Santos Coal Seam Gas Fields

Aquatic Ecology Impact Assessment

Prepared for:

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Glossary

Term	Definition
Aestivate	To be dormant, often buried within the soil or under leaf litter, during months of drought.
Aggradation	The build-up of sediment or some other substance.
Algal mat	A thin layer of algae formed over the surface of the benthos.
Anaerobic	Having or producing no oxygen.
Anthropogenic	Caused by humans or human activity.
Benthos	A term for all of the flora and fauna that live in or on the bottom substrate of waterbodies, including creeks, rivers and wetlands.
Biodiversity	The range of organisms present in a given community or system.
Catchment	The area of land that collects and transfers rainwater into a waterway.
Channelisation	The formation of deeper channels within a waterway.
Crustacean	An arthropod with jointed appendages, a hard protective outer shell, two pairs of antennae and eyes on stalks, e.g. crabs, prawns.
Culvert	A covered channel that carries water, often covered by a bridge or a road.
Desiccation	Drying out due to the effects of the environment.
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DNRW	Queensland Department of Natural Resources and Water
DPI&F	Queensland Department of Primary Industries and Fisheries
Dissolved Oxygen (DO)	The amount of oxygen dissolved in water.
Diversity	The variety of a particular factor.
Ecological	Relating to the relationships between organisms and their environment.
Edge (habitat)	The habitats on the edge of a stream, which may contain undercut banks, trailing bank vegetation, aquatic macrophytes, tree roots etc.
Environmental flow	Freshwater flow that is maintained solely for environmental reasons, e.g. flows to act as an environmental cue, to deliver nutrients and sediment downstream etc.
EPA	Queensland Environmental Protection Agency
Ephemeral	Lasting for a short amount of time, e.g. ephemeral waterways are often dry.

Term	Definition
Erosion	The wearing away of rock or soil caused by physical or chemical processes.
Euryhaline	Tolerant of a wide range of water salinities.
Eutrophic	A body of water impacted by high concentrations of nutrients.
Eutrophication	The process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth. This enhanced plant growth, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.
Habitat	The natural conditions and environment in which a plant or animal lives.
Invertebrate	Animals that don't have a backbone, e.g. insects, crustaceans.
Macroinvertebrate	An invertebrate large enough to be seen without magnification.
Macrophyte	A plant large enough to be seen with the naked eye.
Noxious	Harmful to the environment or ecosystem.
Perennial	Lasting for an indefinite amount of time.
PET richness	The richness of pollution-sensitive invertebrate taxa (**P**lecoptera (stoneflies), **E**phemoptera (mayflies), and **T**richoptera (caddisflies) within an area.
pH	Measure of the acidity or alkalinity of a substance, with 1 being the most acidic, 7 being neutral and 14 being the most alkaline.
Pool	An area in a stream that has no water flow and that is often deeper than other parts of the stream.
Quantitative	An assessment based on the amount or number of something.
Riffle zone	An area within a stream that is characterised by shallow water, rocky sediment and fast water flows.
Riparian	Situated along or near the bank of a waterway.
Run	An area in a stream that is characterised by moderately straight channels and medium water flow.
Senescing	Ageing and deteriorating, e.g. pools that drying out over time.
SIGNAL 2	An index of macroinvertebrate communities that gives an indication of the types of pollution and other physical and chemical factors affecting a site.
Species richness	The number of different species/taxonomic groups present in a given area.
Substrate	The underlying base to something, e.g. the streambed.

Term	Definition
Trailing bank vegetation	Riparian vegetation that hangs over the bank of a creek into the water.
Trophic	Describes the diet of groups of plants or animals within the various levels of a food web.
Turbidity	The clarity of a waterbody; depends on the concentration of particles that are suspended in the water column.
Velocity	The rate of water movement with respect to time.

Executive Summary

This report has been prepared for URS Australia (URS), on behalf of Santos Limited (Santos), who propose to develop and expand its existing CSG Fields in the Bowen and Surat Basins in the area around Roma, in western Queensland. It provides a description of the aquatic environmental values of creeks and artesian springs in the Coal Seam Gas Fields (CSG Fields), and an assessment of the potential impacts of the project on aquatic ecology.

The assessment of potential impacts relates to the development and expansion of the CSG Fields. Given that this development will be subject to an incremental planning process, this assessment has been conducted across the CSG Fields generally, and therefore does not consider the specific locations of potential impacting processes. Rather, it provides an overall assessment of the range of potential impacts at the catchment level, and outlines options for the impact avoidance, minimisation. Therefore, this assessment of potential impacting processes will need to be refined once the specific details of the development have been determined.

Relevant Legislation and Guidelines

Development of the CSG Fields has the potential to impact the following threatened aquatic species and ecological communities (as listed under the *Environment Protection and Biodiversity Conservation Act 1999*): Fitzroy River turtle (*Rheodytes leukops*); Murray cod (*Maccullochella peeli peeli*), and Mound spring communities that are dependent on the natural discharge of water from the Great Artesian Basin (refer Section 5).

The development of the CSG Fields may require operational works in watercourses. This would require an approval under Section 266 of the *Water Act 2000* (Water Act). Additionally, where waters are to be taken from a watercourse, lake, spring or underground water, a permit may be required pursuant to S. 237 of the Water Act.

The construction of structures (including culverts and road crossings) across freshwater waterways in the CSG Fields may require a waterway barrier works approval under Division 8 of the *Fisheries Act 1994* (Fisheries Act).

Aquatic Environmental Values

The Environmental Values of watercourses within the study area are relatively low and consistent with those of the wider catchments. Environmental values are dictated

primarily by the ephemeral nature of many of the region's waterways, although agricultural development (particularly grazing) within the region has significantly influenced water quality and the physical characteristics of aquatic habitat. Water quality is generally poor and is characterised by high turbidity and low or variable dissolved oxygen levels.

The biodiversity of smaller watercourses is relatively low. Nevertheless, these creeks do offer some habitat to the native fish species that were recorded in the study area, and may provide habitat for breeding and dispersal during periods of high flow. In contrast, the larger waterways in the study area support more permanent water, and offer more stable habitat for aquatic organisms. As a result, these waterways would be expected to support more abundant and diverse communities, and contain more taxa that are sensitive to pollution and disturbance. The specific differences in communities between sites appeared to be related to site-specific differences in the availability and diversity of habitat, and the level of connectivity.

The condition of artesian springs in the Upper Dawson Catchment varied considerably between the springs surveyed, with the state of each spring largely dependent on: the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds. The smaller, shallower springs provided little habitat for aquatic organisms, but usually supported some macrophytes. In contrast, the larger more complex springs often supported substantial habitat and macrophytes. Cattle damage and weeds were common and had degraded the condition of many springs.

The endangered macrophyte salt pipewart has been recorded at springs on Hutton Creek in the Upper Dawson Catchment. No other rare or threatened aquatic flora or fauna have been recorded from the watercourses or artesian springs in the CSG Fields. However, the study covered a large area and not all waterways and artesian springs were visited; some may need to be further investigated if any petroleum activities are planned in these areas.

Potential Impacts

The development and operation of the CSG Fields has the potential to impact on aquatic ecology through: discharge or injection of associated water; stormwater and associated water entering creeks or springs as runoff; vegetation clearing and earth moving within or adjacent to creeks and springs; extraction of associated water for CSG production; operation of vehicles and equipment; creation of pipeline creek crossings; construction of vehicle creek crossings; obstruction of flow and aquatic fauna passage; and creation of breeding habitat for biting insects.

Roads and pipelines in the CSG Fields should be planned to avoid artesian springs. Where the construction of roads and pipelines is required in proximity to artesian springs, further detailed assessments of the potential for impact may be required. Where roads and pipelines are located to minimise disturbance to the riparian vegetation and instream habitats of watercourse in the CSG Fields, and the recommended mitigation controls (Table 5.1) are followed, it is unlikely that construction would have an ecologically significant impact on the watercourses of the CSG Fields. However, there may be a temporary impact to the passage of fish and turtles (in waterways that support these species) during construction activities.

Drilling leases should also be planned to avoid artesian springs. A groundwater impact study to assess the potential impacts of drawdown on artesian springs should be conducted prior to the commencement of any drilling works. This study would need to inform the design of a monitoring program aimed at detecting changes in rates of spring discharges over the period of water extraction. Where drilling operations are located to minimize disturbance to the riparian vegetation, and the recommended mitigation controls (Table 5.1) are followed, it is unlikely that drilling works would have an ecologically significant impact on the watercourses of the CSG Fields.

