Birds Agreement
CMS	Convention of Migratory Species of Wild Animals
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
JAMBA	Japan-Australia Migratory Birds Agreement
NC Act	*Nature Conservation Act 1992*
Ramsar	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the information.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. It provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the aquatic fauna expert panel for the Fitzroy region held in Rockhampton on Wednesday 10 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the aquatic fauna panel are provided in Attachment B.

2 Method

2.1 Study area

The Fitzroy section of the GBR catchment is a vast and extremely varied area. It ranges from the high rainfall, short, fast streams surrounded by rainforest on the Whitsunday coast to the slow, turbid, meandering, floodplain streams of the Fitzroy catchment. It encompasses parts of three bioregions, supports Ramsar-listed wetlands and its waters impact on the southern and central GBR. It includes iconic sandstone gorges in places like the Carnarvon Ranges to perched lakes in the upper Comet sub-catchment to world-recognised wetland complexes such as the Goorganga Plains as well as waterfalls, cascades and torrents in the rainforests of the Whitsundays.

The Fitzroy catchment itself is the largest eastward flowing system in Australia and only exceeded by the Murray-Darling system Australia-wide. The area includes two catchments (Waterpark Creek and Repulse Creek) that are almost entirely surrounded by protected areas while in contrast some catchments are highly modified with several rivers heavily regulated by dams, weirs and irrigation development.

The climate of the area is also highly variable. It ranges from distinctly tropical in the north to subtropical in the south. Rainfall is distinctly seasonal with a pronounced wet season from December to March but the amount of rain that falls is amongst the most variable in the world. Between 1976 and 2008, wet season flow to the mouth of the Fitzroy varied from around 349,677 megalitres to 22,903,390 megalitres. Much of the aquatic ecology of the area is driven by variable boom and bust cycles and is consequently amongst the most resilient anywhere.

The largest land use in terms of area is cattle grazing, however extensive cropping and intensive cultivation of sugar cane is also very important. The area also contributes a huge quantity of coal that is vital to the Queensland and Australian economy.

It is not possible to adequately give an overview of such a vast and varied area, so a brief description of the 17 catchment areas is provided in Attachment C. This attachment should be considered when interpreting the contents of this report.

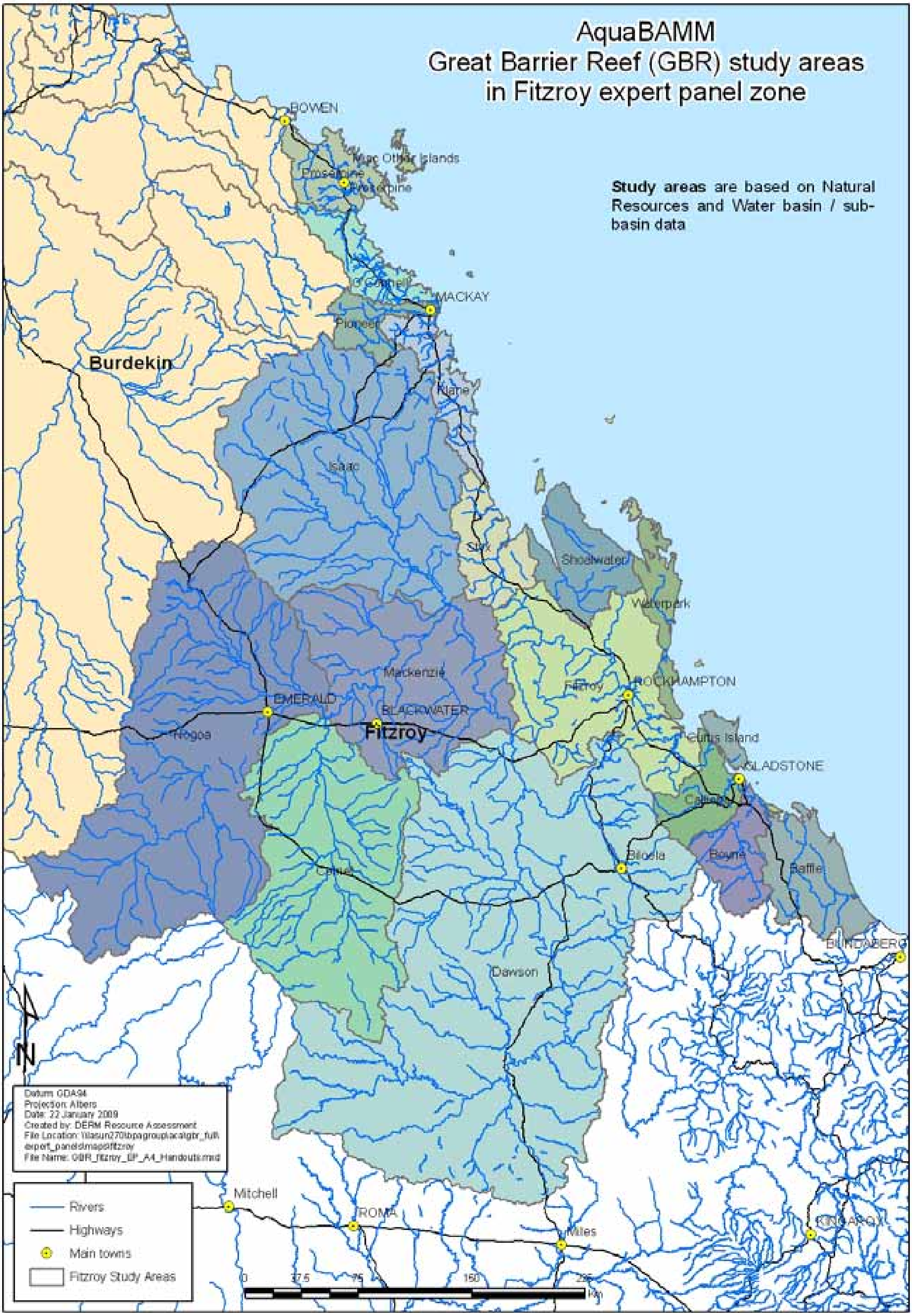

Figure 1 Fitzroy section of the GBR catchment (incorporating 17 individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised invited persons (Table 1) familiar with aquatic fauna in the Fitzroy section of the GBR catchment.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / Organisation	Expertise
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
John Platten	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Biodiversity planning, aquatic ecology and water quality
Pam Malysek	Greening Australia	Turtles
Roger Jaensch	Senior Programme Officer, Wetlands International	Wetland ecology and management, birds
Shaun Pobar	District Advisor, Department of Primary Industries and Fisheries	Fish and aquatic fauna
Steve Elson	Principal Planning Officer, Department of Environment and Resource Management	Biodiversity planning
Thomas Espinoza	Project Leader, Aquatic Ecosystem Program, Department of Environment and Resource Management	Fish and aquatic fauna

Heidi Millington and Steven Howell provided administrative and technical support for the workshop which was facilitated by Selena Inglis.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Rare and threatened fauna

The panel identified seven ‘rare’, seven ‘vulnerable’, six ‘endangered’ and one ‘critically endangered’ fauna taxa in the Fitzroy section of the GBR catchment (Table 2). Only threatened taxa listed either on a schedule of the Queensland *Nature Conservation Act 1992* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and considered to be wetland dependent by the panel were included in Table 2. This list of fauna was used as the basis for identifying areas of significance for ‘Criterion 4 Threatened species and ecosystems’ (4.1.1). A spatial unit with one or more of these species present scored the highest category of 4.

Table 2 Aquatic, semi-aquatic and riparian fauna species listed under Queensland or Commonwealth legislation

This list was used to generate the values for the AquaBAMM measure 4.1.1.

Scientific name	**Common name**	**Status**	**Comments**
Adclarkia dawsonensis	Boggomoss snail	CE[2]	
Adelotus brevis	Tusked frog	V[1]	
Crocodylus porosus	Estuarine crocodile	V[1]	
Denisonia maculata	Ornamental snake	V[1,2]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Erythrotriorchis radiatus	Red goshawk	E[1] , V[2]	
Eulamprus amplus		R[1]	
Lewinia pectoralis	Lewin's rail	R[1]	
Litoria pearsoniana (Kroombit Tops)	Cascade treefrog (Kroombit Tops)	V[1]	Globally restricted to Kroombit Tops
Litoria revelata	Whirring treefrog	R[1]	
Neochmia phaeton	Crimson finch	V	The limited habitat that remains is highly impacted by exotic pastures
Neochmia ruficauda ruficauda	Star finch	E[1,2]	
Nettapus coromandelianus	Cotton pygmy-goose	R[1]	Habitat has been extensively modified and range has become restricted
Rheodytes leukops	Fitzroy River turtle	V[1,2]	
Rheobatrachus vitellinus	Northern gastric brooding frog	E[1] , EX[2]	
Rostratula australis	Australian painted snipe	V[1,2]	Habitat and feeding grounds have been extensively modified. Reduction in population is cause for concern
Sternula albifrons	Little tern	E[1]	Uses lakes sometimes
Tadorna radjah	Radjah shelduck	R[1]	
Taudactylus eungellensis	Eungella dayfrog	E[1] , E[2]	
Taudactylus liemi	Eungella tinkerfrog	R[1]	
Taudactylus pleione	Kroombit tinkerfrog	E[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. *Queensland Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (CE – Critically Endangered; E – Endangered, V – Vulnerable; EX - Extinct)*

4 Priority fauna

The panel deliberated on all aquatic-dependent fauna species within the Fitzroy section of the GBR catchment to identify ‘priority fauna’ (excluding the rare or threatened species listed in Table 2). The panel agreed to a definition of a priority species: namely, a priority species must exhibit one or more of the following significant values.

1. It is endemic to the study area (more than 75 per cent of its distribution is in the study area/catchment).
2. It has experienced, or is suspected of experiencing, a serious population decline.
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
4. It is currently a small population and threatened by loss of habitat.
5. It is a significant disjunct population.
6. It is a migratory species (other than birds).
7. A significant proportion of the breeding population (more than 1 per cent for waterbirds, more than 75 per cent other species) occurs in the waterbody (see Ramsar Criterion 6 for waterbirds).

4.1 Priority species

The panel identified 14 riverine priority fauna species (Table 3). These species were included in ‘Criterion 5 Priority species and ecosystems’ (5.1.2). Point records were buffered using their precision to identify the spatial units having a priority species present. A spatial unit with one or more of these species present scored the highest category of four.

Table 3 Identified priority fauna species and their significant values.

This list was used to generate the values for the AquaBAMM measure (5.1.2).

Scientific name	Common name	Comments
Elseya albagula	Southern snapping turtle	Experiencing a significant reduction in population and distribution. The remaining populations within the study area is significantly disjunct from others reducing gene flow between populations.
Euastacus eungella	Freshwater crayfish	Endemic species with only a small population threatened by loss of habitat.
Euastacus monteithorum	Freshwater crayfish	Endemic species with only a small population threatened by loss of habitat.
Hephaestus fuliginosus	Sooty grunter	Threatened by loss of habitat.
Kuhlia rupestris	Jungle perch	This disjunct population is experiencing a significant population decline and is further threatened by loss of suitable habitat.
Lates calcarifer	Barramundi	Migratory species that has experienced a significant reduction in its already naturally restricted distribution due to habitat modification.
Macquaria ambigua	Yellowbelly	Endemic species that has experienced a significant reduction in its already naturally restricted distribution. Small population is threatened by loss of habitat. Large specimens are only found in the lower catchment, however, eggs and smaller specimens are found higher in the catchment.

Scientific name	Common name	Comments
Megalops cyprinoides	Oxeye herring/tarpon	Migratory species that has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area. Its habitat is also under threat.
Mugil cephalus	Sea mullet	Migratory species that has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area. Its habitat is also under threat.
Myxus petardi	Pinkeye mullet	Migratory species that has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area. Its habitat is also under threat.
Ophiocara porocephala	Spangled gudgeon	Small population that has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area.
Scleropages leichardti	Southern saratoga	Endemic to the study area this species' entire breeding population occurs within wetlands
Scortum hillii	Leathery grunter	Endemic to the study area this species' entire breeding population occurs within wetlands. The small population is also threatened by loss of habitat.
Strongylura krefftii	Freshwater longtom	Experienced a serious population decline and is further threatened by loss of habitat.

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

4.2 Migratory species

In addition to the priority species identified above, the panel nominated migratory species listed under the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA) or the Convention on the Conservation of Migratory Species of Wild Animals (CMS) as priority fauna. A total of four migratory species (Table 4) were included in the AquaBAMM assessment in 'Criterion 5 Priority species and ecosystems' (5.1.3). A spatial unit containing one species record scored a three and a four if more than one migratory species occurred within its boundary.

Table 4 A list of migratory species

This list was used to generate the values for the AquaBAMM measure (5.1.3). Sourced from Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) at:
http://www.environment.gov.au/biodiversity/migratory/waterbirds/index.html

Scientific name	Common name	Agreements/ conventions	Comments
Ardea modesta	Eastern great egret	CAMBA[1], JAMBA[2]	Known or believed to migrate in large numbers to New Guinea and/or Indonesia
Chlidonias leucopterus	White-winged black tern	CAMBA[1], JAMBA[2], CMS[3]	Waterbird that uses the freshwater wetlands in the Fitzroy region that is truly migratory according to the CMS[3]
Gallinago hardwickii	Latham's snipe	CAMBA[1], JAMBA[2], CMS[3]	Waterbird that uses the freshwater wetlands in the Fitzroy region that is truly migratory according to the CMS[3]
Rostratula australis	Australian painted snipe	CAMBA[1]	Habitat loss has reduced numbers and range

- *recent records (>1975) and records with precision <2,000 m only*

1 *China-Australia Migratory Birds Agreement (CAMBA)*
2 *Japan-Australia Migratory Birds Agreement (JAMBA)*
3 *Convention on the Conservation of Migratory Species of Wild Animals (CMS) also known as the "Bonn Convention"*

5 Species richness

Species richness (i.e. total number of species) was scored for each class (frogs, fish, reptiles, waterbirds) of fauna, stratified using 150 m above sea level (ASL) for the Baffle study area (see the Fitzroy wetland ecology expert panel report for more information on stratification). Stratifying the catchments is important to describe variability in richness. For example, fish richness is expected to be greater in the floodplain river channels than headwater streams which are smaller, with less food availability and unable to support high fish richness.

5.1 Fish richness

There were 58 native fish species identified in the freshwaters of the Fitzroy section of the GBR catchment. A further six species were considered to be alien to the region. Table 5 lists fish species that were used under the diversity and richness criterion (3.1.2).

Table 5 Native fish

This list was used to generate the values for the AquaBAMM measure (3.1.2).