Where fuel storage and handling activities are undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols), the risk to the aquatic ecology posed by fuel spilt during construction is considered to be very low.

The discharge of associated water has the potential to reduce seasonality of flows, increase the availability of water, and enhance erosion and scouring at discharge points on watercourses in the CSG Fields. This may favour filamentous algae and exotic flora and fauna and reduce diversity. Discharges should be managed inline with the EPA's operational policy for *Management of Water Production in Association with Petroleum Activities* (*Associated Water*). Where discharges are timed to follow natural flow patterns, and bed stabilising structures are placed at discharge points to reduce erosion, the likelihood of impacts to aquatic ecology is low.

Where appropriate stormwater management facilities are implemented to prevent runoff from transporting contaminants to the waterways of the CSG Fields, the risk of impact to aquatic ecology is low.

Where decommissioning activities are conducted adjacent to artesian springs and watercourses, and the recommended mitigation controls (Table 5.1) are implemented to prevent runoff from entering watercourses and rehabilitate riparian vegetation, the risk of long-term impacts to aquatic ecology is low.

1 Introduction

This report has been prepared for URS Australia (URS), on behalf of Santos Limited (Santos). It provides a description of the aquatic environmental values of creeks and artesian springs in the Coal Seam Gas Fields (CSG Fields) for the Gladstone Liquid Natural Gas Project (the GLNG Project), and an assessment of the potential impacts of the project on aquatic ecology. It does not consider the aquatic environmental values, or potential for impact in any other project area.

1.1 The GLNG Project

Santos is proposing to develop and expand its existing CSG Fields in the Bowen and Surat Basins in the area around Roma, in western Queensland (Figure 1.1 & Figure 1.2). The CSG Fields will be developed to supply the feed gas to a proposed natural gas liquefaction and export facility (the LNG Facility) on Curtis Island, near Gladstone. Santos proposes to drill and complete enough development wells to supply approximately 5300 petajoules (PJ) (140 billion m^3) CSG to LNG Facility. This will likely equate to approximately 600 development wells prior to 2015 and possibly 1400 or more wells after 2015 (excluding exploration wells). In addition to the drilling of wells, development of the CSG Fields will include the construction of: access roads; accommodation camps; water gathering networks and management facilities; gas gathering networks and transport facilities; and field gas compression stations.

The development of the CSG Fields and LNG Facility are two of five components of the overall Project, which includes:

- a natural gas liquefaction and export facility (LNG Facility) of up to approximately 10 million tonne per annum (MTPA) on Curtis Island, near Gladstone, Queensland
- a 435 km long underground gas transmission pipeline corridor, which will accommodate one or more pipelines, for the delivery of the gas from the CSG Fields resources to the LNG facility
- a bridge, road and services corridor to access the LNG facility on Curtis Island from Gladstone, and
- marine facilities such as jetty, materials offloading facility and channel dredging to service the LNG facility.

1.2 The CSG Fields

The CSG Fields stretch from approximately 50 km south of Roma in western Queensland, north to the vicinity of Emerald, and east to the vicinity of Taroom (Figure 1.1 & Figure 1.2). The following project areas comprise the CSG Fields:

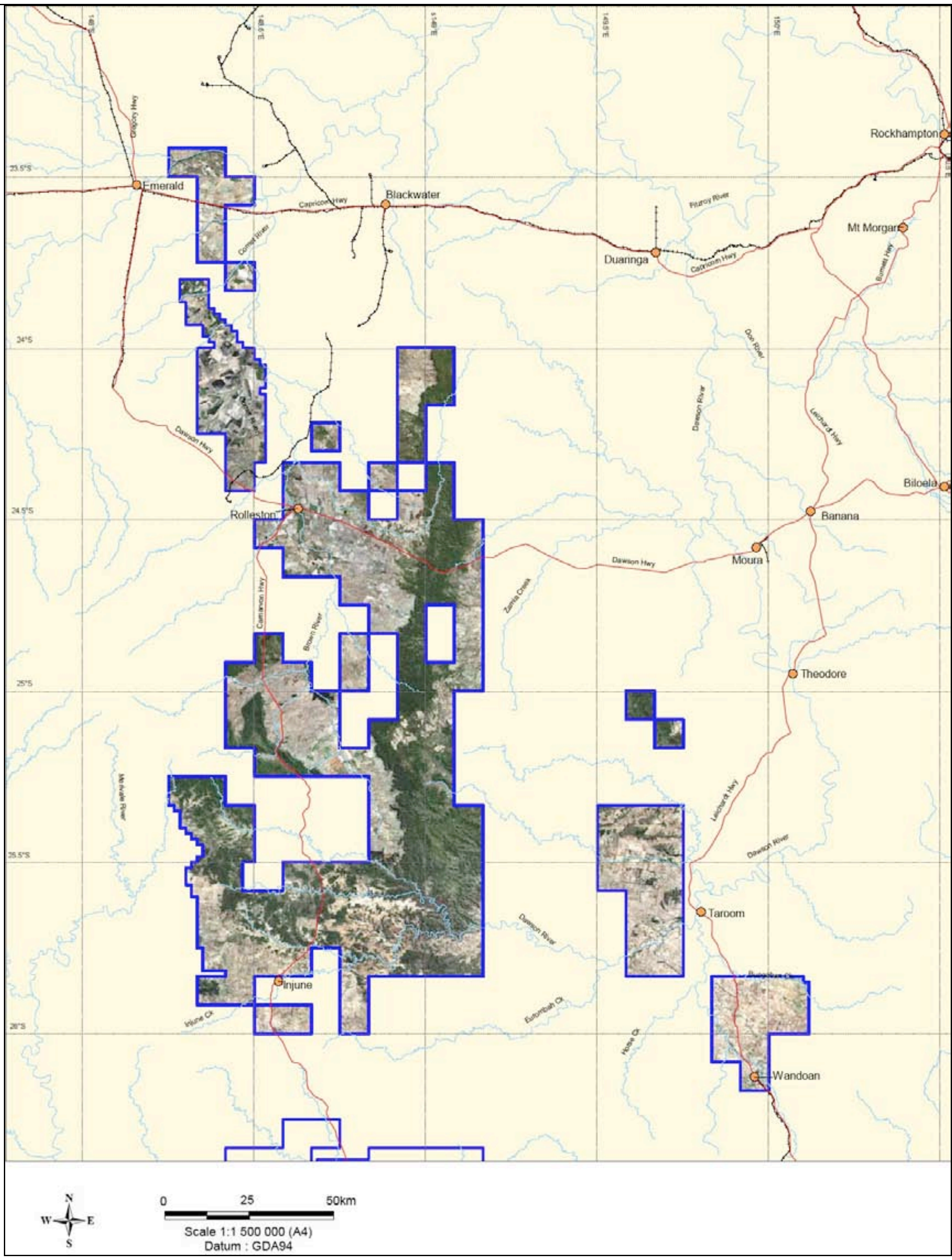
- Denison Trough field (592,310 ha)
- Fairview field (481,790 ha)
- Roma field (839,280 ha)
- Scotia field (75,350 ha)
- Eastern Surat Basin (36,240 ha)
- Mahalo field (62,640 ha), and
- Other areas (131,700 ha).

The CSG Fields lie within the Comet, Dawson and Condamine - Upper Balonne Catchments.

The Comet River originates in the Expedition Ranges and flows into the Mackenzie River approximately 5 km to the north of the town of Comet. The Mackenzie River joins with the Dawson River to become the Fitzroy River, approximately 85 km south west of Rockhampton. The Mackenzie River Catchment is one of the smallest catchments within the Fitzroy Basin (Joo et al. 2000) (Figure 1.3).

The Dawson River originates in the Carnarvon section of the Great Dividing Range and flows into the Fitzroy River, approximately 85 km south west of Rockhampton. The Dawson River is the largest tributary of the Fitzroy River, and the Dawson Catchment covers 35% of the Fitzroy Basin (Joo et al. 2000) (Figure 1.3).

The Condamine River originates in the Great Dividing Range and flows into the Balonne River at its confluence with Dogwood Creek, approximately 60 km east of the town of Surat. The Balonne River flows into the Culgoa River north of the township of Dirranabandi, which joins the Darling River at the town of Burke. The Condamine Catchment covers 13% of the Murray-Darling Basin (CSIRO 2008) (Figure 1.4).



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 1.1 CSG Field, Northern Section.	
	URS Australia 2008	January 2009

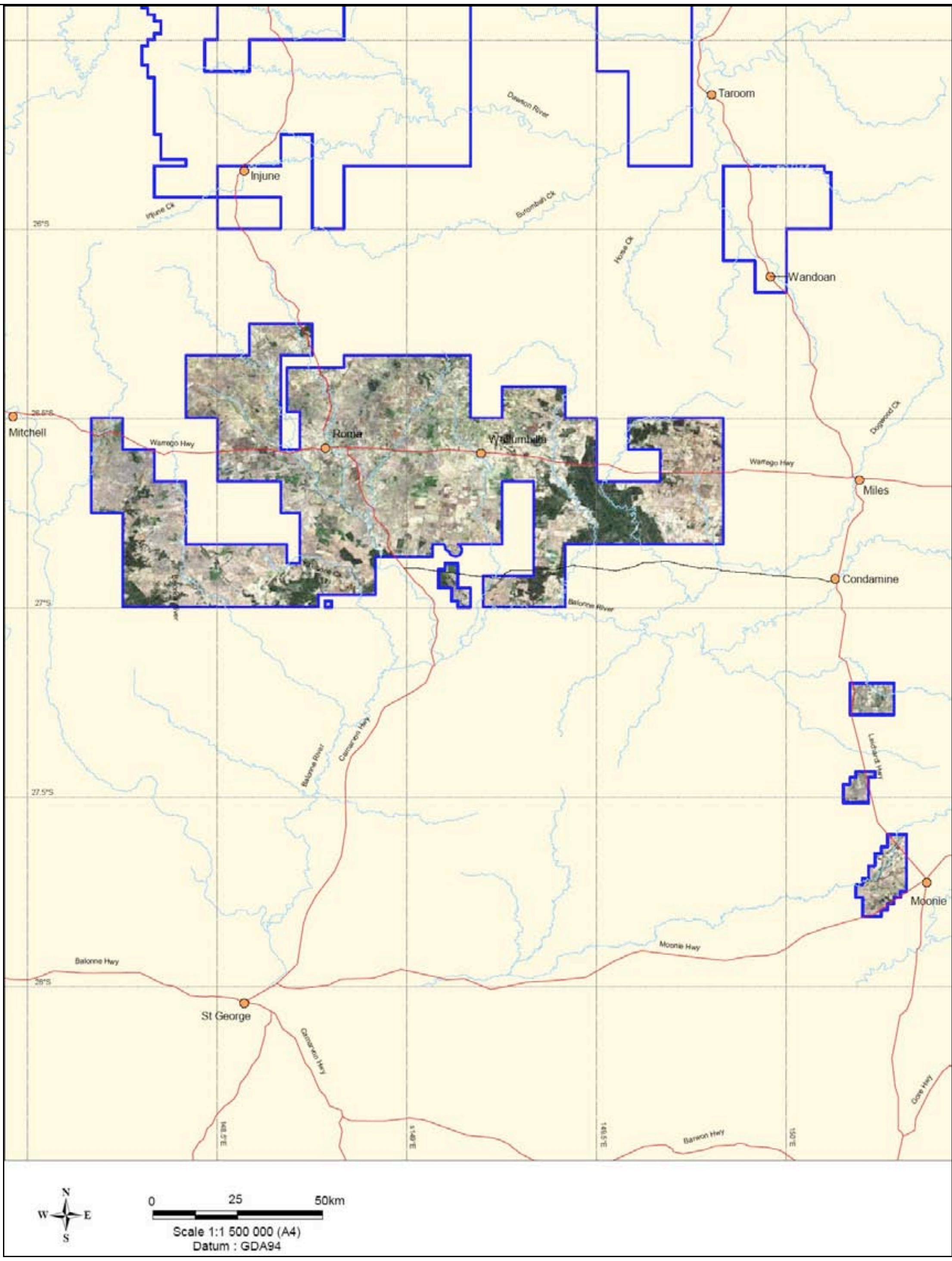


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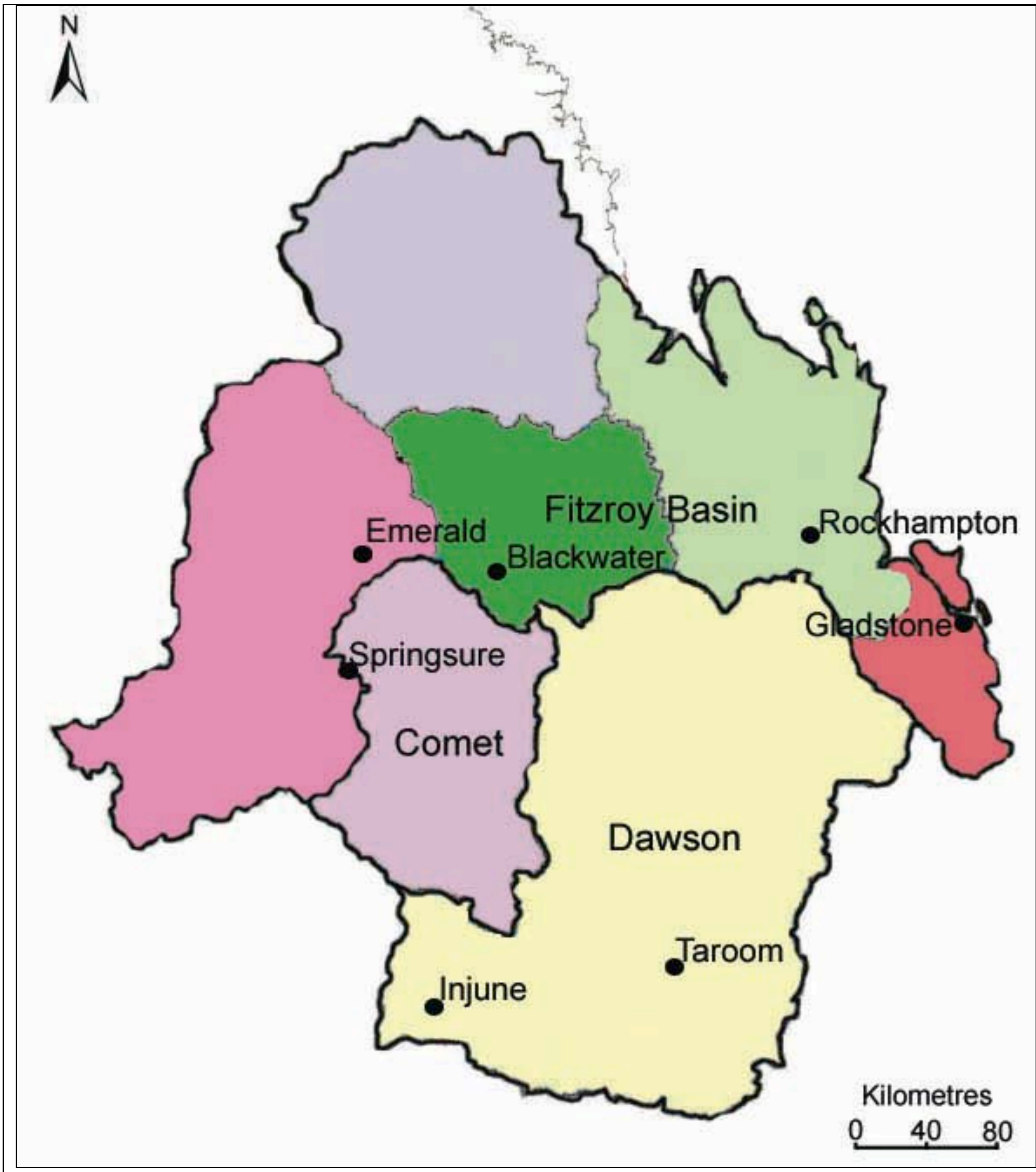
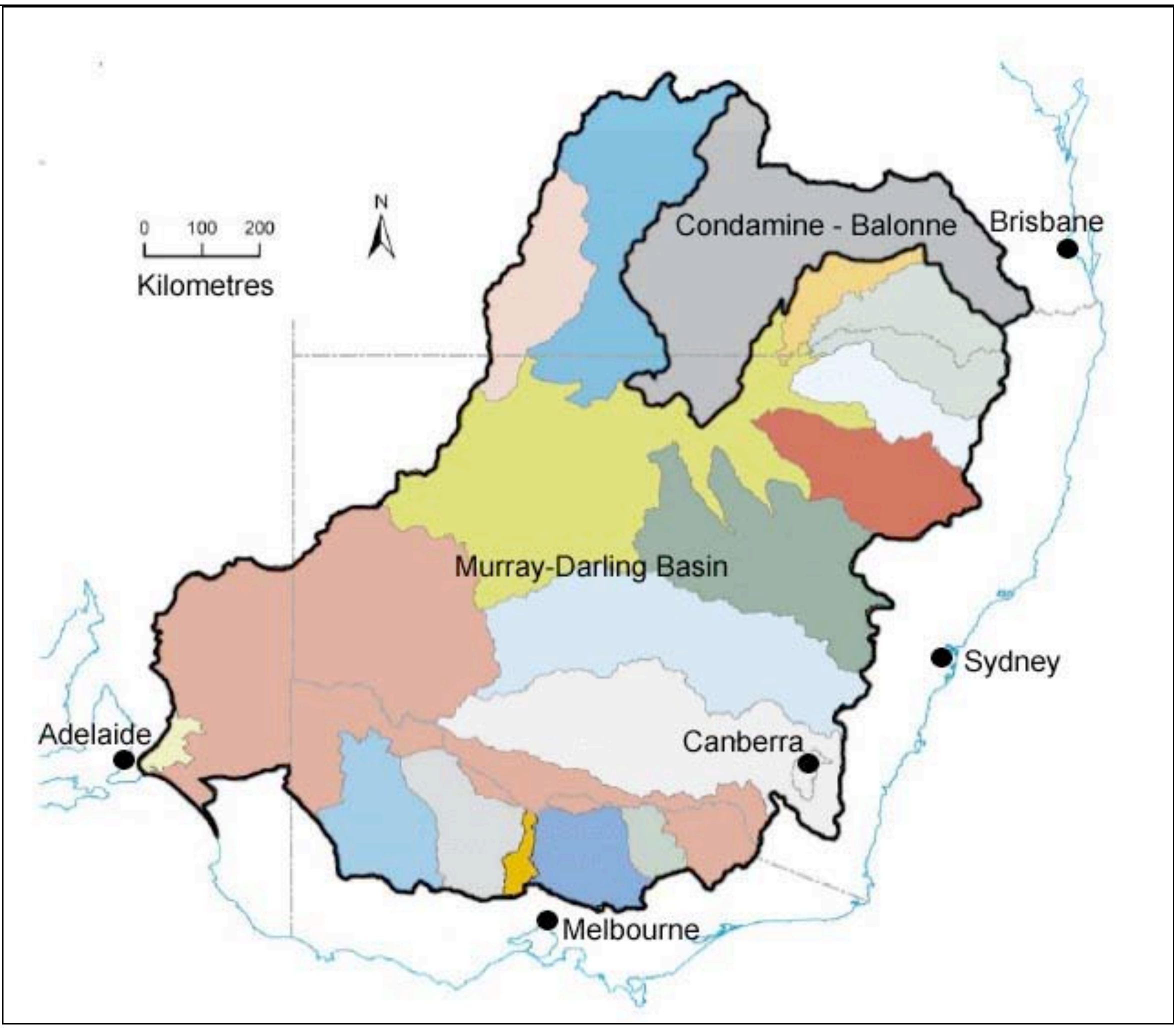
	Figure 1.2 CSG Field, Southern Section.	
	URS Australia 2008	January 2009