Scientific name	Common name	Status	Comments
Acanthopagrus australis	Yellowfin bream	LC[1]	Predominantly estuarine but common in freshwater in some areas, for example Baffle Creek.
Ambassis agassizii	Agassiz's glassfish	LC[1]	Common in the Boyne River.
Amniataba percoides	Barred grunter	LC[1]	
Anguilla obscura	Pacific shortfin eel	LC[1]	Shortfin and longfin eel are easily misidentified. Shortfin eel is primarily found in habitats close to the coast.
Anguilla reinhardtii	Longfin eel	LC[1]	Shortfin and longfin eel are easily misidentified. Longfin eel is found throughout the study area.
Anguilla sp.	Freshwater eel sp.	LC[1]	
Arius graeffei	Blue catfish	LC[1]	Found throughout the study area.
Arrhamphus sclerolepis	Snubnose garfish	LC[1]	
Carcharhinus leucas	Bull shark	LC[1]	Most commonly found in large rivers only as far as the weirs. Found in Calliope River catchment.
Craterocephalus stercusmuscarum	Flyspecked hardyhead	LC[1]	
Gerres filamentosus	Threadfin silverbiddy	LC[1]	Known to occur in freshwater.
Gerres sp.	Silver biddy sp.	LC[1]	Known to occur in freshwater.
Giurus margaritacea	Snakehead gudgeon	LC[1]	
Glossamia aprion	Mouth almighty	LC[1]	
Gobiomorphus australis	Striped gudgeon	LC[1]	There are many records of this species from within the study area but panel members have not encountered it.
Hephaestus fuliginosus	Sooty grunter	LC[1]	Native in northern catchments.
Hypseleotris compressa	Empire gudgeon	LC[1]	
Hypseleotris galii	Firetail gudgeon	LC[1]	
Hypseleotris klunzingeri	Western carp gudgeon	LC[1]	
Hypseleotris sp.	Gudgeon sp.	LC[1]	

Scientific name	Common name	Status	Comments
Hypseleotris sp. A	Midgley's carp gudgeon	LC[1]	
Kuhlia rupestris	Jungle perch	LC[1]	Reliable record from Waterpark, also found further north in the study area.
Lates calcarifer	Barramundi	LC[1]	
Leiopotherapon unicolor	Spangled perch	LC[1]	Found throughout the study area.
Lutjanus argentimaculatus	Mangrove jack	LC[1]	Unique species that uses all habitats from freshwater to coral reefs. Tends to use freshwater environs on an opportunistic basis.
Macquaria ambigua	Yellowbelly	LC[1]	Panel suspects there are two species of Yellowbelly found in the study area but there are only records for this one.
Megalops cyprinoides	Oxeye herring/tarpon	LC[1]	
Melanotaenia duboulayi	Crimson spotted rainbowfish	LC[1]	
Melanotaenia sp.	Rainbowfish sp.	LC[1]	
Melanotaenia splendida	Eastern rainbowfish	LC[1]	
Mogurnda adspersa	Southern purple spotted gudgeon	LC[1]	
Mogurnda sp.	Gudgeon sp.	LC[1]	
Mordacia mordax	Short-headed lamprey	LC[1]	
Mugil cephalus	Sea mullet	LC[1]	
Myxus petardi	Pinkeye mullet	LC[1]	Certainly riverine.
Nematalosa erebi	Bony bream	LC[1]	Excellent indicator of water quality as it is the first species to be affected by poor water quality resulting in a fish kill. Currently absent from Yeppen Lagoon.
Neosilurus ater	Black catfish	LC[1]	
Neosilurus hyrtlii	Hyrtl's catfish	LC[1]	Common throughout the study area.
Neosilurus sp.	Eel-tailed catfish	LC[1]	
Notesthes robusta	Bullrout	LC[1]	
Ophiocara porocephala	Spangled gudgeon	LC[1]	
Oxyeleotris lineolata	Sleepy cod	LC[1]	
Philypnodon grandiceps	Flathead gudgeon	LC[1]	
Philypnodon macrostomus	Dwarf flathead gudgeon	LC[1]	
Philypnodon sp.	Gudgeon sp.	LC[1]	
Porochilus rendahli	Rendahl's catfish	LC[1]	
Pseudogobius sp.	Goby sp.	LC[1]	
Pseudomugil signifer	Pacific blue eye	LC[1]	
Redigobius bikolanus	Speckled goby	LC[1]	
Retropinna semoni	Australian smelt	LC[1]	Occurs in Baffle but is not common north of there.
Rhadinocentrus ornatus	Ornate rainbowfish	LC[1]	Reliable records from Shoalwater Bay.
Scleropages leichardti	Southern saratoga	LC[1]	
Scortum hillii	Leathery grunter	LC[1]	Not commonly found on the coast.

Scientific name	Common name	Status	Comments
Selenotoca multifasciata	Striped scat	LC[1]	Panel agrees it occurs in freshwater.
Strongylura krefftii	Freshwater longtom	LC[1]	Population fluctuates markedly. It is found in Awonga Dam, Calliope and Callide River catchments.
Tandanus tandanus	Freshwater catfish	LC[1]	
Terapon jarbua	Crescent grunter	LC[1]	Found in the Calliope River.
Zenarchopterus buffonis	Northern river garfish	LC[1]	Records of this species occurring in the study area.

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (EX – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

5.2 Reptile richness

There were14 native reptile species identified in the freshwaters of the Fitzroy section of the GBR catchment. Table 6 lists the wetlands-dependant reptiles that were considered in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.3).

Table 6 Freshwater reptiles

This list was used to generate the values for the AquaBAMM measure (3.1.3).

Scientific name	Common name	Status	Comments
Chelodina longicollis	Eastern snake-necked turtle	LC[1]	
Chelodina sp.	Turtle sp.	LC[1]	This taxa suspected to be *Chelodina longicollis*
Crocodylus porosus	Estuarine crocodile	V[1]	
Denisonia maculata	Ornamental snake	V[1,2]	
Elseya albagula	Southern snapping turtle	LC[1]	
Emydura macquarii krefftii	Krefft's river turtle	LC[1]	
Eulamprus amplus		R[2]	
Eulamprus quoyii	Eastern water skink	LC[1]	
Hemiaspis signata	Black-bellied swamp snake	LC[1]	Largely non-riverine as it prefers swampy areas with frogs as a food source
Macrochelodina expansa	Broad-shelled river turtle	LC[1]	
Physignathus lesueurii	Eastern water dragon	LC[1]	
Rheodytes leukops	Fitzroy River turtle	V[1,2]	
Tropidonophis mairii	Freshwater snake	LC[1]	
Wollumbinia latisternum	Saw-shelled turtle	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (EX – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

5.3 Waterbird richness

There were 48 native waterbird species identified in the freshwaters of the Fitzroy section of the GBR catchment. Table 7 lists the wetlands-dependant waterbirds that were considered in the AquaBAMM under 'Criterion 3 Diversity and richness' (3.1.4). These species were expert panel derived using WildNet and Queensland Museum records. Only those species that were considered to inhabit freshwater wetland environments for part or all of their natural life functions were included (Table 7).

Table 7 Native waterbirds

This list was used to generate the values of the AquaBAMM measure (3.1.4).

Scientific name	Common name	Status	Comments
Acrocephalus australis	Australian reed-warbler	LC[1]	
Amaurornis cinerea	White-browed crake	LC[1]	
Amaurornis moluccana	Pale-vented bush-hen	LC[1]	
Anas castanea	Chestnut teal	LC[1]	
Anas gracilis	Grey teal	LC[1]	
Anhinga melanogaster	Australasian darter	LC[1]	
Ardea intermedia	Intermediate egret	LC[1]	
Ardea modesta	Eastern great egret	LC[1]	
Ardea pacifica	White-necked heron	LC[1]	
Ardea sumatrana	Great-billed heron	LC[1]	
Aythya australis	Hardhead	LC[1]	
Ceyx azureus	Azure kingfisher	LC[1]	
Ceyx pusilla	Little kingfisher	LC[1]	
Chlidonias hybrida	Whiskered tern	LC[1]	Verified as freshwater living
Chlidonias leucopterus	White-winged black tern	LC[1]	Verified as freshwater living
Chroicocephalus novaehollandiae	Silver gull	LC[1]	Verified as freshwater living
Egretta garzetta	Little egret	LC[1]	
Egretta novaehollandiae	White-faced heron	LC[1]	
Ephippiorhynchus asiaticus	Black-necked stork	R[1]	
Erythrogonys cinctus	Red-kneed dotterel	LC[1]	
Erythrotriorchis radiatus	Red Goshawk	E[1] , V[2]	
Fulica atra	Eurasian coot	LC[1]	
Gallinago hardwickii	Latham's snipe	LC[1]	
Gallinula tenebrosa	Dusky moorhen	LC[1]	
Gelochelidon nilotica	Gull-billed tern	LC[1]	Verified as freshwater living
Hydroprogne caspia	Caspian tern	LC[1]	Verified as freshwater living
Irediparra gallinacea	Comb-crested jacana	LC[1]	
Ixobrychus dubius	Australian little bittern	LC[1]	
Ixobrychus flavicollis	Black bittern	LC[1]	
Lewinia pectoralis	Lewin's rail	R[1]	
Lichenostomus versicolor	Varied honeyeater	LC[1]	
Megalurus gramineus	Little grassbird	LC[1]	
Microcarbo melanoleucos	Little pied cormorant	LC[1]	
Neochmia phaeton	Crimson finch	V[1]	
Neochmia ruficauda ruficauda	Star finch	E[1,2]	
Nettapus coromandelianus	Cotton pygmy-goose	R[1]	

Scientific name	Common name	Status	Comments
Nettapus pulchellus	Green pygmy-goose	LC[1]	
Pelecanus conspicillatus	Australian pelican	LC[1]	
Phalacrocorax carbo	Great cormorant	LC[1]	
Phalacrocorax sulcirostris	Little black cormorant	LC[1]	
Phalacrocorax varius	Pied cormorant	LC[1]	
Porphyrio porphyrio	Purple swamphen	LC[1]	
Rostratula australis	Australian painted snipe	V[1,2]	
Sternula albifrons	Little tern	E[1]	Uses lakes sometimes
Tadorna radjah	Radjah shelduck	R[1]	
Todiramphus chloris	Collared kingfisher	LC[1]	
Tribonyx ventralis	Black-tailed native-hen	LC[1]	
Vanellus miles	Masked lapwing	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (EX – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

5.4 Frog richness

There were 10 species of amphibians identified in the freshwaters of the Fitzroy section of the GBR catchment. Table 8 lists frog species that were used in the AquaBAMM under ‘Criterion 3 Diversity and richness’ (3.1.1 and 3.1.6).

Table 8 Native frogs

This list was used to generate the values of the AquaBAMM measure (3.1.1 and 3.1.6).

Scientific name	Common name	Status	Comment
Adelotus brevis	Tusked frog	V[1]	Restricted within the region to Kroombit Tops and Blackdown Tableland. Its main threats are disease (chytridiomycosis) and habitat alteration by introduced pigs, cattle and horses. There has been an apparent decline in numbers.
Litoria chloris	Orange eyed treefrog	LC[1]	Apparent population decline in upland sites.
Litoria pearsoniana (Kroombit Tops)	Cascade treefrog (Kroombit Tops)	V[1]	Morphotype, likely to be a separate species. Globally restricted to Kroombit Tops. Main threats are small population size, disease (chytridiomycosis) and habitat alteration by introduced pigs, cattle and horses.
Litoria revelata	Whirring treefrog	R[1]	
Litoria wilcoxii		LC[1]	Many records from across the study area but distribution is still poorly understood and risks to species are unknown.
Mixophyes fasciolatus	Great barred frog	LC[1]	Within the region it is restricted to Kroombit Tops.
Rheobatrachus vitellinus	Northern gastric brooding frog	E[1] , EX[2]	
Taudactylus eungellensis	Eungella dayfrog	E[1] , E[2]	
Taudactylus liemi	Eungella tinkerfrog	R[1]	

Scientific name	Common name	Status	Comment
Taudactylus pleione	Kroombit tinkerfrog	E[1], V[2]	Globally restricted to rainforest streams of Kroombit Tops. Main threats are small population size, disease (chytridiomycosis) and habitat alteration by introduced pigs, cattle and horses. Population has declined at upland sites.

- *recent records (>1975) and records with precision <2,000 m only*

[#] *Crinia tinnula data is based on habitat distribution model*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (EX – Extinct, CE – Critically Endangered, E – Endangered, V – Vulnerable)*

5.5 Mammal richness

There were four species of mammal identified in the freshwaters of the Fitzroy section of the GBR catchment. Table 9 lists mammal species that were used in the AquaBAMM under ‘Criterion 3 Diversity and richness’ (3.1.7).

Table 9 Native mammals

This list was used to generate the values of the AquaBAMM measure (3.1.7)

Scientific name	Common name	Status	Comments
Ornithorhynchus anatinus	Platypus	LC[1]	Common species which thrives even in disturbed habitats
Myotis macropus	Large-footed myotis	LC[1]	Fishing bat
Hydromys chrysogaster	Water rat/ white tailed water rat	LC[1]	
Rattus lutreolus	Swamp rat	LC[1]	

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (E – Endangered, V – Vulnerable)*

5.6 Macroinvertebrate richness

There were seven species of macroinvertebrates identified in the freshwaters of the Fitzroy section of the GBR catchment. Table 8 lists macroinvertebrate species that were used in the AquaBAMM under ‘Criterion 3 Diversity and richness’ (3.2.1).

Table 10 Native macroinvertebrates.

This list was used to generate the values of the AquaBAMM measure (3.2.1)

Scientific Name	Common Name	Status	Comments
Euastacus eungella	Freshwater crayfish	LC[1]	Found in Eungella area within the Pioneer River catchment
Euastacus monteithorum	Freshwater crayfish	LC[1]	
Euastacus sp.	Freshwater crayfish sp.	LC[1]	
Adclarkia dawsonensis	Boggomoss snail	CE[2]	
Austrochloritis sp. - Camaenidae SQ 8	Land snail – Camaenidae SQ 8	LC[1]	Recorded only once from the Baffle Creek catchment
Sphaerospira sp. - Camaenidae SQ 1	Land snail – Camaenidae SQ 1	LC[1]	Recorded from the Baffle Creek catchment
Velesunio sp.	Freshwater mussel	LC[1]	Additional records from Midgley 1979

- *recent records (>1975) and records with precision <2,000 m only*

1. Queensland *Nature Conservation Act 1992 (E – Endangered, V – Vulnerable, R – Rare, LC – Least Concern)*
2. *Environment Protection and Biodiversity Conservation Act 1999 (CE – Critically Endangered, E – Endangered, V – Vulnerable)*

6 Exotic fauna

Seven fish, one crustacean and twelve vertebrate species were nominated by the panel (Table 11) as exotic wetland fauna. Some species identified by the panel were considered to only be exotic in certain areas of the Fitzroy region despite being a native species. This was mainly due to translocations or introductions upstream of natural instream barriers. The presence of aquatic exotic fauna species were recorded under 'Criterion 1 Naturalness (aquatic)' (1.1.1).

Table 11 Alien fauna

This list was used to generate the values of the AquaBAMM measure (1.1.1)

Scientific name	Common name	Comments
Bos indicus	Zebu	
Bos sp.	Cattle	
Carassius auratus	Goldfish	Common throughout the Fitzroy River catchments. Uncertain of its impact. Primarily a riverine species.
Cherax quadricarinatus	Redclaw crayfish	Translocated native taxa that is likely to be replacing other indigenous *Cherax* species. It is common in most dams including Fairburn Dam, and the Callide and Nogoa rivers as well as Theresa Creek.
Felis catus	Cat	Widespread throughout the study area.
Gambusia holbrooki	Mosquitofish	Widespread throughout the study area.
Hemidactylus frenatus	House gecko	
Pavo cristatus	Indian peafowl	
Poecilia reticulata	Guppy	
Rattus norvegicus	Brown rat	
Rattus rattus	Black rat	
Rhinella marina	Cane toad	Widespread throughout the study area.
Sus scrofa	Pig	
Xiphophorus helleri	Swordtail	Mainly found close to towns, especially Gladstone, as it is usually a fish tank escapee.
Xiphophorus maculatus	Platy	Mainly found close to towns as it is usually a fish tank escapee.
Tilapia mariae	Spotted tilapia	

- *recent records (>1975) and records with precision <2,000 m only*

7 Special features

The panel identified several special features in the Fitzroy section of the GBR catchment (Table 12). These were identified for their aquatic fauna values. Where special features nominated by the aquatic fauna expert panel were also considered to have additional values (e.g. flora, ecology) by the aquatic flora or wetland ecology expert panels, the special area was implemented as a wetland ecology special feature.