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 1.3 The Fitzroy River Basin, showing the Comet and Dawson Catchments.	
	Adapted from FBA 2005	January 2009



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 1.4 The Murray-Darling Basin, showing the Condamine Upper – Balonne Catchment.	
	Adapted from CSIRO 2008	January 2009

2 Relevant Legislation and Guidelines

2.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Any actions that are likely to have a significant impact on a Matter of National Environmental Significance are subject to assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval process. Matters of National Environmental Significance include:

- World Heritage properties
- National Heritage places
- wetlands of International importance
- threatened species and ecological communities
- migratory species
- Commonwealth marine areas, and
- nuclear actions.

The project has the potential to impact on a number of these Matters of National Environmental Significance and was referred to the Minister for the Environment and Water Resources in March 2007; it will be treated as a controlled action under the EPBC Act. The development of the CSG Fields has the potential to impact on threatened species and ecological communities and migratory species.

2.1.1 World Heritage Properties (Great Barrier Reef)

The EPBC Act regulates actions that will, or are likely to, have a significant impact on the World Heritage values of a World Heritage property. This includes relevant actions that occur outside the boundaries of a World Heritage Area. The Fitzroy Basin drains to the Great Barrier Reef World Heritage Area, approximately 550 km downstream from the CSG Fields. The development of the CSG Fields is not expected to result in a significant impact to the values of the Great Barrier Reef World Heritage Area.

2.1.2 Wetlands of International Importance (Ramsar Wetlands)

The EPBC Act regulates actions that will, or are likely to, have a significant impact on the ecological character of a Ramsar wetland. This includes relevant actions that occur outside the boundaries of a Ramsar wetland. There are no Ramsar wetlands or wetlands of national importance in the Project area.

The Fitzroy Basin drains into the Shoalwater and Corio Bays Ramsar site, a Wetland of International Significance (DEWHA 2008a). The Shoalwater and Corio Bays Ramsar wetland is approximately 550 km downstream from the CSG Fields; development of the CSG Fields is not expected to result in a significant impact to the ecological character of this Ramsar Wetland.

The Narran Lake Nature Reserve Ramsar wetland is part of a large terminal wetland system at the end of the Condamine River system (DEWHA 2008c). The Narran Lake Nature Reserve Ramsar wetland is approximately 500 km downstream from the CSG Fields; development of the CSG Fields is not expected to result in a significant impact to the ecological character of this Ramsar Wetland.

2.1.3 Threatened Species and Ecological Communities

Fitzroy River Turtle

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act. Its distribution is restricted to the Fitzroy Basin, and it has been recorded from the Dawson and Mackenzie River systems (DEWHA 2007; EPA 2007b).

Murray Cod

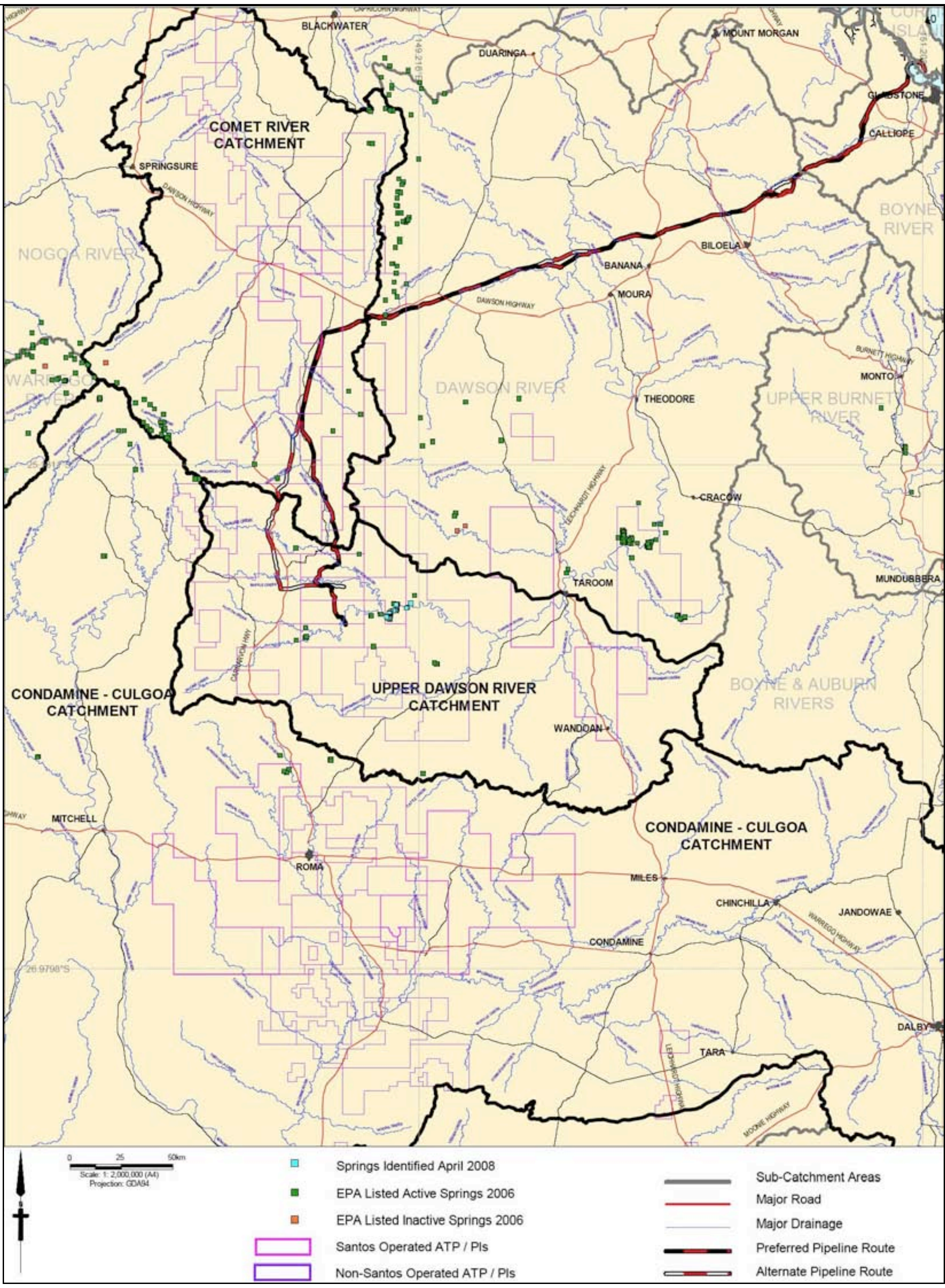
The Murray cod (*Maccullochella peeli peeli*) is listed as vulnerable under the EPBC Act. It is found in a range of warm-water habitats in the waterways of the Murray Darling Basin and may occur in the Fitzroy Basin (DEWHA 2007); where they have been translocated for recreational anglers (Berghuis & Long 1999) (DEWHA 2008d).

Mound Spring Communities

Mound spring communities that are dependent on the natural discharge of water from the Great Artesian Basin are listed as threatened ecological communities under the EPBC

Act. In the CSG Fields, these communities occur in each of the Comet, Upper Dawson and Condamine – Upper Balonne Catchments (Figure 2.1).

Mound spring communities support a number of species that are listed as threatened under the EPBC Act, the Queensland Nature Conservation (Wildlife) Regulation 2006 (NCWR), which documents rare and threatened species in Queensland, and the International *IUCN Red List of Threatened Species* (IUCN 2008). Threatened species are listed in Table 2.1.



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment
	Figure 2.1 Location of mound spring communities in the CSG Fields.
	URS Australia 2008 / December 2008

Table 2.1 Threatened aquatic fauna and flora that are associated with Queensland's Great Artesian Basin spring wetlands (EPA 2005).

Common Name	Species	NCWR Status	EPBC Status	IUCN Status
Fish				
Edgbaston goby	*Chlamydogobius squamigenus*	endangered	vulnerable	critically endangered
Elizabeth springs goby	*Chlamydogobius micropterus*	endangered	endangered	critically endangered
Red-finned blue-eye	*Scaturiginichthys vermeilipinnis*	endangered	endangered	critically endangered
Invertebrates				
Snail	*Jardinella acuminata*	-	-	endangered
Snail	*Jardinella jesswiseae*	-	-	endangered
Snail	*Jardinella pallida*	-	-	endangered
Snail	*Jardinella isolata*	-	-	vulnerable
Snail	*Jardinella carnarvonensis*	-	-	vulnerable
Snail	*Jardinella coreena*	-	-	vulnerable
Snail	*Jardinella corrugata*	-	-	vulnerable
Snail	*Jardinella edgbastonensis*	-	-	vulnerable
Snail	*Jardinella eulo*	-	-	vulnerable
Boggomoss snail	*Adclarkia dawsonensis*	-	critically endangered	-
Herbs				
Thornless blue devil	*Eryngium fontanum*	endangered	endangered	-
Salt pipewort	*Eriocaulon carsonii*	endangered	endangered	-
Artesian milfoil	*Myriophyllum artesium*	endangered	-	-
Grasses				
Spring grass	*Sporobolus pamelae*	endangered	-	-
Hairy-joint grass	*Arthraxon hispidus*	vulnerable	vulnerable	-
Ferns				
Fern	*Thelypteris confluens*	vulnerable	-	-

2.2 Queensland *Water Act 2000*

The purpose of the *Water Act 2000* (Water Act) is to provide for the sustainable management of water and other resources. Under Section 266 of the Water Act, a riverine protection permit is required from the Department of Natural Resources and Water (DNRW) to:

- destroy vegetation in a watercourse
- excavate in a watercourse, and
- place fill in a watercourse.

The development of the CSG Fields may require operational works in watercourses (with the construction of: access roads; water gathering networks and management facilities; and gas gathering networks and transport facilities). Approvals will be required under the Water Act to conduct operational works in watercourses. Additionally, where waters are to be taken from a watercourse, lake, spring or underground water, a permit may be required pursuant to S. 237 of the Water Act.

2.3 Queensland *Fisheries Act 1994*

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act). If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore and non-tidal land), in waters, or in a fish habitat, and it appears to the Chief Executive of the Department of Primary Industries & Fisheries (DPI&F) that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive (DPI&F) may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

Under Division 8 of the Fisheries Act, a waterway barrier works approval is needed to build any structure across a freshwater waterway. The purpose of this part of the Act is to provide a balance between the need to construct dams and weirs and the need to maintain fish movement. Such structures include culverts and road crossings, which may need to be constructed to develop access roads in the CSG Fields. If approval is given the Chief Executive (DPI&F), may direct the building of a specified fishway for the barrier if required.

To get an approval, an application must be made to DPI&F and lodged with the required fees. The DPI&F assess the application to determine whether or not an approval should be issued, and whether a fishway is required. To assess the requirements for a fishway on a proposed structure, the following sorts of questions are assessed:

- are there fish in the waterway that need to move across the site of the waterway barrier works?
- are there habitats upstream and/or downstream of the proposed works that the fish need to move into?
- what are the effects of existing barriers (natural or man-made) up or downstream of the site of the waterway barrier works?
- Will the drown-out characteristics of the proposed waterway barrier works allow adequate fish passage? and
- can a fishway be incorporated into the proposed works?

When a fishway is required, DPI&F have developed a standard design process. This ensures that both biologists and engineers are involved in developing the fishway design. Once the fishway is built, monitoring is required to confirm that the fishway is effective, or to identify any adjustments needed. Fishways are not expected to be a requirement for this Project, and have not been considered further.

Potential Impacts of the development of the CSG Fields on fish passage are addressed in Section 0.

2.4 Queensland *Nature Conservation Act 1992*

The Fitzroy River turtle (*Rheodytes leukops*) is recognised as vulnerable under the Queensland *Nature Conservation Act 1992* (NC Act), as listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR).

Potential Impacts of the development of the CSG Fields on this species are addressed in Section 0.

3 Study Methodology

Aquatic floral and faunal surveys and collection of water quality data were undertaken from the 23rd of September to the 3rd of November 2008. Watercourse sites in each catchment were surveyed between the 23rd of September and the 11th of October. Artesian spring sites were surveyed between the 29th of October and the 3rd of November. The weather was generally fine during the survey, however heavy rainfall was recorded at Roma, Injune and Taroom on the 10th and 11th of October. Rainfall was variable in the months prior to the survey; Roma Airport recorded 67.2 mm in August and 89.5 mm in September; Taroom Post Office recorded 13.6 mm in August and 74 mm in September; and Rolleston recorded 6.0 mm in August and 63.2 mm in September (BOM 2008).

3.1 Study Area

This study assessed the aquatic ecology of waterways and artesian springs in the CSG Fields (Figure 1.1 & Figure 1.2). The CSG Fields lie within the Comet, Dawson and Condamine - Upper Balonne Catchments. Given the large area of the CSG Fields, not all waterways and artesian springs were visited. The locations of sites assessed in this study are shown in Figures 3.1 to 3.4.