Each spatial unit that intersected with a particular ecosystem or feature in Table 12 was given a score equal to the conservation rating.

Table 12 Identified priority ecosystems and special features and their values

Decisions listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for 'Criterion 6 Special features'. All implemented special features were given a conservation rating of between 1 and 4 assigned by the panel.

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Baffle Creek	Freshwater areas of Baffle Creek that provide important habitat for mangrove jack (*Lutjanus argentimaculatus*). The area covered by this decision is from the estuarine limit of Baffle Creek.	Baffle	ba_r_fa_01	6.3.1	4
Deep Water Swamp	This open system between fresh and salt waters that is important for certain fish species. Note: This decision was not implemented as its extent is covered under a wetland ecology decision (ba_r_ec_01).	Baffle	ba_r_fa_02	6.3.1	4
Worthington and Eurimbula Creek	This open system between fresh and salt waters that is important for certain fish species.	Baffle	ba_r_fa_03	6.2.1	3
Creek on 'Bindaree'	The creek on the Bindaree property has cobble geomorphology which provides special habitat for frogs, especially stony creek frogs (*Litoria wilcoxii*), and is an extensive frog breeding area north east of Miriam Vale. Note: This decision was not implemented as its extent is covered under a wetland ecology decision (ba_r_ec_03).	Baffle	ba_r_fa_04	6.3.1	4
Below Awonga Dam	This site is the most important section of a small 1 km freshwater stretch of river immediately below Awonga Dam. It is the only section where fish can complete the freshwater part of their lifecycle in this catchment.	Boyne	bo_r_fa_01	6.3.1	4
Above Awonga Dam	The area above Awonga Dam is good frog habitat. There is a significant amount of water in the Boyne at this location.	Boyne	bo_r_fa_02	6.3.1	3

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Mimosa creek	Mimosa Creek is the main stream running off the Blackdown Tableland. The area is a unique wetland situated on land zone 5 containing sand beds and is often dry. Despite this, it provides habitat for a diverse range of fish including a wide range of size classes from small to large.	Dawson	dn_r_fa_01	6.3.1	2
Dawson River near Willawa Nature Reserve	This site is an important recruitment area for the southern snapping turtle (*Elseya albagula*). The area has good riffle zones and sand beds and supports a significant population of the Fitzroy River turtle (*Rheodytes leukops*) behind Theodore Weir.	Dawson	dn_r_fa_02	6.3.1 6.3.3	3
Dawson River north of Wide Water	This section of the Dawson River is the last natural section left. The reach is very intact containing no infrastructure and an unmodified hydrological regime despite surrounding land uses. The area is good habitat for yellowbelly (*Macquaria ambigua*).	Dawson	dn_r_fa_03	6.1.1 6.3.1	4
Raglan Creek and Twelve Mile Creek	These creeks are very well connected perennial systems which are very important for catadromous fish species. The area is the most important fresh water riverine habitat in the central Queensland coast bioregion. A significant population of the southern snapping turtle (*Elseya albagula*) is known to occur in Raglan Creek.	Fitzroy	fi_r_fa_01	6.3.1 6.3.3	4
Fitzroy River above Alligator Creek	The sandy banks in this area provide prime nesting habitat for the Fitzroy River turtle (*Rheodytes leukops*).	Fitzroy	fi_r_fa_02	6.3.1	4
Fitzroy River near Glenroy Crossing	The sandy banks in this area provide prime nesting habitat for the Fitzroy River turtle (*Rheodytes leukops*) and is the southern most known nesting point for estuarine crocodiles (*Crocodylus porosus*).	Fitzroy	fi_r_fa_03	6.3.1	3
Connors River at Cardowen	This area provides good turtle habitat supporting a breeding populations of the Fitzroy River turtle (*Rheodytes leukops*).	Isaac	is_r_fa_01	6.3.1	4
Nogoa River upstream of Fairburn Dam	This section of the Nogoa River has extremely high numbers of yellowbelly (*Macquaria ambigua*) individuals and eggs. There are more eggs in this area than typically found in the Murray-Darling basin. The long stretches of water are favourable to the planktonic eggs. The river in this area is very intact containing no infrastructure and an unmodified hydrological regime despite surrounding land uses (see Roberts, Divenvoorden & Stewart, 2008).	Nogoa	no_r_fa_01	6.3.1 6.3.3	4
Andromache River	The Andromache River provides good habitat which supports an abundance of fish. The catchment is fairly intact and in part feeds the Goorganga Plains. The catchment has good connectivity, with a few sand dams in lower reaches providing good habitat. The upper catchment has small pockets of good habitat with the rest of the system dominated by sand.	O'Connell	oc_r_fa_01	6.1.1 6.3.1	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Cattle Creek & Finch Hatton Creek	This area of intact ecosystem provides good frog habitat and supports a number of rare and threatened species. Most of the population of the endangered kroombit tinkerfrog (*Taudactylus pleione)* is found here*.* The rainforest streams also provide prime habitat for freshwater crayfish (*Euastacus eungella).*	Pioneer	pi_r_fa_01	6.3.1	4
Endeavour Creek	This area is known to be good frog, sooty grunter (*Hephaestus fuliginosus*) and freshwater catfish (*Tandanus tandanus*) habitat. It contains relatively intact and undisturbed ecosystems with only minor grazing.	Pioneer	pi_r_fa_02	6.3.1	4
Herbert Creek upstream from Block Creek, including Boundary Lagoons	This site provides good fish habitat and important waterbird habitat but is heavily cleared due to the Magnetite mines throughout the area.	Shoalwater	sh_r_fa_01	6.3.1	3
Granite Creek and Tooloomba Creek	These stream systems provide good freshwater in between the estuary and the highway. They have good connectivity between estuarine and freshwater being relatively intact without fish barriers and good riparian zone. There is much ponded pasture in this area that is good habitat for waterbirds including yellow chats (*Epthianura crocea macgregori*).	Styx	st_r_fa_01	6.2.1 6.3.1 7.1.2 7.5.1	4

Attachments

Attachment A – GBR catchment study area

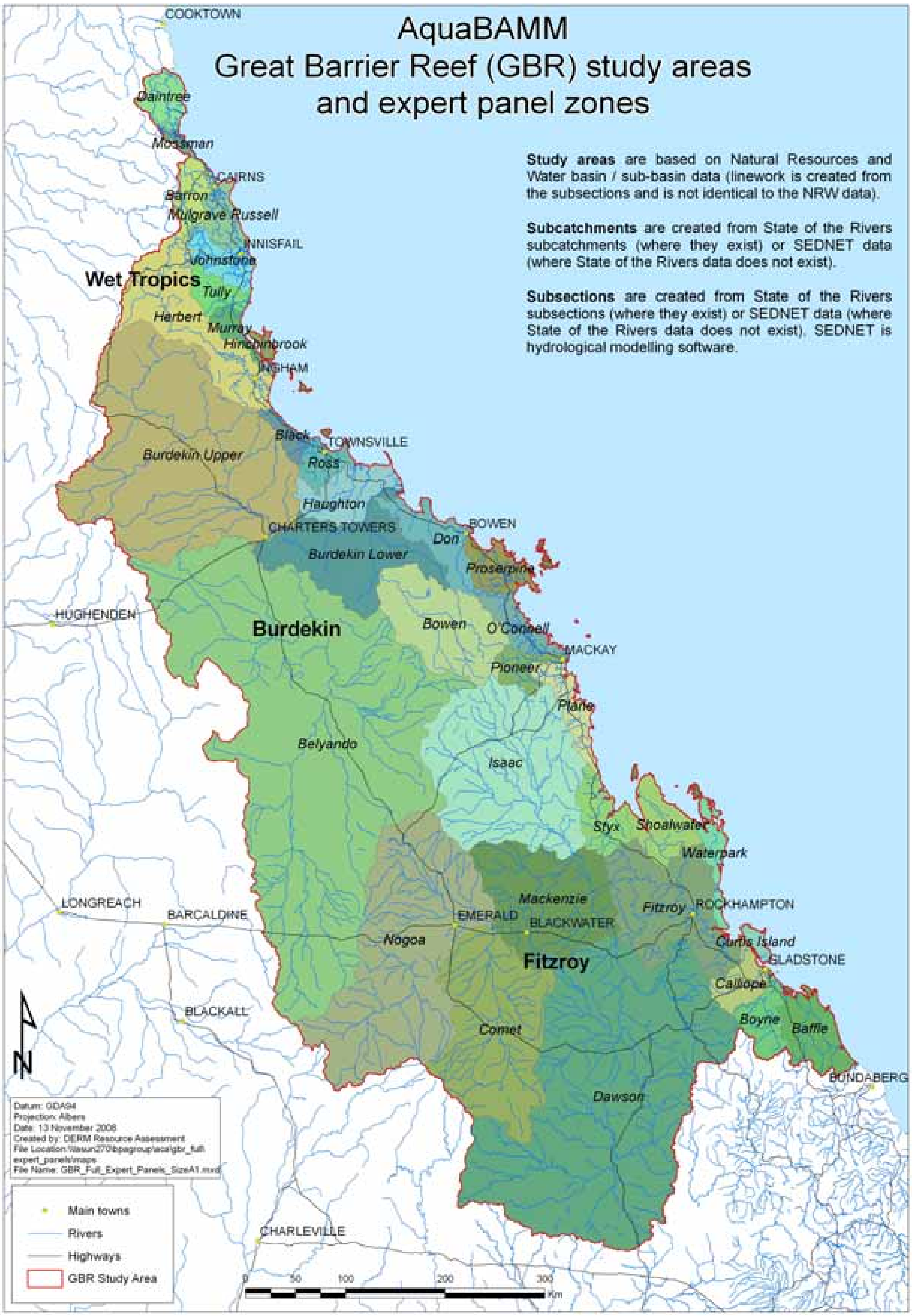

Figure 2 GBR catchment study area

Attachment B – Terms of reference (aquatic fauna expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to gain information about a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Aquatic fauna

The aquatic fauna expert panel was established to provide expert advice on priority species, special features and/ or ecosystems that are of ecological significance to the riverine and non-riverine wetlands of the GBR catchment. The panel consisted of professionals with expertise relating to aquatic fauna values.

The tasks undertaken by the panel included, but without limitation, the following:

- review relevant existing spatial data (species point records) and available information
- provide advice on riverine and non-riverine threatened fauna species, habitat and localities
- provide advice on riverine and non-riverine priority fauna species, habitat and localities
- identify priority ecosystems or areas important for significant faunal communities or species
- provide advice on riverine and non-riverine ecosystem exotic fauna species localities and abundance
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Fitzroy catchment descriptions

Boyne catchment

The Boyne catchment is found to the south of Gladstone and includes the townships of Nagoorin, Ubobo, Boyne Island, Tannum Sands and Benaraby. The Boyne River and its tributaries are the major streams in the area. The Boyne is highly regulated by the large Awoonga Dam that supplies water to Gladstone and to the power station on Callide Creek in the Dawson catchment to the west. The headwaters of the Boyne drain from Kroombit Tops, Castletower, Bulberin and Dawes National Parks and these upper reaches are surrounded by high ecological value (HEV) habitat. The Boyne catchment is largely within the South-east Queensland (SEQ) bioregion.

Calliope catchment

The Calliope catchment is located to the north and west of Gladstone. Most of the catchment is within the Brigalow Belt (BRB) bioregion. It includes the Calliope and its tributaries and some small coastal creeks such as Boat and Manduran creeks. The Calliope River is one of few east coast rivers that are not regulated by a dam or weir and good ecological connectivity is maintained from its source to its estuary. Its freshwater reaches are relatively natural. However, its estuary flows through several major industrial sites including a power station that releases cooling water into its lower reaches.

Most of the catchments' freshwaters are surrounded by grazing lands. Townships within the catchment include Gladstone, Calliope and Mount Larcom.

Comet catchment

The Comet sub-catchment of the Fitzroy is located west of the Great Dividing Range largely to the south and east of Emerald. Townships in the sub-catchment include Rolleston, Springsure and Comet. The major river system is the Comet and its tributaries such as Orion and Humboldt creeks.

This sub-catchment originates in the Carnarvon and Expedition Ranges and flows across a relatively flat floodplain into the Mackenzie River. The catchment is flatter and the streams less steep than any others in the Fitzroy catchment.

The catchment has a number of levees and water harvesting infrastructure and the Comet Weir is found near its confluence with the Mackenzie. Several large perched lakes including Lake Nugga Nugga occur in its headwaters. The major industry of the sub-catchment is grazing but significant coal mines and cropping also occur in the sub-catchment.

Curtis Island

The Curtis Island catchment contains few freshwater streams but has significant non-riverine wetlands. These are of particular value in that they generally have good connectivity to estuarine systems. Most of the catchments' wetlands are surrounded by grazing lands or are within the Curtis Island National Park and Curtis Island Conservation Park.

Dawson catchment

The Dawson sub-catchment is the largest of the Fitzroy sub-catchments. Its sources include the Carnarvon Range to the south, the Expedition Range and Blackdown Tableland to the west and the Kroombit and Mount Morgan ranges to the east. The Dawson has several major tributaries including the Don and Dee rivers, Callide, Mimosa, Palm Tree, Juandah, Eurombah and Injune creeks.

Townships within the sub-catchment include Injune, Wandoan, Taroom, Theodore, Moura, Baralaba, Biloela, Mount Morgan and Duaringa. There is extensive grazing throughout the catchment as well as irrigated and dry-land cropping. There are several large coal mines and coal seam methane gas production is a significant and growing land use in the area that impacts on water flows.

The Dawson sub-catchment has a number of dams and weirs including the Glebe, Orange Creek, Gyranda, Theodore, Moura and Neville Hewitt weirs on the Dawson and Kroombit and Callide dams on the Callide Creek system. There are also dams on the Dee River near Mount Morgan to provide water for the township and others to contain contaminated water runoff from the Mount Morgan Mine tailings. Water is also flood harvested from the Dawson into offstream storage at Moura. Water is also pumped over the range from the Awoonga Dam on the Boyne River into Callide Dam.

The Dawson Valley tends to be relatively flat and the river frequently splits into anabranches and oxbow lakes in some places. The river intersects sandstone gorges, notably the Nathan Gorge near Taroom and has complex groundwater links that produce unusual mound springs in some areas.

Most of the flows in the Dawson occur in summer but its southern catchments may also receive significant winter rains in some years.

Fitzroy Sub-catchment

The Fitzroy sub-catchment receives its waters from the Mackenzie and Dawson rivers. It also receives significant inflows from Marlborough, Neerkol and Alligator creeks. The area also includes smaller Fitzroy delta streams including Raglan Creek.