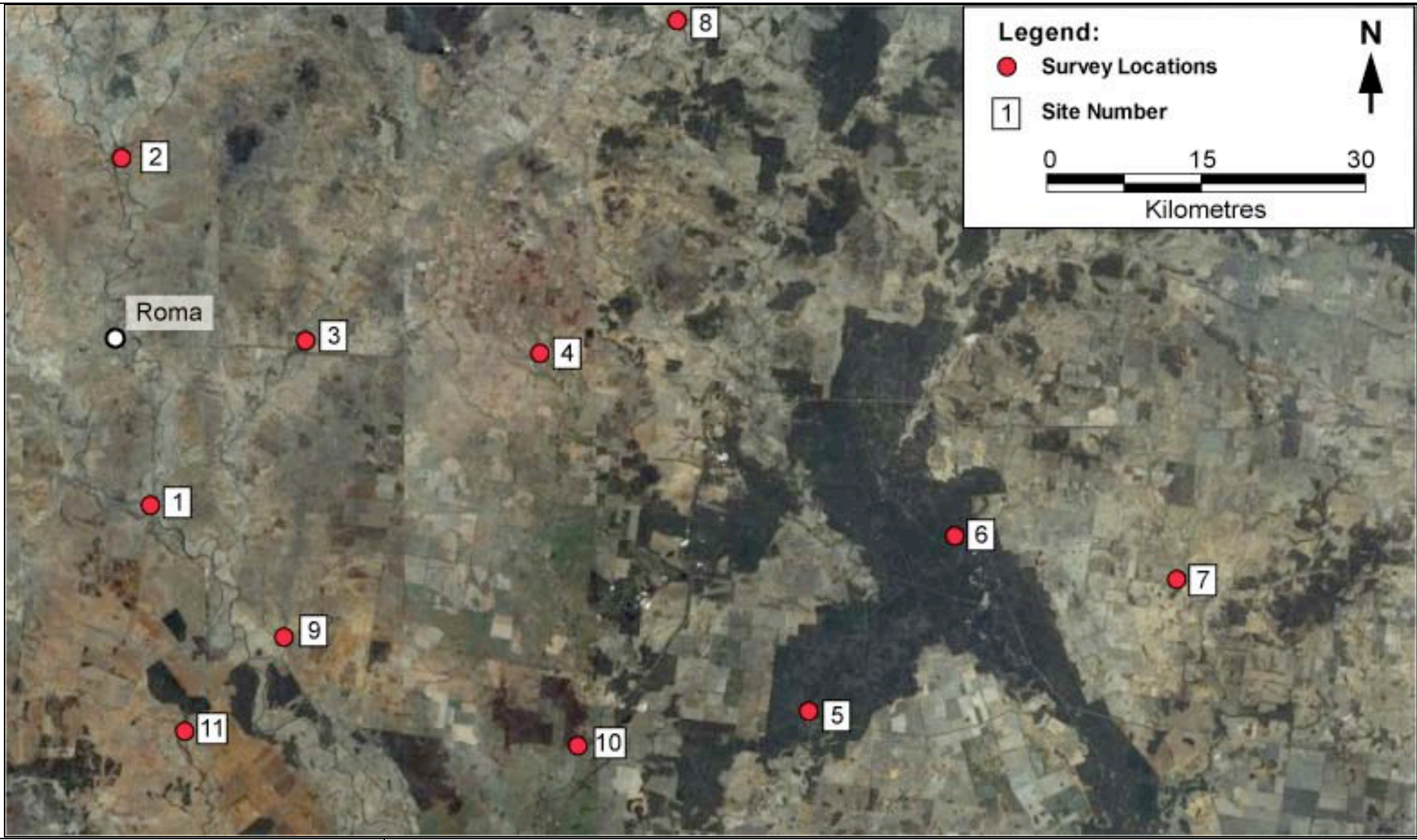
3.1.1 Watercourse Sites

A total of thirty-two waterways were assessed, eleven waterways from each of the Condamine – Upper Balonne and Upper Dawson Sub-catchments, and ten from the Comet Sub-catchments (Table 3.1, Figure 3.1 to Figure 3.3). Sites were selected to provide for a broad geographic spread of sampling locations in each sub-catchment, and to allow for the survey of a range of stream sizes and adjacent land uses. Due to difficulties in obtaining land access, all waterways were assessed at road crossings. Road crossing sites were selected to ensure that conditions were representative of those of the greater sub-catchments, following relevant *State of the Rivers* reports (Telfer 1995, Henderson 2000, Van Manen 2001).

At all sites, the broad habitat type, channel pattern, water level and flow, substrate character and cover, bed and bank stability, and riparian cover were described using AusRivAS protocols (Refer to Section 3.2.1). Water was present at twenty-eight of the sites surveyed; water quality measurements and aquatic flora (macrophyte) and fauna surveys were conducted at each of these sites (Table 3.1).

Table 3.1 Date and type of survey completed at ***watercourse*** sites in the CSG Fields.

Site	Watercourse Name	Date Survey Completed			
		Aquatic Habitat	Water Quality	Macrophytes	Fauna
Condamine – Upper Balonne Catchment					
1	Bungeworgorai Creek	26/9/08	26/9/08	26/9/08	26/9/08
2	Bungil Creek	27/9/08	27/9/08	27/9/08	27/9/08
3	Blyth Creek	24/9/08	24/9/08	24/9/08	24/9/08
4	Wallumbilla Creek	24/9/08	24/9/08	24/9/08	24/9/08
5	Yuleba Creek	25/9/08	25/9/08	25/9/08	25/9/08
6	Tchanning Creek	23/9/08	23/9/08	23/9/08	23/9/08
7	Dulacca Creek	23/9/08	23/9/08	23/9/08	23/9/08
8	Yuleba Creek	24/9/08	24/9/08	24/9/08	24/9/08
9	Bony Creek	26/9/08	26/9/08	26/9/08	26/9/08
10	Wallumbilla Creek	25/9/08	25/9/08	25/9/08	25/9/08
11	Yalebone Creek	25/9/08	25/9/08	25/9/08	25/9/08
Upper Dawson Catchment					
12	Dawson River	30/9/08	30/9/08	30/9/08	30/9/08
13	Bungaban Creek	1/10/08	1/10/08	1/10/08	1/10/08
14	Roche Creek	1/10/08	1/10/08	1/10/08	1/10/08
15	Kinnoul Creek	30/9/08	30/9/08	30/9/08	30/9/08
16	Dawson River	22/9/08	22/9/08	22/9/08	22/9/08
17	Hutton Creek	27/9/08	27/9/08	27/9/08	27/9/08
18	Baffle Creek	28/9/08	28/9/08	28/9/08	28/9/08
19	Dawson River	28/9/08	28/9/08	28/9/08	28/9/08
20	Injune Creek	28/9/08	28/9/08	28/9/08	28/9/08
21	Commissioner Creek	29/9/08	29/9/08	29/9/08	29/9/08
Comet Catchment					
22	Lake Nuga Nuga	7/9/08	7/9/08	7/9/08	7/9/08
23	Brown River	2/10/08	2/10/08	2/10/08	2/10/08
24	Carnarvon Creek	6/10/08	6/10/08	6/10/08	6/10/08
25	Clematis Creek	7/10/08	7/10/08	7/10/08	7/10/08
26	Consuelo Creek	8/10/08	8/10/08	8/10/08	8/10/08
27	Comet River	8/10/08	8/10/08	8/10/08	8/10/08
28	Planet Creek	8/10/08	Dry	Dry	Dry
29	Humboldt Creek	9/10/08	Dry	Dry	Dry
30	Comet River	9/10/08	9/10/08	9/10/08	9/10/08
31	Minerva Creek	9/10/08	Dry	Dry	Dry
32	Orion Creek	9/10/08	Dry	Dry	Dry



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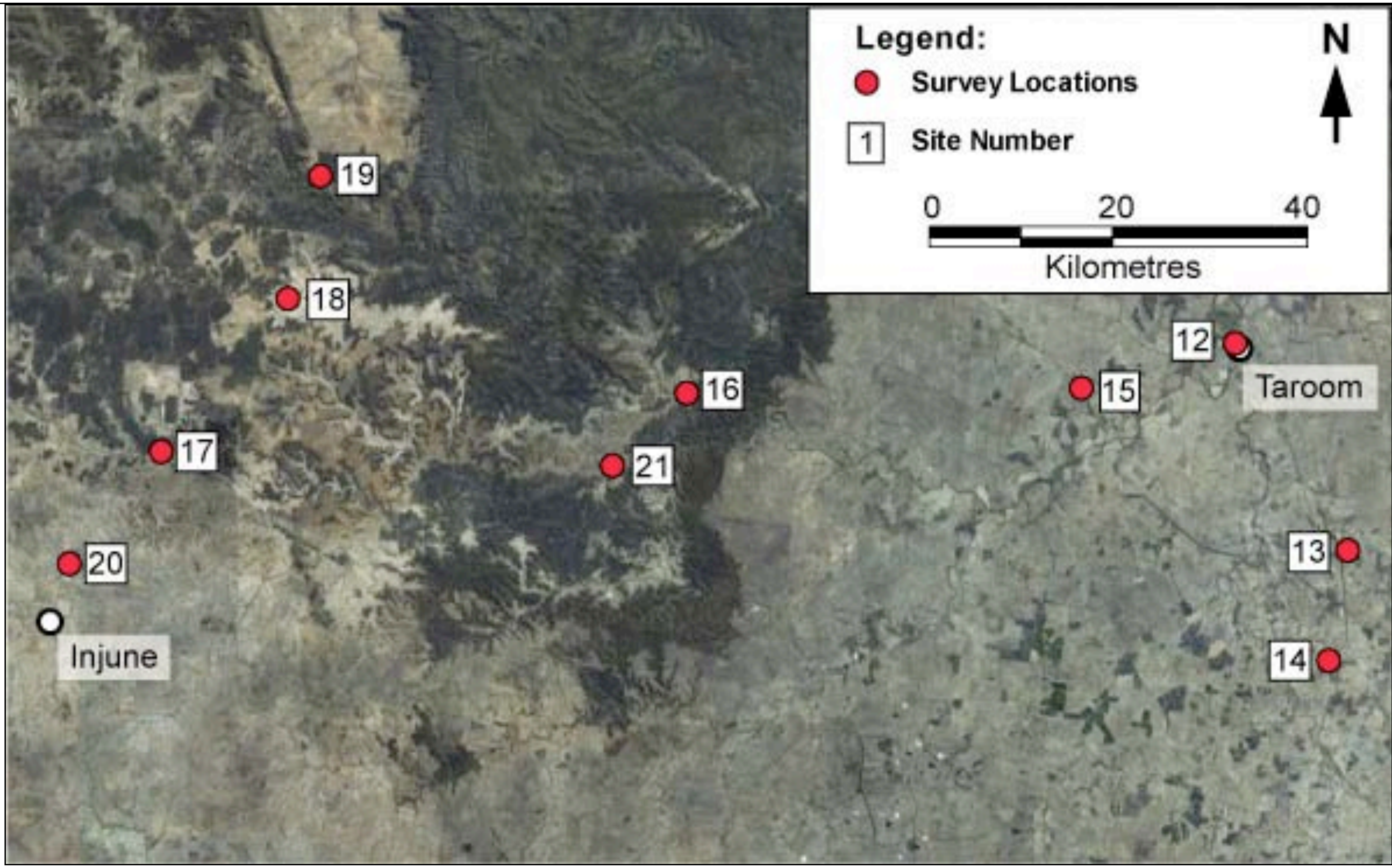
Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment

Figure 3.1 Location of watercourse sites in the Condamine – Balonne Catchment.

January 2009



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Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment

Figure 3.2 Location of watercourse sites in the Upper Dawson Catchment.

January 2009

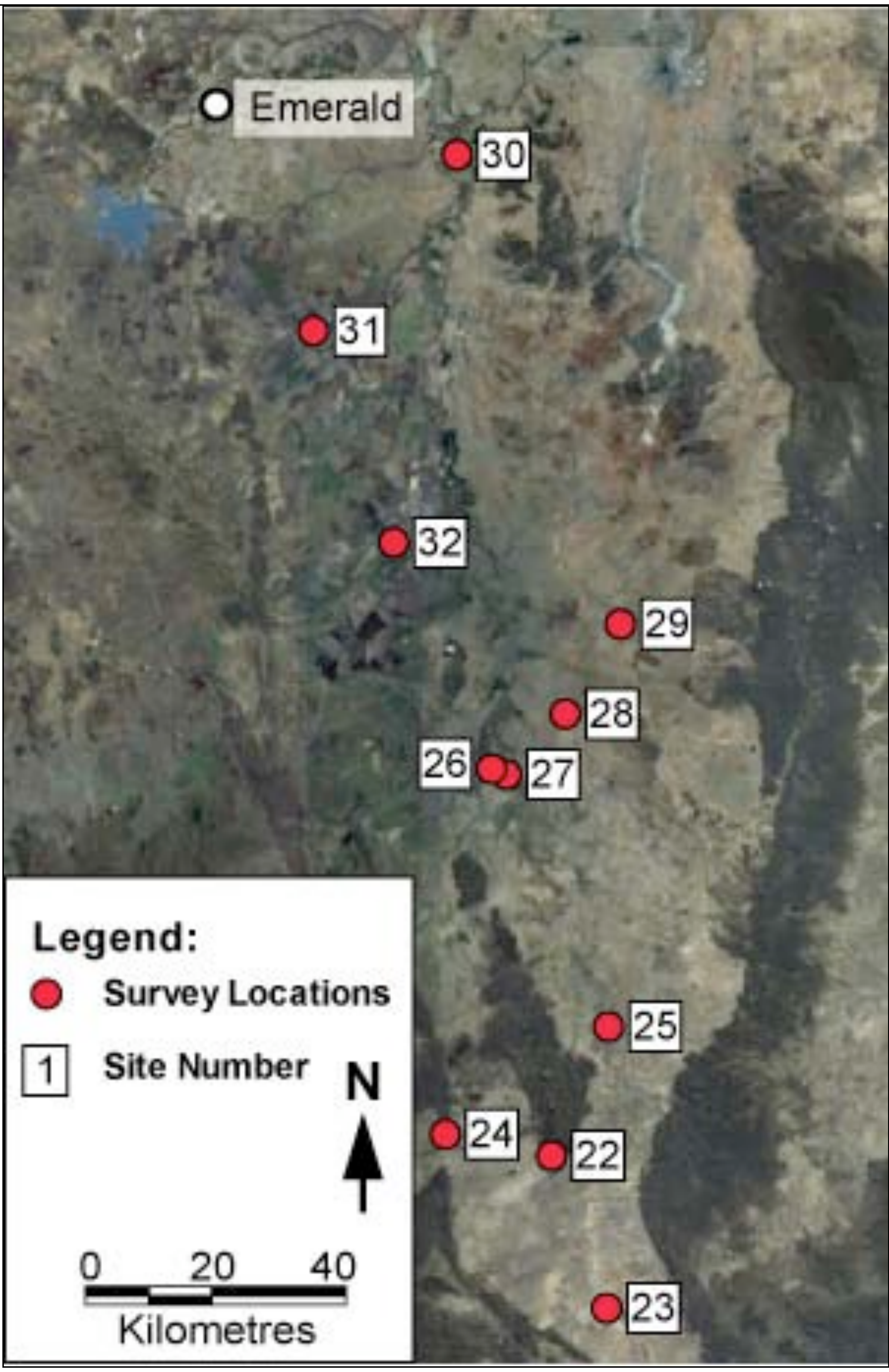

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	Figure 3.3 Location of watercourse sites in the Comet Catchment.
	January 2009