In terms of area, grazing is the predominant land use. However there are industrial developments close to the river including two large meatworks and the Stanwell Power Station. The Fitzroy River estuary flows through the city of Rockhampton and the townships of Marlborough, Yaamba, Westwood, Bajool and Raglan.

The Fitzroy is highly regulated as a result of upstream dams and weirs, Eden Bann Weir and the Fitzroy Barrage that prevents tidal saltwaters from moving upstream. Eden Bann Weir provides water for Stanwell Power Station and the Barrage provides water for Rockhampton and the Capricorn Coast. Raglan Creek is an almost perennial stream that flows into the Fitzroy Delta.

There are several large offstream wetlands through the Fitzroy Delta including Woolwash, Yeppen, Frogmore, Crescent, Nankin, Serpentine and Gracemere lagoons.

Isaac catchment

The Isaac-Connors sub-catchment of the Fitzroy is located west of the Great Dividing Range roughly from west of Sarina to west of Marlborough. Townships in the sub-catchment include Nebo and Moranbah.

This sub-catchment provides most of the flow that reaches the Fitzroy Estuary. This is particularly so of the Connors River whose tributaries originate in the wet Clarke Connors Range to the west of Mackay and Sarina. The western side receives much less rain than the rest of the catchment and consequently flows in the upper Isaac River are much smaller. The lower Isaac and Connors rivers become split into complex multi-channels and anabranches that can become separated lagoons during the dry season.

Grazing is the predominant land use in the catchment but there is a significant number of coal mines, particularly to the west. This catchment is currently less regulated than any of the other Fitzroy sub-catchments with only small dams occurring in the upper Isaac River (e.g. Burton Gorge Dam). There are significant quantities of water pumped from the Burdekin catchment into the catchment to supply the needs of coal mining.

The Dipperu National Park (scientific) is the only park within the Isaac Connors subcatchment.

Mackenzie catchment

The Mackenzie sub-catchment of the Fitzroy receives flows from the Nogoa, Comet and Isaac rivers. The catchment extends downstream to the confluence with the Dawson River after which it becomes the Fitzroy. Townships in the sub-catchment include Middlemount, Blackwater and Dingo.

Grazing is the predominant land use in the catchment but there is a significant number of coal mines, and irrigated and dry-land cropping are also important. The catchment is highly regulated with flows being controlled through Bingegang, Bedford and Tartrus weirs as well as a number of water harvesting operations.

Most of the upper catchment flows through a single channel. However at the confluence with the Isaac River, the river has several large floodplain waterholes such as Lake Mary on its floodplain that may become river channels during floods.

There is one national park—Taunton National Park—and several state forests within the sub-catchment.

Nogoa catchment

The Nogoa sub-catchment of the Fitzroy is located west of the Great Dividing Range, largely to the west of Emerald. Townships in the sub-catchment include Emerald, Rubyvale, Sapphire, Clermont and Capella. The major river system is the Nogoa and its tributaries such as Theresa and Crinum creeks.

This sub-catchment originates between Carnarvon Range and Clermont and shares its origins with the Burdekin, Burnett and Murray-Darling systems. It is totally landlocked and flows into the Mackenzie River system. Grazing is the predominant land use in the catchment but there is a significant number of coal mines and cropping is important in the Emerald irrigation area. The catchment is highly regulated downstream of the large Fairbairn Dam near Emerald with several small weirs and the Theresa Creek Dam also regulating flows.

There is one national park—Carnarvon National Park—at the south western corner of the subcatchment and several large state forests such as Kettle and Fairbairn State Forests.

O’Connell catchment

The O’Connell catchment is located to the south of Proserpine and north of Mackay. It forms part of the Central Queensland Coast bioregion

Despite its name, this ‘catchment’ is actually several small coastal catchments, including the Andromache, and O’Connell rivers and smaller creeks such as Murray, Constant and Blackrock creeks.

Townships in the area include Bloomsbury, Calen, Kuttabul and Seaforth. The major industries of the area include tourism, cane growing, cattle grazing and fishing.

The O’Connell catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters across a highly modified coastal plain extensively developed for sugar cane growing.

Pioneer catchment

The Pioneer catchment is located on the east coast flowing through the city of Mackay. It forms part of the Central Queensland Coast bioregion

This catchment includes the Pioneer River and its tributaries such as Cattle, Finch Hatton, Teemburra, Blacks and Black Waterhole creeks. The Pioneer River is highly regulated with a major dam (Teemburra Dam) and a series of weirs (Marian, Mirani and Dumbleton). Water is also diverted through a series of creeks to be used in the Pioneer Valley Irrigation Scheme and also pumped to the nearby Kinchant Dam, the major storage for the Eton Irrigation Scheme in the Plane Creek catchment.

The headwaters of the catchment rise in high conservation value rainforest and then flow across a highly modified coastal plain through the city of Mackay.

Townships in the area include Mackay, Marian, Mirani and Pinnacle. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. Most of the headwaters of the Pioneer rise in national parks, such as the Eungella National Park, or state forest (including Crediton State Forest).

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Plane catchment

The Plane catchment is located on the east coast of Queensland, to the south of Mackay. It forms part of the Central Queensland Coast bioregion. Despite its name, this ‘catchment’ is actually comprised of small coastal catchments including Bakers, Sandy, Alligator, Plane, Rocky Dam, Marion, Carmilla, West Hill and Clairview creeks.

Townships within the catchment include Sarina, Koumala, Carmila and Clairview. The northern streams form part of the Eton Irrigation Scheme supplying water for irrigated cane growing. Water from the Pioneer River is flood harvested and transferred into these streams in part through the large offstream storage Kinchant Dam. Plane Creek has a series of small weirs regulating its flows. Streams tend to be less regulated and modified in the southern parts of the catchment.

The Plane catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters. In the north they flow across a highly modified coastal plain extensively developed for sugar cane growing.

Southern streams largely rise in state forests such as the West Hill and Kelvin State Forest. Cape Palmerston National Park is found on the coast within the catchment.

Proserpine catchment

The Proserpine catchment is located on the east coast, to the south of Bowen and north of Mackay. It forms part of the Central Queensland Coast bioregion.

Despite its name, this ‘catchment’ actually comprises small coastal catchments including the Proserpine, and Gregory rivers and smaller creeks such as Repulse Creek and includes the world recognised wetlands of Goorganga Plain. Streams in the area tend to be short and fast flowing, usually with headwaters in rainforest.

Repulse Creek is one of few streams almost entirely enclosed in a protected area (predominantly Conway National Park). In contrast, the Proserpine River is highly regulated with a major storage (Peter Faust Dam) in its headwaters. Water is released from this dam through a series of stream diversions to facilitate irrigated sugar cane growing.

Townships in the area include Proserpine, Airlie Beach, Dingo Beach and Midge Point. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. There are also major national parks including the Whitsunday Islands and Conway National Park.

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Shoalwater catchment

The Shoalwater catchment is located to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It is largely bounded by the western coast of Shoalwater Bay and the shores of Stanage Bay. It includes the small streams flowing into Stanage Bay such as Herbert and Wadallah creeks. It includes the settlement of Stanage Bay.

There are extensive non-riverine wetlands in the vicinity of the Torilla Plains and Glenprairie to the east and west of Stanage Bay. The major modification to local water regime is the construction of extensive levees to stop saltwater intrusion. These have modified several estuarine wetlands to become extensive freshwater palustrine areas.

The Shoalwater catchment has a tropical to subtropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep, fast streams to the north and the long, slow-flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north.

Styx River catchment

The Styx catchment is located on the east coast of Queensland, to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt North bioregion. The major streams in this small catchment are the Styx River and St Lawrence Creek. Locations within the catchment include St Lawrence and Ogmore. St Lawrence Creek is regulated by a small weir.

The Styx catchment has a tropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep fast streams to the north and the long, slow-flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north. The highly dispersive soils of the area make the streams naturally more turbid.

The major industries in the area are cattle grazing and fishing with some horticulture and plantation forestry in the north.

Two small state forests (Glencoe and Mt Buffalo) and a small conservation park (Newport) exist in the catchment.

Waterpark catchment

The Waterpark catchment is located to the north-east of Rockhampton. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It includes the Shoalwater Bay Military Training Area south to the mouth of the Fitzroy River. The northern section from the mouth of Waterpark Creek is one of the least disturbed catchment areas in Queensland with only infrequent use in relatively small areas. It is closely managed as part of the Shoalwater Bay Military Training Area, the Byfield National Park and Byfield State Forest, with limited access and largely natural remnant vegetation.

The largest stream in the area is Waterpark Creek that rises from sand dunes in the north and flows south and then east into Corio Bay almost exclusively through protected areas. Its water quality and source from within sand dunes makes it unique within the Fitzroy study area. Within Shoalwater Bay, there are several small streams including Shoalwater Creek and a large wetland complex (Dismal Swamp) but no large rivers. Further south creeks such as Coorooman Creek have much more disturbed catchments. The acid Wallum wetlands of the Dismal Swamp area are very unusual within the central Fitzroy area.

The area includes the townships of Yeppoon, Emu Park and Keppel Sands.

Attachment D – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a 'starter set' for consideration in setting the assessment parameters for each assessment.

AquaBAMM does not allow criteria change, addition or deletion. It does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. However, modification of the default set of indicators is generally discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 13 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – Riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features.
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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Attachment I GBR catchments ACA – Wetland ecology expert panel report (Fitzroy region)

Natural Resources and Environment Division
Queensland Department of Environment and Resource Management

An Aquatic Conservation Assessment

for the riverine wetlands of the

Great Barrier Reef catchment

Wetland ecology
Expert panel report

Fitzroy region

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Tables

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Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
ASL	Above sea level
BPA	Biodiversity Planning Assessment
CS	Connectivity score
DERM	Department of Environment and Resource Management
DIWA	Directory of Important Wetlands
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FPR	Fish passage rating
GBR	Great Barrier Reef
GIS	Geographic information system
HEV	High ecological value (under a water quality improvement plan)
ICS	Intrinsic connectivity score
NC Act	*Nature Conservation Act 1992*
RAMSAR	Ramsar Convention on Wetlands
RE	Regional ecosystem

1 Introduction

The Department of Environment and Resource Management (DERM) conducted an Aquatic Conservation Assessment (ACA) for the non-riverine wetlands in the Great Barrier Reef (GBR) catchment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton *et al*. 2006). The ACA relied upon expert panels convened to address 'aquatic fauna', 'aquatic and riparian flora' and 'wetland ecology' for some of the information.

AquaBAMM provides a robust and easily accessible analysis of wetland conservation values associated with a catchment or other defined study area. It provides a decision support tool that utilises existing information, with moderation by expert panels (e.g. flora, fauna and wetland ecology expert panels) to ensure scientific rigour and accountability, resulting in an ACA for a nominated geographic area.

The potential for adding additional data into the system as it becomes available, with consequent updates to planning outcomes, is not limited. The AquaBAMM tool is a map/data output in a geographic information system (GIS) environment based on spatial mapping units that describe conservation significance or value for planning and assessment purposes.

The GBR catchment is made up of 35 individual catchments from the Daintree River north of Cairns, to Baffle Creek south of Gladstone. DERM applied AquaBAMM separately to the non-riverine (palustrine and lacustrine) and riverine wetlands within each of the 35 GBR catchments. In effect, there are 70 ACAs for the entire GBR catchment—covering non-riverine and riverine wetlands. A map of the GBR catchment showing each study area is provided in Attachment A.

A series of nine expert panels were conducted to address aquatic fauna, aquatic and riparian flora, and wetland ecology for the GBR catchments. The non-riverine and riverine wetlands were covered in combined workshops. The panels, held in Cairns, Townsville and Rockhampton during November and December 2008, involved invited experts with expertise in aquatic fauna, aquatic and riparian flora and/or wetland ecology in the Wet Tropics, Burdekin and Fitzroy sections of the GBR catchment.

This report documents the findings and recommendations of the wetland ecology expert panel for the Fitzroy region held in Rockhampton on Thursday 21 December 2008. The report presents supporting information and panel input that addresses both riverine and non-riverine wetland systems. Terms of reference for the wetland ecology panel are provided in Attachment B.

2 Method

2.1 Study area

The Fitzroy section of the GBR catchment is a vast and extremely varied area. It ranges from the high rainfall, short fast streams surrounded by rainforest on the Whitsunday coast to the slow, turbid meandering floodplain streams of the Fitzroy catchment. It encompasses parts of three bioregions, supports Ramsar listed wetlands and its waters impact on the southern and central GBR. It includes iconic sandstone gorges in places like the Carnarvon Ranges to perched lakes in the upper Comet sub-catchment to world recognised wetland complexes such as the Goorganga Plains as well as waterfalls, cascades and torrents in the rainforests of the Whitsundays.

The Fitzroy catchment itself is the largest eastward flowing system in Australia and only exceeded by the Murray-Darling system Australia wide. The area includes two catchments (Waterpark Creek and Repulse Creek) that are almost entirely surrounded by protected areas while in contrast some catchments are highly modified with a number of rivers heavily regulated by dams, weirs and irrigation development.

The climate of the area is also highly variable. It ranges from distinctly tropical in the north to subtropical in the south. Rainfall is distinctly seasonal with a pronounced wet season from December to March but the amount of rain that falls is amongst the most variable in the world. Between 1976 and 2008, wet season flow to the mouth of the Fitzroy varied from around 349, 677 megalitres to 22,903,390 megalitres. Much of the aquatic ecology of the area is driven by variable boom and bust cycles and is consequently amongst the most resilient anywhere.

The largest land use in terms of area is cattle grazing, however extensive cropping and intensive cultivation of sugar cane is also very important. The area also contributes a huge quantity of coal that is vital to the Queensland and Australian economy.

It is not possible to adequately give an overview of such a vast and varied area, so a brief description of the 17 catchment areas is provided in Attachment C. This attachment should be considered when interpreting the contents of this report.

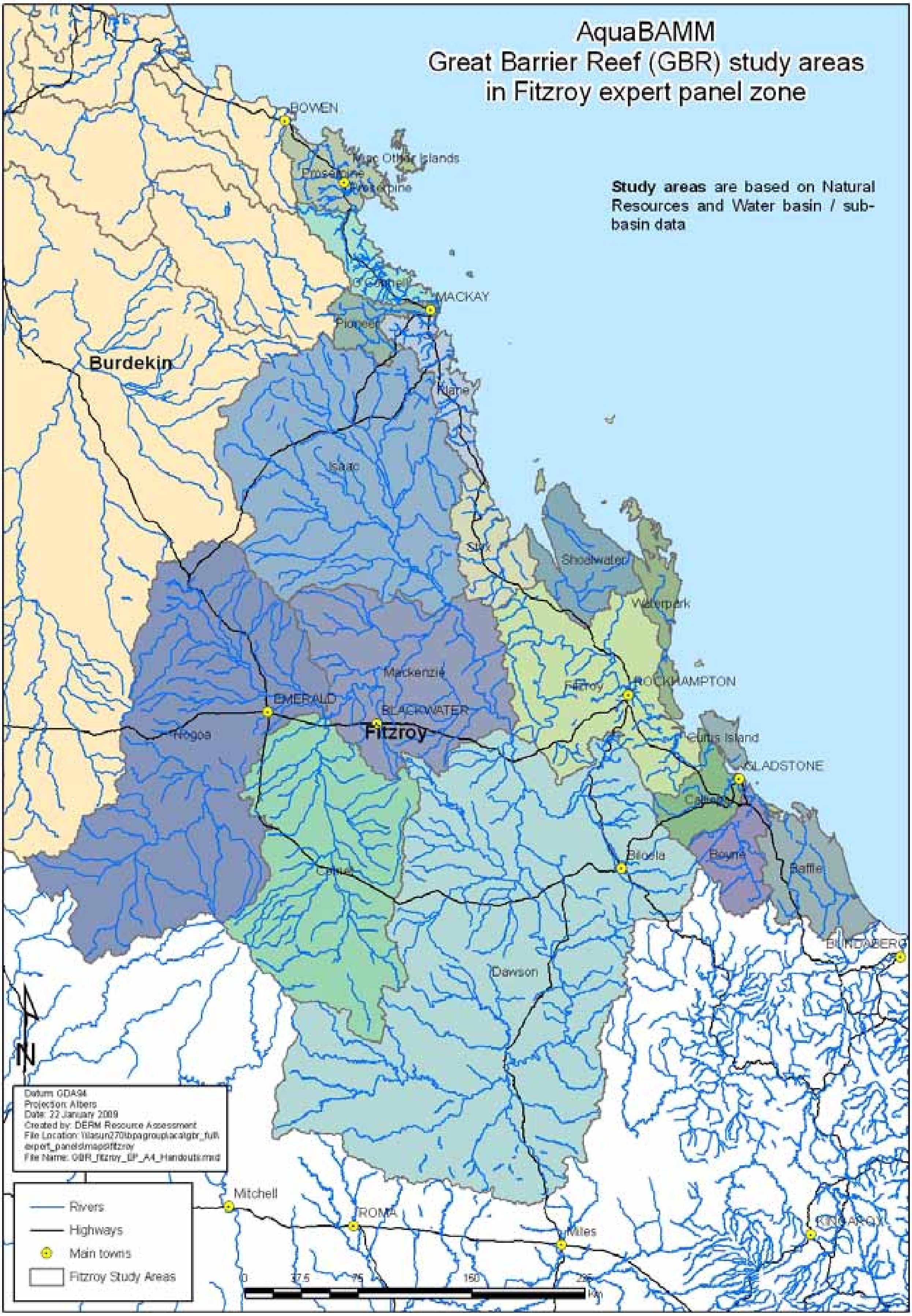

Figure 1 Fitzroy section of the GBR catchment (incorporating 17 individual catchments)

2.2 Panel composition

The expert panel (the panel) comprised invited persons (Table 1) familiar with non-riverine and riverine wetland ecology in the Fitzroy section of the GBR catchment. This included fish, macroinvertebrates, water quality, hydrology, geomorphology and vegetation.

Some members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Table 1 Panel members

Name	Position / organisation	Expertise
Jeanette Kemp	Principal Botanist, Department of Environment and Resource Management	Native and exotic flora
Jim Tait	Ecologist, Ecoconcern Pty Ltd	Wetland ecology and management
John McCabe	Senior Extension Officer, Nature Refuges, Department of Environment and Resource Management	Waterbirds, flora, and landscape restoration
John Platten	Principal Biodiversity Planning Officer, Department of Environment and Resource Management	Biodiversity planning, aquatic ecology and water quality
Leo Duivenvoorden	Senior Lecturer/Researcher, Central Queensland University	Aquatic and semi-aquatic plants.
Nick Cuff	Principal Botanist, Queensland Herbarium, Department of Environment and Resource Management	Botany and regional ecosystem assessment
Steve Elson	Principal Planning Officer, Department of Environment and Resource Management	Biodiversity planning
Thomas Espinoza	Project Leader, Aquatic Ecosystem Program, Department of Environment and Resource Management	Fish and aquatic fauna

Selena Inglis, Heidi Millington and Steven Howell provided administrative and technical support for the workshop which was facilitated by Steven Howell.

2.3 Workshop format

The workshop used an interactive approach of ArcView GIS software to display point records of species and their spatial distributions. Where necessary, a background of topographic 1:250,000 maps, roads, rivers and other relevant datasets were used to identify areas of interest. Additional supporting information on fauna and flora in the GBR catchment was also sourced from various technical reports.

3 Special features

The panel identified several riverine special features in the Fitzroy section of the GBR catchment (Table 2). These were identified for their ecological values. Some special features nominated by either the aquatic flora and/or the aquatic fauna expert panels considered to have additional values (e.g. geomorphological or hydrological) were implemented as wetland ecology special features.

Each spatial unit that intersected with a particular ecosystem or feature in Table 2 was given a score equal to the conservation rating.

Table 2 Identified priority ecosystems and special features

Decisions listed alphabetically by catchment. These features were intersected with the spatial units to identify the values for 'Criterion 6 Special features'. All implemented special features were given a conservation rating of between one and four assigned by the panel.

Special feature	**Identified values**	**Catchment**	**Decision implementation number**	**Criteria/ indicator/ measure**	**Conservation rating (1-4)**
Deep Water area dunes	These acid drainage lines in wallum areas close to the coast (land zone 2) provide important habitat for acid tolerant species. Note: This decision was also included in the non-riverine ACA assessment (decision number ba_nr_ec_01). See the Fitzroy non-riverine report for more details.	Baffle	ba_r_ec_01	6.1.1	4
Brackish tidal zone of Baffle Creek	The extensive freshwater-marine interface within Baffle Creek provides an unusual area for aquatic processes. For example, the conductivity is much lower than for typical estuarine systems. The interface area is very large which adds to its unusual attributes.	Baffle	ba_r_ec_02	6.2.1	4
Creek on 'Bindaree'	The creek on the Bindaree property north-east of Miriam Vale has cobble geomorphology which provides special habitat for frogs and is an extensive frog breeding area, especially for the stony creek frog (*Litoria lesueuri*).	Baffle	ba_r_ec_03	6.3.1	4
Granite Creek wetlands	The riverine wetlands upstream of the confluence of Granite Creek and Baffle Creek occur in gorges with incised geomorphology. This area coincides with the Directory of Important Wetlands. There is good groundwater connectivity in the Granite Creek area with permanent pools and spring fed breakthrough areas along river banks. Note: These values are also present for the official Directory of Important Wetlands (DIWA) areas along Granite Creek.	Baffle	ba_r_ec_04	6.3.3	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Creek confluence near Miriam Vale	The riverine wetland areas near the confluence of creeks at Miriam Vale retain groundwater aquifer connection. There is distinct groundwater and surface water interactions which can be seen in the form of boggy/quicksand areas and strong flows to the stream via gravel seeps. This hydrological interaction is visible in further downstream riverine and non-riverine areas. Nitrogen removal processes are also evident here.	Baffle	ba_r_ec_05	6.4.1	4
Deepwater Creek	Deepwater Creek has a unique groundwater hydrology relative to the whole Baffle Creek catchment. The groundwater and surface water interactions remain intact and are fed from dunes. Water extraction in this area is currently minimal.	Baffle	ba_r_ec_06	6.4.1	4
Boyne crossing	The Boyne crossing (approximately 15km south of Calliope) provides excellent habitat for waterplants with 22 species of waterplants being recorded from this locality. With crystal clear waters, there is high fish diversity and is considered to be only one of five sites like this in the entire region. However, this area is within the impoundment of Awonga Dam and may be affected by clearing of the riparian zone.	Boyne	bo_r_ec_01	6.3.1	4
Kroombit Tops National Park and Forest Reserve	The creeks flowing through sandstone geology of Kroombit Tops contain the northern limit of warm temperate rainforest. The area contains wet montane heath and springs, coachwood palm forests along upper creeks and unique geomorphology. It also provides good habitat for the rare and threatened kroombit tinker frog (*Taudactylus pleione*) and other fauna. <u>Note</u>: This decision straddles the Dawson and Boyne study areas. The Dawson component of this decision is covered by decision number dn_r_ec_05.	Boyne	bo_r_ec_02	6.1.1 6.3.1	4
Calliope River from Larcombe Creek to Mount Alma	This extensive waterhole within the Calliope River has good connectivity and is unmodified, meaning that its flow regime is still natural. It is the last remaining major river on the coast that has not been dammed and as a result it has a diverse suite of macrophytes. It provides good fish habitat and supports a diversity of fish including mullet and barramundi (*Lates calcarifer*). It is considered to be an area of high diversity for macrophytes.	Calliope	ca_r_ec_01	6.3.1	4
Monduran Creek	The Monduran Creek is an important barramundi (*Lates calcarifer*) and other fish nursery area. The area also contains good riparian vine scrub. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number ca_nr_ec_02). See the Fitzroy non-riverine report for more details.	Calliope	ca_r_ec_02	6.3.1	2
Carnarvon gorge	The Carnarvon gorge is a unique perennial riverine system with unique geomorphology that supports a relictual plant community containing high macrophyte diversity including species such as the giant fern (*Angiopteris evecta*). In addition there are springs and very clear waters containing *Potamogeton perfoliatus*.	Comet	ct_r_ec_01	6.3.1 6.4.1	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Palm Tree Creek and Robinson Creek	The wetlands in this area contain sandstone geomorphology that provides good habitat for *Livistona nitida* and supports extensive *Eleocharis* swamps. The area contains rare and threatened species and a high waterbird diversity including magpie geese (*Anseranas semipalmata*) and cotton pygmy geese (*Nettapus coromandelianus*). Aquatic macrophyte diversity in this area is very high, despite some of these wetlands completely drying out at times. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number dn_nr_ec_01). See the Fitzroy non-riverine report for more details.	Dawson	dn_r_ec_01	6.1.1 6.3.1 6.3.3	4
Isla Delusion crossing	This area supports well developed palm swamps (*Livistona nitida*) and is outside the influence of weirs. The area is in good condition enabling good fish recruitment and very clear waters. The waters in this area are much clearer than the rest of the Dawson River, particularly the creek section where the Isla delusion connects to the Dawson River. The substrate here is very gravely.	Dawson	dn_r_ec_02	6.3.1	3
Nathan Gorge	The Nathan Gorge provides very important fish habitat supporting a wide range of fish species including yellowbelly (*Macquaria ambigua*), leathery grunter (*Scortum hillii*) and saratoga (*Scleropages leichardti*). The limestone gorges support rare and threatened plants and ancient flora as well as livistona palms.	Dawson	dn_r_ec_03	6.3.1	4
Dee River headwaters	This area has very high macrophyte diversity particularly when compared to the remainder of the Dawson River catchment. In addition to this there is a high diversity of macroinvertebrate taxa with around 30 taxa known from the area.	Dawson	dn_r_ec_04	6.3.1	4
Kroombit Tops National Park and Forest Reserve	The creeks flowing through sandstone geology of Kroombit Tops contain the northern limit of warm temperate rainforest. The area contains wet montane heath and springs, coachwood palm forests along upper creeks and unique geomorphology. It also provides good habitat for rare and threatened kroombit tinker frog (*Taudactylus pleione*) and other fauna. <u>Note:</u> This decision straddles the Dawson and Boyne study areas. The Boyne component of this decision is covered by decision number bo_r_ec_02.	Dawson	dn_r_ec_05	6.1.1 6.3.1	4
The amphitheatre (Robinson National Park)	This area has unique sandstone geomorphology providing unique habitats despite some disturbance by grazing.	Dawson	dn_r_ec_06	6.1.1 6.3.1	3
Isla Gorge	The Isla Gorge supports rare and threatened plants and ancient flora as well as livistona palms	Dawson	dn_r_ec_07	6.3.1	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Headlow Basin & Creek	This area contains remnants of regional ecosystem 8.3.13a and includes Serpentine Lagoon, Lake Mary and Green Lake. It is geomorphologically and hydrologically unique having a high water table and a basin area that floods out regularly and picks up backwater floodwater off the Fitzroy River. The water also often builds up and overflows into Alligator Creek. The creek has been stocked with barramundi (*Lates calcarifer*) because fish passage has been impeded by a barrage. The area is also important for waterbirds despite being quite modified. Note: This decision was also included in the non-riverine ACA assessment (decision number fi_nr_ec_01). See the Fitzroy non-riverine report for more details.	Fitzroy	fi_r_ec_01	6.3.1 6.3.3	4
Fitzroy Floodplain	The Fitzroy Floodplain is listed separately on the Directory of Important Wetlands (DIWA) from the Fitzroy Delta. The floodplain contains deep water lagoon systems and is a very important nursery habitat for fish. The area has unique geomorphology and is one of the least modified large floodplains on the eastern seaboard. Other areas like this have been cleared for agriculture. The area provides good waterbird habitat with over 30,000 waterbirds recorded here in a recent survey (as part of the national waterbird inventory). Note: This decision was also included in the non-riverine ACA assessment (decision number fi_nr_ec_02). See the Fitzroy non-riverine report for more details.	Fitzroy	fi_r_ec_02	6.1.1 6.3.1 6.3.3	4
Fitzroy Delta	The Fitzroy Delta is listed separately on the DIWA from the Fitzroy floodplain. The area has large sedge swamps, very important nursery habitat for fish as well as good waterbird habitat. Aquatic macrophytes of the Nankin Creek area have high diversity. Note: This decision was also included in the non-riverine ACA assessment (decision number fi_nr_ec_03). See the Fitzroy non-riverine report for more details.	Fitzroy	fi_r_ec_03	6.3.1 6.3.3	4
Mt Etna tufa dams	This area forms a series of tufa dams which are rare in Australia. They are calcified dams associated with the Mt Etna limestone.	Fitzroy	fi_r_ec_04	6.1.1	4
Marlborough Creek	Marlborough Creek is important for serpentinite plant species and is known to support very large macrophyte beds as well as a number of rare and threatened plants. The area contains a good nesting site for the Fitzroy River turtle (*Rheodytes leukops)* with large numbers having been recorded there. The area supports a good population of crocodiles and a diversity of fish species. The area has good connectivity and very clear waters.	Fitzroy	fi_r_ec_05	6.3.1 6.3.3	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Canal Creek (part of Alligator Creek catchment)	This massive meander system incorporates the largest polygon of regional ecosystem 11.3.4 in the entire Brigalow Belt bioregion. The area supports mature specimens of hollow bearing blue gums and includes some of the regional ecosystem 11.3.38. Canal creek supports a diversity of macroinvertebrates and aquatic macrophytes. It is also quite sandy with a hard layer of clay metres beneath the sandy sediments. The aquatic values in this area are similar to Headlow Creek.	Fitzroy	fi_r_ec_06	6.3.1	4
Neerkol Creek near Stanwell	This section of Neerkol Creek is a good stretch of permanently flowing water with high macrophyte and fish diversity. It provides habitat for rare and threatened species including the black ironbox (*Eucalyptus raveretiana*). The natural water conductivity can reach up to about 5000 however the nearby power station regulates this at about 2000.	Fitzroy	fi_r_ec_07	6.3.1	2
Funnel Creek, Bee Creek and Connors River to the intersection of Isaac River	This area supports the last population of the crimson finch (*Neochmia phaeton*) with habitat provided by native grasses in the braided stream. There are also very deep, clear, long pools in this area.	Isaac	is_r_ec_01	6.3.1 6.3.3	4
Denison Creek and Funnel Creek	These creek systems support a mixture of fish species including saratoga, translocated sooty grunter (*Hephaestus fuliginosus*) and yellowbelly (*Macquaria ambigua*) as well as rainforest species. The long, deep waterholes have paperbarks over them which support large numbers of platypus (*Ornithorhynchus anatinus*). Overall it is a relatively short stream in good condition with permanent water and is prime habitat for rare and threatened species such as black ironbox (*Eucalyptus raveretiana*). <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number is_nr_ec_01). See the Fitzroy non-riverine report for more details.	Isaac	is_r_ec_02	6.3.1	4
Isaac River where it joins Mackenzie River down to Coolmaringa	This section of the Isaac River has unique geomorphology and stream morphology with many braided flood plain creeks as well as numerous large, long permanent pools. This provides good habitat for saratoga. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number ma_nr_ec_01). See the Fitzroy non-riverine report for more details.	Mackenzie	ma_r_ec_01	6.1.1 6.3.1	4
Downstream from Bingegang Weir	This area is important habitat for fauna species. The area is prime habitat for macroinvertebrates and over 30 taxa can be found.	Mackenzie	ma_r_ec_02	6.3.1	4
Springs of Nogoa River headwaters	This area contains a number of spring-fed sand bed flow systems.	Nogoa	no_r_ec_01	6.1.1	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Marion, West Hill & Basin creeks	In this area there are no barriers and very little water extraction resulting in well vegetated riparian zones and a good diversity of fish. It is particularly good habitat for diadromous fish. The short creeks south of Flaggy Rock are in good condition with good water quality and fish passage despite being under the influence of dry cane farming. <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number pl_nr_ec_01). See the Fitzroy non-riverine report for more details.	Plane	pl_r_ec_01	6.3.1	4
Repulse Creek	This intact ecosystem is contained largely within the National Park. It is a short fast stream in excellent natural condition and provides habitat for the Proserpine rock-wallaby (*Petrogale persephone*) as well as rare and threatened flora species. The creeks have good connectivity, good water quality and support an abundance of fish including jungle perch (*Kuhlia rupestris*) and mangrove jack (*Lutjanus argentimaculatus*).	Proserpine	pr_r_ec_01	6.3.1	4
Proserpine River at Goorganga Plane	The Central Queensland Coast BPA Panel nominated all of Goorganga Plain (from Proserpine River to O'Connell River as a state significant–nationally important wetland, to be listed on the Directory of Important Wetlands in Australia. The area of beach scrub and regional ecosystem 8.3.13b are only found in this area. The area also contains the most southern population of *Livistona drudei* (vulnerable) at Conway Beach/Wilsons Beach. In addition, the Proserpine river has the highest density of crocodiles (*Crocodylus porosus*) in the region and also provides habitat for false water-rats (*Xeromys myoides*), sea turtles and species listed in the JAMBA convention. Links from Goorganga to Proserpine River provide important wildlife corridors and should be included with the Goorganga Plain for its importance as wildlife refugia. In addition, the area boasts very high species richness and provides significant breeding and roosting sites throughout. Threats to the area include Condor Oil Shale development.	Proserpine	pr_r_ec_02	6.3.1 6.3.3	4
Shoalwater Creek	This intact ecosystem is within a pristine landscape and is the only creek with any significant freshwater on that side. It has good connectivity and provides a very good reference site for water quality.	Shoalwater	sh_r_ec_01	6.4.1 7.1.1	4

Special feature	Identified values	Catchment	Decision implementation number	Criteria/ indicator/ measure	Conservation rating (1-4)
Waterpark Creek catchment	This area is derived from coastal sands and granite and has unique drainage. It has a very low pH of about 5.5 with clear deep pools and contains excellent water quality. There are large numbers of mullet (*Myxus petardi*) and tarpon (*Megalops cyprinoides*) and the area may provide habitat for jungle perch (*Kuhlia rupestris*) as well. The area supports alluvial rainforest and palm swamps and feather palm rainforest as well as rare and threatened species such as *Sowerbaea, Phaius australis* and the endemic Byfield fern (*Bowenia serrulata*). <u>Note</u>: This decision was also included in the non-riverine ACA assessment (decision number wa_nr_ec_01). See the Fitzroy non-riverine report for more details.	Waterpark	wa_r_ec_01	6.3.1	4

4 Connectivity

The panel members were asked to develop and/or identify a set of principles that could be applied to determine relative connectivity scores of riverine spatial units within the GBR catchment and within the non-riverine wetlands. After some time discussing connectivity for non-riverine wetlands, the panel members agreed that connectivity Criterion 7 be turned off for the GBR non-riverine ACA due to issues associated with its implementation including method and resources). Hence, the following sections focus on implementing the connectivity measures for riverine wetlands. Discussion on non-riverine wetland connectivity is recorded here where relevant.

4.1 Importance of connectivity

There was broad agreement by the panel that the concept of connectivity is important, and it is directly or indirectly linked to most facets of aquatic ecology, geomorphology and water quality. The scientific literature reviewed for the AquaBAMM program reflects this view.

The ecological value of a particular reach of river is directly linked in quantity and quality to the movement both up and downstream—and between adjoining terrestrial lands—of resources such as water, sediment and debris and the recruitment and distribution of species (Cullen 2003).

An inherent connectivity, or lack of connectivity in drier periods, is a significant feature of fresh waters. In arid-zone systems and floodplains, the irregular flow regime and sporadic connectivity underpins the conservation of the instream and floodplain wetland biota such as the invertebrate assemblages (Sheldon *et al*. 2002).

Similarly, this relationship is evident for maintaining the health and productivity of end-of-river estuarine systems (Cullen 2003).

A largely unknown and unseen linkage occurs within the hyporheic zone between surface waters and groundwater ecosystems sustaining many endemic or relictual invertebrate fauna (Boulton *et al*. 2003).

4.2 Applying principles for measuring connectivity

The practicalities of measuring connectivity in a riverine environment are complex making general principles difficult to develop and implement. Connectivity in its broadest meaning incorporates hydrological processes (quantity and quality, temporal and spatial variability), organism dispersal (barriers) and disturbances from natural conditions. Connectivity can be bi-directional movements within a stream (e.g. fish passage), uni-directional contribution to a downstream spatial unit or special area, or lateral connectivity to floodplain wetlands or groundwater ecosystems. These aspects of connectivity combine to provide a matrix of competing and differing values from an ecological conservation viewpoint.

4.3 Fish passage (riverine)

The principles for the fish passage connectivity rating (measure 7.1.2) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) were tabled at the wetland ecology expert panel workshop. It was agreed that this method could be implemented in the Fitzroy section of the GBR catchment.

An agreed assumption is that barriers lower in the catchment have more impact on fish passage then those in upper reaches of the catchment. There was also recognition that each barrier can be rated according to its relative level of fish passage. The steps outlined below were used to calculate a connectivity score for each spatial unit.

Step 1: Each stream segment is scored for its intrinsic connectivity according to its stream order (1:100,000).

An intrinsic connectivity value for each stream segment can be calculated from a fish migration point of view. The higher the stream order, the higher its intrinsic connectivity score

for fish species. Table 3 provides the scoring system using the stream order of each stream segment.

Table 3 The intrinsic connectivity score for streams

Stream order was calculated using the buffered stream network at a scale of 1:100,000.

Stream order	Intrinsic connectivity score
1	1
2 & 3	2
4 & 5	3
>5	4

Step 2: Modify the intrinsic connectivity score using the fish passage rating for each barrier.

The former Department of Primary Industries and Fisheries (DPIF) rated the major instream barriers in the GBR catchment for their ability to allow fish passage both up and downstream based on the storage height at the spillway (Table 4). Only artificial barriers were considered for a fish passage rating. This fish passage rating is then subtracted from the intrinsic connectivity score to provide a connectivity score for each segment of stream within a spatial unit as shown below:

Connectivity score (CS) = Intrinsic connectivity score (ICS) – Fish passage rating (FPR)

For example, the ICS score for a river segment having a stream order of six would be four, and if a barrier exists on this river reach, its FPR score would be two resulting in an overall CS score of two (measure 7.1.2) for the spatial unit (i.e., ICS – FPR = 4 – 2 = 2). Table 4 provides the calculation matrix for each combination using the rules outlined below.

Table 4 Calculation matrix for the connectivity score (7.1.2)

	Fish passage rating (FPR)			
Intrinsic connectivity score (ICS)	**No barrier present**	**1 Good**	**2 Moderate**	**3 Poor**
1 (Low)	1	1	1	1
2 (Medium)	2	1	1	1
3 (High)	3	2	1	1
4 (Very high)	4	3	2	1

Rules for calculating the connectivity score:

- the CS cannot be lower than 1
- a spatial unit's CS pertains to the highest stream order present in the unit
- where there is no barrier within a spatial unit, the ICS for the highest stream order is used as the CS.

These ratings were used to score the fish passage connectivity in the AquaBAMM measure (7.1.2).

The panel recommended that flow rates available in this region be considered for integration with intrinsic connectivity scores through the use of flow duration curves from each IQQM site to determine how well it is connected. Although this approach has merit, it was not implemented in the ACA for the GBR catchment as further work is required prior to application.

Although the list of fish barriers used under measure 7.1.2 for the Fitzroy region is too extensive to present as part of this report (more than 500 barriers were listed), the full list can be obtained from the Department of Environment and Resource Management by forwarding an email to aquabamm@derm.qld.gov.au.

4.4 Connectivity between freshwater and estuarine wetlands

Connectivity between freshwater wetlands (riverine and non-riverine) and estuarine ecosystems was also recognised by the panel as being important. The panel members discussed several methods for assessing the lateral connectivity of freshwater and estuarine wetlands and agreed that anything that is connected hydrologically and/or biologically to estuarine areas should be given a higher connectivity rating.

Connectivity was only considered for estuarine areas that are directly downstream rather than right next to riverine areas. A higher value should be placed on the smaller streams that are connected to the estuarine areas.

The Wet Tropics and Burdekin panels recommended assigning a 3 to an area with hydrological estuarine connectivity and a 4 to an area that has freshwater wetlands and hydrological estuarine and/or biological connectivity. Although this approach has merit, it was not implemented as part of the ACA for the GBR catchment as further investigation is required prior to application. This approach is expected to be investigated during the implementation of future ACAs.

4.5 Connectivity of special features

The panel members were also asked to develop principles for scoring connectivity for special features such as waterfalls, macrophyte beds, significant instream habitats and other areas or features identified through expert opinion. This question primarily relates to uni-directional connectivity i.e. quantity or quality of flow to a downstream special feature.

The principles for assessing connectivity values for special features (measures 7.1.1, 7.2.1) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton *et al* 2006) was tabled at the panel workshop. The panel agreed that the model four inverse exponential scoring of spatial units upstream method could be implemented in the Fitzroy section of the GBR catchment. This model is presented below.

Inverse exponential scoring of spatial units upstream:

This model uses the spatial units rather than a distance to determine how they are scored. Every contributing spatial unit above a particular special feature was logarithmically scored with the spatial units immediately upstream of a special feature being scored a four,the next adjoining upstream spatial units received a score of two and the remainder above a special feature were scored a one. The spatial unit having the special feature located within it would not receive a score because it was already scored in Criterion 6. Where a spatial unit had more than one calculation—i.e. overlapping scores— the maximum value was incorporated.

This model better reflects the importance of spatial units immediately above a special feature by applying a logarithmic threshold to scoring. It is also an efficient and practical application of a complex issue. A disadvantage of this model is that it treats all special features such as macrophyte beds, geomorphological and hydrological features equally where there may be reasons to differentiate between them. Also, this model can result in some variation of the real distances upstream of a special feature being scored.

The panel also recognised that there is some value that can be placed on downstream spatial units connected to special features e.g. some fish need to move downstream to breed. This approach was not applied in the assessment because further investigation is required to determine whether this model can be applied downstream based on the values in the Fitzroy.

5 Modelled natural flows

Cullen (2003) proposed an Australian river classification based solely on flow extractions from rivers (Table 5). He argued that flow diversion is the most important threatening process, and one that is easily understood and managed. Cullen (2003) believed a flow classification could be useful in water planning in Australia. These flow extraction thresholds were used as thresholds for the AquaBAMM measure 1.4.2–per cent natural flows–modelled flows remaining relative to predevelopment. The results for measure 1.4.2 are depicted in Figure 5.

Table 5 Australian River Classification

River class	Per cent mean annual flow
Heritage river	>95%
Conservation river	85 – 95%
Sustainable working river	67 – 85%
Managed working river	<67%

The Department of Environment and Resource Management was able to interpret flow data for the Fitzroy region of the GBR catchments and identify areas of modified hydrology. Through this exercise, the flow classes above represent only broad-scale trends with spatial boundaries between classes necessarily approximate. The per cent natural flow class of the highest stream order within a spatial unit was assigned to all of the other streams within a spatial unit.

6 Stratification

Study area stratification for application to relevant measures of AquaBAMM is a user decision and is not mandatory for successful assessment. However, AquaBAMM makes provision for data to be stratified in any user-defined way that is determined to be ecologically appropriate. Stratification mitigates the effects of data averaging across large study areas and is particularly important where ecological diversity and complexity is high. An example where stratification may be appropriate is fish diversity where fewer species inhabit the upland zone compared to lowland floodplains. Stratification is unwarranted for measure datasets where there is an equal probability of scoring across a range of values throughout the study area. To date, the use of strata in completed ACAs has been limited to 150 m above seal level (ASL) for coastal flowing catchments and 400 m ASL for catchments west of the Great Dividing Range in the Murray-Darling Basin.

Stratification was considered by the panel and it was recommended that is was not necessary to stratify any of the study areas within the Fitzroy. After further investigation post panel, and to maintain consistency with other ACAs, it was decided to adopt the stratification of 150 m ASL for the Baffle study area only (as used in the recently released Baffle ACA).

7 Weighting of measures

The panel members and project officers that attended the nine workshops weighted the measures within each indicator. Measures were weighted according to their importance to an indicator and based on the following rules:

1. At least one measure within each indicator must be weighted 10, which is the highest weight.

2. Weight the other measures within each indicator compared to the weighting of 10 assigned in the first step.

3. It is okay to have different measures with the same weight (i.e. all measures could be weighted 10).

4. Some indicators only have one measure and have already been given a weighting of 10.

5. Don't weight a measure down because of the quality or lack of data for that measure.

The individual weights were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final weights it was decided to average the weights across all three expert panel zones within the Great Barrier Reef study area, rather than average the weights for each zone or study area.

The final weights for each measure were then applied in the AquaBAMM assessment (Table 6). The measure number in **Error! Reference source not found.** relates to the hierarchical approach of the AquaBAMM method. The first number refers to a criterion and the second number to an indicator within a criterion followed by the individual measure number.

There are different methods for eliciting expert information. However, many of these can become very complicated and time-intensive. The benefits of refining the weights through a more detailed method were considered minimal. The result from the approach adopted at the workshop was considered by the AquaBAMM development team to accurately reflect the expert panel's decisions.

Table 6 The average weights for each measure

Maximum score is 10; total number of participants was approximately 20.

Criteria & indicators	Measures		Weight
1 Naturalness aquatic			
1.1 Exotic flora/fauna	1.1.1	Presence of ‘alien' fish species within the wetland	7.4
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland	10
	1.1.3	Presence of exotic invertebrate fauna within the wetland	5.9
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	7.2
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition	10
	1.2.2	SIGNAL2 score (Max)	8.5
	1.2.3	AUSRIVAS[2] score – Edge (Min band)	7.8
	1.2.4	AUSRIVAS[2] score – Pool (Min band)	7.9
	1.2.9	AUSRIVAS[2] score – Riffle (Min band)	7.9
1.3 Habitat features modification	1.3.1	SOR[1] bank stability	5.6
	1.3.2	SOR[1] bed & bar stability	5.4
	1.3.3	SOR[1] aquatic habitat condition	8.1
	1.3.4	Presence/absence of dams/weirs within the wetland	8.1

Criteria & indicators	Measures		Weight
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)	7.3
	1.3.14	Aquatic habitat condition using acknowledged metric	7.5
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment	9.7
	1.4.7	WRP (Water Resource Plan) hydraulic habitat	9.7
	1.4.8	HEV (High Ecological Value areas	9.7
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines.	10
2 Naturalness catchment			
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit	10
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to pre-clearing extent within buffered riverine wetland or watercourses	9.8
	2.2.2	Total number of regional ecosystems relative to pre-clearing number of regional ecosystems within buffered riverine wetland or watercourses	7.6
	2.2.3	SOR[1] reach environs	6.7
	2.2.4	SOR[1] riparian vegetation condition	7.7
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)	9.1
	2.3.2	% "grazing" land-use area	8.3
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)	8.4
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)	8.8
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area	10
3 Diversity and richness			
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)	8.9
	3.1.2	Richness of native fish	9.5
	3.1.3	Richness of native aquatic dependent reptiles	8.5
	3.1.4	Richness of native waterbirds	8.8
	3.1.5	Richness of native aquatic plants	9.6
	3.1.7	Richness of native aquatic dependent mammals	8.2
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa	9.2
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance	7.9
3.3 Habitat	3.3.1	SOR[1] channel diversity	8.3
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)	9.0
	3.3.3	Richness of wetland types within the sub-catchment	9.2
3.4 Geomorphology	3.4.1	Richness of geomorphic features	10
4 Threatened species and ecosystems			
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]	9.9
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]	9.9
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]	10
5 Priority species and ecosystems			
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)	9.4
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species	9.5
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)	8.7
	5.1.4	Habitat for significant numbers of waterbirds	8.1

Criteria & indicators	Measures		Weight
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem	10

6 Special features			
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features	10
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes	10
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)	9.5
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, Regional Coastal Management Planning, World Heritage Areas, etc.	8.2
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study	9.2
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. Spring fed stream, ephemeral stream, boggomoss)	10
7 Connectivity			
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6	9.6
	7.1.2	Migratory or routine ' passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit	9.4
7.1 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)	10
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6	10

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

8 Ranking of indicators

The panel members and project officers that attended the nine workshops ranked the indicators within each criterion. Indicators were ranked according to their importance to a criterion and based on the following rules:

1. At least one indicator within each criterion must be ranked 1 which is the highest ranking.
2. Rank the other indicators within each criterion relative to the ranking of 1 assigned in the first step.
3. It's okay to have different indicators with the same ranking (i.e. all indicators may be ranked 1).
4. Don't rank an indicator down because of the quality or lack of data for that indicator.

The individual rankings were averaged and reviewed with particular attention to averages having a high variance. In order to improve the statistical reliability of the final rankings it was decided to average the ranks across all three expert panel zones within the GBR study area, rather than average the ranks for each zone or study area.

The final ranks for each indicator were then applied in the AquaBAMM assessment (Table 7).

Table 7 The average rank for each indicator

Maximum rank is 1; total number of participants was approximately 20.

Indicator	Description	Rank
1 Naturalness aquatic		
1.1	Exotic flora/fauna	2
1.2	Aquatic communities/ assemblages	1
1.3	Habitat features modification	2
1.4	Hydrological modification	1
1.5	Water quality	2
2 Naturalness catchment		
2.1	Exotic flora/fauna	2
2.2	Riparian disturbance	1
2.3	Catchment disturbance	1
2.4	Flow modification	2
3 Diversity and richness		
3.1	Species	1
3.2	Communities/ assemblages	1
3.3	Habitat	1
3.4	Geomorphology	2
4 Threatened species and ecosystems		
4.1	Species	2
4.2	Communities/ assemblages	1
5 Priority species and ecosystems		
5.1	Species	2
5.2	Ecosystems	1
6 Special features		
6.1	Geomorphic features	3
6.2	Ecological processes	2
6.3	Habitat	1
6.4	Hydrological	3

Indicator	Description	Rank
7 Connectivity		
7.1	Significant species or populations	1
7.2	Groundwater dependant ecosystems	1
7.3	Floodplain and wetland ecosystems	1
7.5	Estuarine and marine ecosystems	2

Attachments

Attachment A – GBR catchment study area

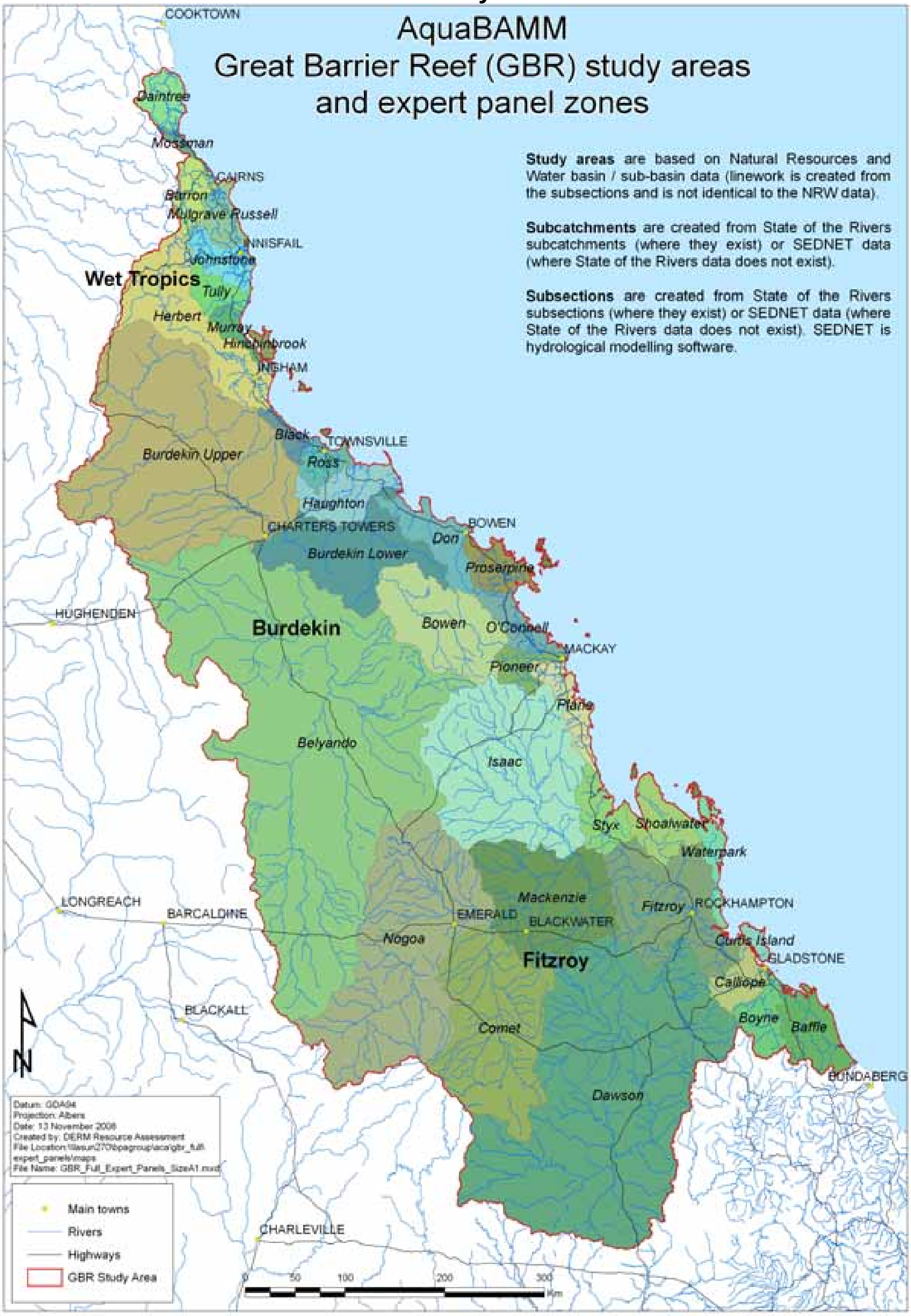

Figure 2 GBR catchment study area

Attachment B – Terms of reference (wetland ecology expert panel)

The terms and reference presented below are to be read in conjunction with the AquaBAMM report that requires expert panel workshops to be run to gain information for a number of AquaBAMM criteria and their associated indicators and measures (Clayton *et al*. 2006).

Members of the expert panel were experts in scientific disciplines relevant to freshwater ecosystems, processes and species. Panel members were required to have professional or semi-professional standing in their fields of expertise and have direct knowledge and experience of the GBR catchment. Experience in the identification and assessment of riverine and non-riverine values including natural processes, species and places of significance was an important factor in the selection process; the panel included members with experience in these areas, as well as in their areas of specialist technical expertise. Panel members were appointed on the basis of their individual standing rather than as representatives of a particular interest group or organisation.

Wetland ecology

The wetland ecology expert panel was established to provide expert advice based on experience and demonstrated scientific theory on natural ecological, geological or geo-morphological and hydrological processes, and issues of connectivity between aquatic systems within the riverine and non-riverine wetlands of the GBR. The panel consisted of professionals in fields of expertise relating to riverine and wetland ecology, water quality, geomorphology, fisheries and hydrological processes.

The tasks undertaken by the panel included, but without limitation, the following:

- identify areas of significant geomorphological, ecological or hydrological processes, or priority areas – special features
- provide advice on biodiversity 'hot-spots' or areas of particular significance for species or communities
- establish principles for applying the connectivity criterion (bi-directional, unidirectional and lateral directions) in the wetland ecosystems
- weight measures relative to their importance for an indicator
- rank indicators relative to their importance for a criterion.

Attachment C – Fitzroy catchment descriptions

Boyne catchment

The Boyne catchment is found to the south of Gladstone and includes the townships of Nagoorin, Ubobo, Boyne Island, Tannum Sands and Benaraby. The Boyne River and its tributaries are the major streams in the area. The Boyne is highly regulated by the large Awoonga Dam that supplies water to Gladstone and to the power station on Callide Creek in the Dawson catchment to the west. The headwaters of the Boyne drain from Kroombit Tops, Castletower, Bulberin and Dawes National Parks and these upper reaches are surrounded by high ecological value (HEV) habitat. The Boyne catchment is largely within the south-east Queensland (SEQ) bioregion.

Calliope catchment

The Calliope catchment is located to the north and west of Gladstone. Most of the catchment is within the Brigalow Belt (BRB) bioregion. It includes the Calliope and its tributaries and some small coastal creeks such as Boat and Manduran creeks. The Calliope River is one of few east coast rivers that are not regulated by a dam or weir and good ecological connectivity is maintained from its source to its estuary. Its freshwater reaches are relatively natural. However, its estuary flows through several major industrial sites including a power station that releases cooling water into its lower reaches.

Most of the catchments' freshwaters are surrounded by grazing lands. Townships within the catchment include Gladstone, Calliope and Mount Larcom.

Comet catchment

The Comet sub-catchment of the Fitzroy is located west of the Great Dividing Range largely to the south and east of Emerald. Townships in the sub-catchment include Rolleston, Springsure and Comet. The major river system is the Comet and its tributaries such as Orion and Humboldt creeks.

This sub-catchment originates in the Carnarvon and Expedition Ranges and flows across a relatively flat floodplain into the Mackenzie River. The catchment is flatter and the streams less steep than any others in the Fitzroy catchment.

The catchment has levees and water harvesting infrastructure and the Comet Weir is found near its confluence with the Mackenzie. Several large perched lakes including Lake Nugga Nugga occur in its headwaters. The major industry of the sub-catchment is grazing but significant coal mines and cropping also occur in the sub-catchment.

Curtis Island

The Curtis Island catchment contains few freshwater streams but has significant non-riverine wetlands. These are of particular value in that they generally have good connectivity to estuarine systems. Most of the catchment's wetlands are surrounded by grazing lands or are within the Curtis Island National Park and Curtis Island Conservation Park.

Dawson catchment

The Dawson sub-catchment is the largest of the Fitzroy sub-catchments. Its sources include the Carnarvon Range to the south, the Expedition Range and Blackdown Tableland to the west and the Kroombit and Mount Morgan ranges to the east. The Dawson has several major tributaries including the Don and Dee rivers, Callide, Mimosa, Palm Tree, Juandah, Eurombah and Injune creeks.

Townships within the sub-catchment include Injune, Wandoan, Taroom, Theodore, Moura, Baralaba, Biloela, Mount Morgan and Duaringa. There is extensive grazing throughout the catchment as well as irrigated and dry-land cropping. There are several large coal mines and coal seam methane gas production is a significant and growing land use in the area that impacts on water flows.

The Dawson sub-catchment has a number of dams and weirs including the Glebe, Orange Creek, Gyranda, Theodore, Moura and Neville Hewitt weirs on the Dawson and Kroombit and Callide dams on the Callide Creek system. There are also dams on the Dee River near Mount Morgan to provide water for the township and others to contain contaminated water runoff from the Mount Morgan Mine tailings. Water is also flood harvested from the Dawson into offstream storage at Moura. Water is also pumped over the range from the Awoonga Dam on the Boyne River into Callide Dam.

The Dawson Valley tends to be relatively flat and the river frequently splits into anabranches and oxbow lakes in some places. The river intersects a number of sandstone gorges, notably the Nathan Gorge near Taroom and has complex groundwater links that produce unusual mound springs in some areas.

Most of the flows in the Dawson occur in summer but its southern catchments may also receive significant winter rains in some years.

Fitzroy sub-catchment

The Fitzroy sub-catchment receives its waters from the Mackenzie and Dawson rivers. It also receives significant inflows from Marlborough, Neerkol and Alligator creeks. The area also includes smaller Fitzroy delta streams including Raglan Creek.

In terms of area, grazing is the predominant land use. However, there are industrial developments close to the river including two large meatworks and the Stanwell Power Station. The Fitzroy River estuary flows through the city of Rockhampton and the townships of Marlborough, Yaamba, Westwood, Bajool and Raglan.

The Fitzroy is highly regulated as a result of upstream dams and weirs, Eden Bann Weir and the Fitzroy Barrage that prevents tidal saltwaters from moving upstream. Eden Bann Weir provides water for Stanwell Power Station and the barrage provides water for Rockhampton and the Capricorn Coast. Raglan Creek is an almost perennial stream that flows into the Fitzroy Delta.

There are several large offstream wetlands through the Fitzroy Delta including Woolwash, Yeppen, Frogmore, Crescent, Nankin, Serpentine and Gracemere lagoons.

Isaac catchment

The Isaac-Connors sub-catchment of the Fitzroy is located west of the Great Dividing Range roughly from west of Sarina to west of Marlborough. Townships in the sub-catchment include Nebo and Moranbah.

This sub-catchment provides most of the flow that reaches the Fitzroy Estuary. This is particularly so of the Connors River whose tributaries originate in the wet Clarke Connors Range to the west of Mackay and Sarina. The western side receives much less rain than the rest of the catchment and consequently flows in the upper Isaac River are much smaller. The lower Isaac and Connors rivers become split into complex multi-channels and anabranches that can become separated lagoons during the dry season.

Grazing is the predominant land use in the catchment but there are a significant number of coal mines particularly to the west. This catchment is currently less regulated than any of the other Fitzroy sub-catchments with only small dams occurring in the upper Isaac River e.g.

Burton Gorge Dam. There are significant quantities of water pumped from the Burdekin catchment into the catchment to supply the needs of coal mining.

The Dipperu National Park (scientific) is the only park within the Isaac Connors sub-catchment.

Mackenzie catchment

The Mackenzie sub-catchment of the Fitzroy receives flows from the Nogoa, Comet and Isaac rivers. The catchment extends downstream to the confluence with the Dawson River after which it becomes the Fitzroy. Townships in the sub-catchment include Middlemount, Blackwater and Dingo.

Grazing is the predominant land use in the catchment but there are a significant number of coal mines and irrigated and dry-land cropping are also important. The catchment is highly regulated with flows being controlled through Bingegang, Bedford and Tartrus weirs as well as a number of water harvesting operations.

Most of the upper catchment flows through a single channel. However, at the confluence with the Isaac River the river has several large floodplain waterholes such as Lake Mary on its floodplain that may become river channels during floods.

There is one National Park—Taunton National Park—and several state forests within the sub-catchment.

Nogoa catchment

The Nogoa sub-catchment of the Fitzroy is located west of the Great Dividing Range largely to the west of Emerald. Townships in the sub-catchment include Emerald, Rubyvale, Sapphire, Clermont and Capella. The major river system is the Nogoa and its tributaries such as Theresa and Crinum creeks.

This sub-catchment originates between Carnarvon Range and Clermont and shares its origins with the Burdekin, Burnett and Murray Darling systems. It is totally landlocked and flows into the Mackenzie River system. Grazing is the predominant land use in the catchment but there are a significant number of coal mines and cropping is important in the Emerald irrigation area. The catchment is highly regulated downstream of the large Fairbairn Dam near Emerald with several small weirs and the Theresa Creek Dam also regulating flows.

There is one national park—Carnarvon National Park—at the south-western corner of the subcatchment and a number of large state forests such as Kettle and Fairbairn State Forests.

O’Connell catchment

The O’Connell catchment is located to the south of Proserpine and north of Mackay. It forms part of the Central Queensland Coast bioregion.

Despite its name, this catchment actually comprises small coastal catchments including the Andromache and O’Connell rivers and several smaller creeks including Murray, Constant and Blackrock creeks.

Townships in the area include Bloomsbury, Calen, Kuttabul and Seaforth. The major industries of the area include tourism, cane growing, cattle grazing and fishing.

The O’Connell catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters across a highly modified coastal plain extensively developed for sugar cane growing.

Pioneer catchment

The Pioneer catchment is located on the east coast flowing through the city of Mackay. It forms part of the Central Queensland Coast bioregion.

This catchment includes the Pioneer River and its tributaries such as Cattle, Finch Hatton, Teemburra, Blacks and Black Waterhole creeks. The Pioneer River is highly regulated with a major dam (Teemburra Dam) and a series of weirs (Marian, Mirani and Dumbleton). Water is also diverted through a series of creeks to be utilised in the Pioneer Valley Irrigation Scheme and also pumped to the nearby Kinchant Dam which is the major storage for the Eton Irrigation Scheme in the Plane Creek catchment.

The headwaters of the catchment rise in high conservation value rainforest and then flow across a highly modified coastal plain through the city of Mackay.

Townships in the area include Mackay, Marian, Mirani and Pinnacle. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. Most of the headwaters of the Pioneer rise in national parks, such as the Eungella National Park, or state forest (including Crediton State Forest).

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Plane catchment

The Plane catchment is located on the east coast of Queensland, to the south of Mackay. It forms part of the Central Queensland Coast bioregion. Despite its name, this ‘catchment’ is actually several small coastal catchments including Bakers, Sandy, Alligator, Plane, Rocky Dam, Marion, Carmilla, West Hill and Clairview creeks.

Townships within the catchment include Sarina, Koumala, Carmila and Clairview. The northern streams form part of the Eton Irrigation Scheme supplying water for irrigated cane growing. Water from the Pioneer River is flood harvested and transferred into these streams in part through the large offstream storage Kinchant Dam. Plane Creek has a series of small weirs regulating its flows. Streams tend to be less regulated and modified in the southern parts of the catchment.

The Plane catchment has a tropical climate with a pronounced wet season between December and March. The streams tend to be relatively short and fast flowing from rainforest headwaters. In the north they flow across a highly modified coastal plain extensively developed for sugar cane growing.

Southern streams largely rise in state forests such as the West Hill and Kelvin State Forest. Cape Palmerston National Park is found on the coast within the catchment.

Proserpine catchment

The Proserpine catchment is located on the east coast, to the south of Bowen and north of Mackay. It forms part of the Central Queensland Coast bioregion.

Despite its name, this ‘catchment’ is actually several small coastal catchments including the Proserpine and Gregory rivers and smaller creeks such as Repulse Creek, and it includes the world-recognised wetlands of Goorganga Plain. Streams in the area tend to be short and fast flowing usually with headwaters in rainforest.

Repulse Creek is one of few streams almost entirely enclosed in protected area (predominantly Conway National Park). In contrast the Proserpine River is highly regulated with a major storage (Peter Faust Dam) in its headwaters. Water is released from this dam through a series of stream diversions to facilitate irrigated sugar cane growing.

Townships in the area include Proserpine, Airlie Beach Dingo Beach and Midge Point. The major industries of the area include tourism, cane growing, cattle grazing, forestry (including plantations), and fishing. There are also major national parks including the Whitsunday Islands and Conway National Park.

The Proserpine catchment has a tropical climate with a pronounced wet season between December and March.

Shoalwater catchment

The Shoalwater catchment is located to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It is largely bounded by the western coast of Shoalwater Bay and the shores of Stanage Bay. It includes the small streams flowing into Stanage Bay such as Herbert and Wadallah creeks, and includes the settlement of Stanage Bay.

There are extensive non-riverine wetlands in the vicinity of the Torilla Plains and Glenprairie to the east and west of Stanage Bay. The major modification to local water regime is the construction of extensive levees to stop saltwater intrusion. These have modified a number of estuarine wetlands to become extensive freshwater palustrine areas.

The Shoalwater catchment has a tropical to subtropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep fast streams to the north and the long slow-flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north.

Styx River catchment

The Styx catchment is located on the east coast of Queensland, to the north of Rockhampton and south of Mackay. It forms part of the Brigalow Belt North bioregion. The major streams in this small catchment are the Styx River and St Lawrence Creek. Locations within the catchment include St Lawrence and Ogmore. St Lawrence Creek is regulated by a small weir.

The Styx catchment has a tropical climate with a pronounced wet season between December and March. It represents a transitional zone between the steep fast streams to the north and the long slow-flowing streams of the Fitzroy Basin. Streams are less steep and slower flowing than those further north. The highly dispersive soils of the area make the streams naturally more turbid.

The major industries in the area are cattle grazing and fishing with some horticulture and plantation forestry in the north.

Two small state forests (Glencoe and Mt Buffalo) and a small conservation park (Newport) exist in the catchment.

Waterpark catchment

The Waterpark catchment is located to the north-east of Rockhampton. It forms part of the Brigalow Belt and Central Queensland Coast bioregions. It includes the Shoalwater Bay Military Training Area south to the mouth of the Fitzroy River. The northern section from the mouth of Waterpark Creek is one of the least disturbed catchment areas in Queensland with only infrequent use in relatively small areas. It is closely managed as part of the Shoalwater Bay Military Training Area, the Byfield National Park and Byfield State Forest with limited access and largely natural remnant vegetation.

The largest stream in the area is Waterpark Creek, which rises from sand dunes in the north and flows south and then east into Corio Bay almost exclusively through protected areas. Its water quality and source from within sand dunes makes it unique within the Fitzroy study area. Within Shoalwater Bay, there are several small streams including Shoalwater Creek and a large wetland complex (Dismal Swamp) but no large rivers. Further south creeks such as Coorooman Creek have much more disturbed catchments. The acid Wallum wetlands of the Dismal Swamp area are very unusual within the central Fitzroy area.

The area includes the townships of Yeppoon, Emu Park and Keppel Sands.

Attachment D – Criteria, indicators and measures for the GBR catchment

The criteria, indicators and measures (CIM) list indicates the CIM that were implemented as part of the riverine Aquatic Conservation Assessment (ACA) using AquaBAMM of the freshwater wetlands of the GBR catchment.

The list has been developed from a default list of criteria, indicators and measures that may be considered when an Aquatic Conservation Assessment (ACA) is conducted using AquaBAMM. The default CIM list is not mandatory for any particular ACA however it provides a 'starter set' for consideration in setting the assessment parameters for each assessment.

AquaBAMM does not allow criteria change, addition or deletion. AquaBAMM does allow addition or deletion of indicators and/or measures for each ACA when its assessment parameters are set. Generally, however, modification of the default set of indicators is discouraged because the list has been developed to be generic and inclusive of all aquatic ecosystems. Modification of the default set of measures may or may not be necessary but full flexibility is provided in this regard using AquaBAMM. In particular, measures may need to be added where unusual or restricted datasets are available that are specific to an ACA or study area.

Table 8 CIM list for the GBR catchment

Criteria & indicators	Measures	
1 Naturalness aquatic		
1.1 Exotic flora/fauna	1.1.1	Presence of 'alien' fish species within the wetland
	1.1.2	Presence of exotic aquatic and semi-aquatic plants within the wetland
	1.1.3	Presence of exotic invertebrate fauna within the wetland
	1.1.4	Presence of feral/exotic vertebrate fauna (other than fish) within the wetland
1.2 Aquatic communities/ assemblages	1.2.1	SOR[1] aquatic vegetation condition
	1.2.2	SIGNAL2 score (Max)
	1.2.3	AUSRIVAS[2] score – Edge (Min band)
	1.2.4	AUSRIVAS[2] score – Pool (Min band)
	1.2.9	AUSRIVAS[2] Score – riffle (Min band)
1.3 Habitat features modification	1.3.1	SOR[1] bank stability
	1.3.2	SOR[1] bed & bar stability
	1.3.3	SOR[1] aquatic habitat condition
	1.3.4	Presence/absence of dams/weirs within the wetland
	1.3.5	Inundation by dams/weirs (% of waterway length within the wetland)
	1.3.14	Aquatic habitat condition using acknowledged metric
1.4 Hydrological modification	1.4.2	Percent natural flows – modelled flows remaining relative to predevelopment
	1.4.7	WRP (Water Resource Plan) hydraulic habitat
	1.4.8	HEV (High Ecological Value) areas
1.5 Water quality	1.5.10	Water quality index/score – an acknowledged metric calculated considering local, state or national water quality guidelines
2 Naturalness catchment		
2.1 Exotic flora/fauna	2.1.1	Presence of exotic terrestrial plants in the assessment unit
2.2 Riparian disturbance	2.2.1	% area remnant vegetation relative to preclear extent within buffered riverine wetland or watercourses
	2.2.2	Total number of regional ecosystems relative to preclear number of regional ecosystems within buffered riverine wetland or watercourses
	2.2.3	SOR[1] reach environs
	2.2.4	SOR[1] riparian vegetation condition
2.3 Catchment disturbance	2.3.1	% "agricultural" land-use area (i.e. cropping and horticulture)
	2.3.2	% "grazing" land-use area
	2.3.3	% "vegetation" land-use area (i.e. native veg + regrowth)
	2.3.4	% "settlement" land-use area (i.e. towns, cities, etc)

Criteria & indicators	Measures	
2.4 Flow modification	2.4.1	Farm storage (overland flow harvesting, floodplain ring tanks, gully dams) calculated by surface area
3 Diversity and richness		
3.1 Species	3.1.1	Richness of native amphibians (riverine wetland breeders)
	3.1.2	Richness of native fish
	3.1.3	Richness of native aquatic dependent reptiles
	3.1.4	Richness of native waterbirds
	3.1.5	Richness of native aquatic plants
	3.1.7	Richness of native aquatic dependent mammals
3.2 Communities/ assemblages	3.2.1	Richness of macroinvertebrate taxa
	3.2.2	Richness of regional ecosystems along riverine wetlands or watercourses within a specified buffer distance
3.3 Habitat	3.3.1	SOR[1] channel diversity
	3.3.2	Richness of wetland types within the local catchment (e.g. SOR sub-section)
	3.3.3	Richness of wetland types within the sub-catchment
3.4 Geomorphology	3.4.1	Richness of geomorphic features.
4 Threatened species and ecosystems		
4.1 Species	4.1.1	Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act[4], EPBC Act[5]
	4.1.2	Presence of rare or threatened aquatic ecosystem dependent flora species – NC Act[4], EPBC Act[5]
4.2 Communities/ assemblages	4.2.1	Conservation status of wetland Regional Ecosystems – Herbarium biodiversity status, NC Act[4], EPBC Act[5]
5 Priority species and ecosystems		
5.1 Species	5.1.1	Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB[6], WWF, etc)
	5.1.2	Presence of aquatic ecosystem dependent 'priority' flora species
	5.1.3	Habitat for, or presence of, migratory species (expert panel list/discussion and/or JAMBA[7]/CAMBA[8] agreement lists and/or Bonn Convention)
	5.1.4	Habitat for significant numbers of waterbirds
5.2 Ecosystems	5.2.1	Presence of 'priority' aquatic ecosystem
6 Special features		
6.1 Geomorphic features	6.1.1	Presence of distinct, unique or special geomorphic features
6.2 Ecological processes	6.2.1	Presence of (or requirement for) distinct, unique or special ecological processes
6.3 Habitat	6.3.1	Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose)
	6.3.2	Significant wetlands identified by an accepted method such as Ramsar, Australian Directory of Important Wetlands, regional coastal management planning, World Heritage Areas, etc
	6.3.3	Ecologically significant wetlands identified through expert opinion and/or documented study
6.4 Hydrological	6.4.1	Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)
7 Connectivity		
7.1 Significant species or populations	7.1.1	The contribution (upstream or downstream) of the spatial unit to the maintenance of significant species or populations, including those features identified through criteria 5 and/ or 6
	7.1.2	Migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit
7.2 Groundwater dependant ecosystems	7.2.1	The contribution of the special unit to the maintenance of groundwater ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6 (e.g. karsts, cave streams, artesian springs)

Criteria & indicators	Measures	
7.3 Floodplain and wetland ecosystems	7.3.1	The contribution of the spatial unit to the maintenance of floodplain and wetland ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6
7.5 Estuarine and marine ecosystems	7.5.1	The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through criteria 5 and/or 6.

[1] SOR – State of the Rivers
[2] AUSRIVAS – Australian River Assessment System
[3] APFD – Annual Proportional Flow Deviation
[4] NC Act – Nature Conservation Act 1992 (Queensland legislation)
[5] EPBC Act – Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth legislation)
[6] ASFB – Australian Society of Fish Biology
[7] JAMBA – Japan-Australia Migratory Bird Agreement
[8] CAMBA – China-Australia Migratory Bird Agreement

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