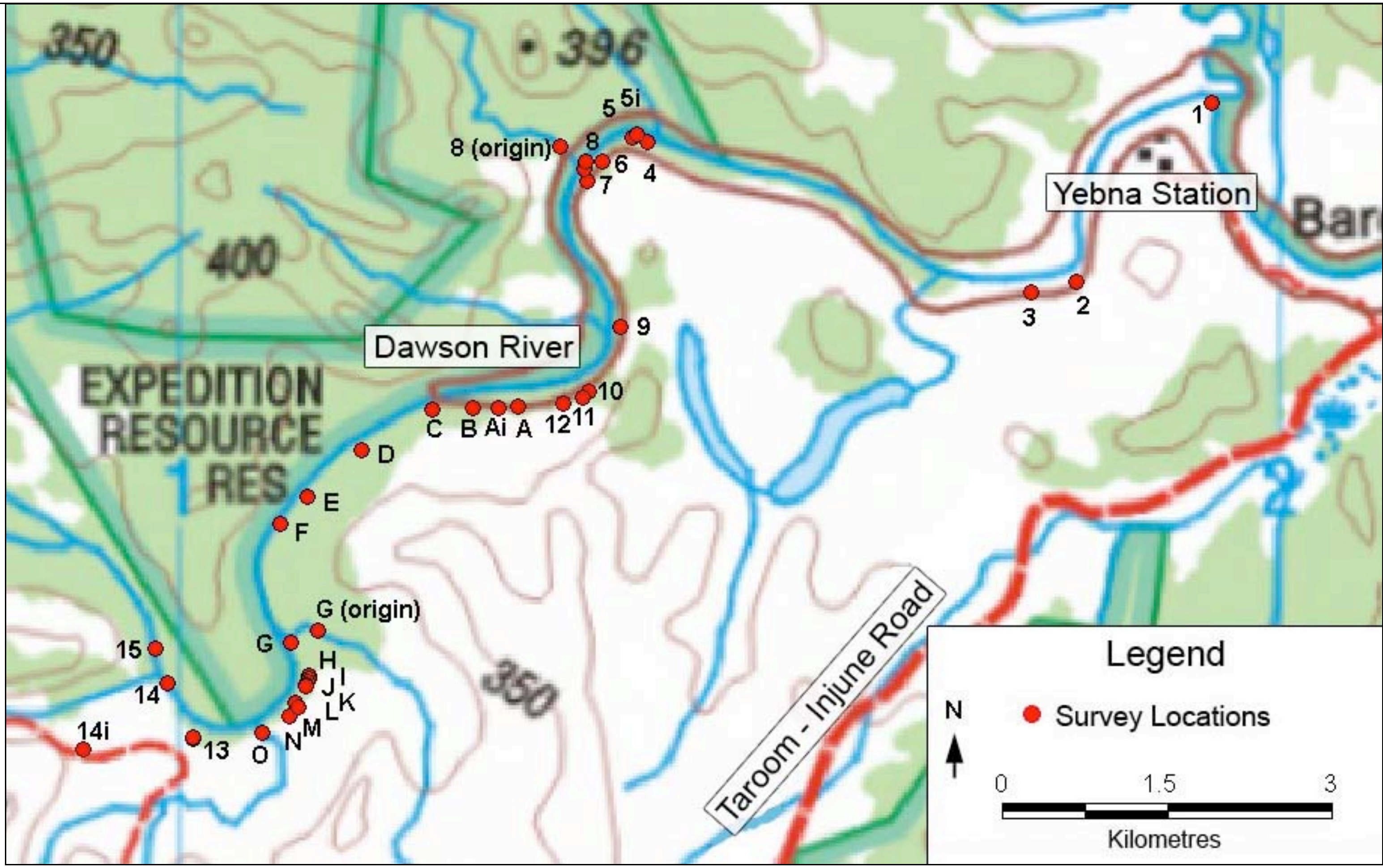
3.1.2 Spring Sites

Thirty-three artesian mound springs were assessed in our survey; all springs were located on Yebna Station in the Upper Dawson Catchment (Table 3.2 & Figure 3.4). The location of all artesian spring sites was provided by URS Australia (which was aquired from metadata held by the EPA). At each site, we assessed water quality and rate of discharge, and described the condition of the spring, noting the presence and extent of any weeds and stock damage. We also described the aquatic floral and faunal communities of each spring (Refer to Section 3.9).

Table 3.2 Date and type of survey completed at ***spring*** sites in the CSG Fields.

Site	Spring Type	Date Survey Completed		
		Aquatic Habitat	**Water Quality**	**Macrophytes**
1	small dry seep, right bank	30/10/08	-	30/10/08
2	small moist seep, right bank	30/10/08	-	30/10/08
3	small moist seep, right bank	30/10/08	-	30/10/08
4	spring under riverbed	30/10/08	30/10/08	30/10/08
5	spring from gully	30/10/08	30/10/08	30/10/08
5i	large wet seep, left bank	30/10/08	30/10/08	30/10/08
6	small seep from right bank	30/10/08	30/10/08	30/10/08
7	spring from right bank	30/10/08	30/10/08	30/10/08
8	spring from gully	30/10/08	30/10/08	30/10/08
8i	large wet seep	30/10/08	30/10/08	30/10/08
9	spring from gully	3/11/08	3/11/08	3/11/08
10	spring from gully	3/11/08	3/11/08	3/11/08
11	spring from gully	3/11/08	3/11/08	3/11/08
12	spring from gully	3/11/08	3/11/08	3/11/08
13	spring from right bank	31/11/08	31/11/08	31/11/08
14	spring from gully	31/11/08	31/11/08	31/11/08
14i	seep within gully	31/11/08	31/11/08	31/11/08
15	spring from right bank	31/11/08	31/11/08	31/11/08
A	spring from gully	2/11/08	2/11/08	2/11/08
Ai	seep from right bank	2/11/08	-	-
B	spring from right bank	2/11/08	2/11/08	2/11/08
C	spring from gully	2/11/08	2/11/08	2/11/08
D	dry spring from right bank	2/11/08	-	2/11/08
E	spring from gully	2/11/08	2/11/08	2/11/08
F	small spring from right bank	2/11/08	2/11/08	2/11/08

Site	Spring Type	Date Survey Completed		
		Aquatic Habitat	Water Quality	Macrophytes
G	large spring from gully	2/11/08	2/11/08	2/11/08
H	small spring from right bank	1/11/08	1/11/08	1/11/08
I	spring from gully	1/11/08	1/11/08	1/11/08
J	spring from right bank	31/10/08	31/10/08	31/10/08
K	spring from right bank	31/10/08	31/10/08	31/10/08
L	spring from right bank	31/10/08	31/10/08	31/10/08
M	spring from gully	31/10/08	31/10/08	31/10/08
N	dry seep from right bank	31/10/08	-	31/10/08
O	moist seep from right bank	31/10/08	-	31/10/08
P	Dry spring from right bank	31/10/08	-	31/10/08



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 3.4 Location of spring sites in the Upper Dawson Catchment.	
		December 2008

3.2 Aquatic Habitat

3.2.1 Of the CSG Fields

At each watercourse site, habitat descriptions and observations were recorded, and photographs taken. The broad habitat type, channel pattern, water level and flow, substrate composition and cover, bed and bank stability, and riparian cover were described using AusRivAS protocols (DNRM 2001).

Based on these descriptions, each site was given a habitat assessment score following the River Bioassessment Program scoring system (DNRM 2001). These scores were used to give each site a habitat condition rating (Appendix A).

3.2.2 A Regional and Ecological Perspective

The typical aquatic habitat of the streams and creeks in the Comet, Upper Dawson and the Condamine – Upper Balonne Catchments were described through literature review, to provide a regional context for the condition of the creeks in the CSG Fields.

3.3 Water Quality

3.3.1 Of the CSG Fields

Water quality was measured at each site using a TPS 90 FLMV water quality meter. Parameters measured included:

- water temperature (°C)
- electrical conductivity (μS/cm)
- pH
- dissolved oxygen (% saturation), and
- turbidity.

Water quality measurements at sites in the Comet and Upper Dawson Catchments were compared to the Queensland Water Quality Guidelines (QWQG) values for upland (altitude >150 m) streams in the central coast region (EPA 2007a). These QWQG are used in preference to the national ANZECC & ARMCANZ guidelines where possible (EPA 2007a; ANZECC & ARMCANZ 2000), however there are no Queensland Water Quality

Guidelines (QWQG) values for the Murray Darling Basin (EPA 2007a). Therefore, water quality parameters at sites in the Condamine – Upper Balonne Catchment have been compared to the national ANZECC & ARMCANZ guidelines (ANZECC & ARMCANZ 2000). The QWQG note that the national guidelines are unlikely to be appropriate for the flood-plain reaches of the Queensland rivers within the basin, and recommend that local Water Quality Objectives (WQOs) be derived. However, while specific WQOs have been developed for many waterways within south east Queensland, no WQOs have been prescribed for the waterways within the study area.

3.3.2 A Regional and Ecological Perspective

The typical water quality of the streams and creeks in the Comet, Upper Dawson and the Condamine – Upper Balonne Catchments were described through literature review, to provide a regional context for the condition of the creeks in the CSG Fields.

3.4 Aquatic Flora

3.4.1 Of the CSG Fields

The description of aquatic flora (macrophytes) included:

- submerged, floating (free-floating or rooted) and emergent macrophytes
- macroscopic algae, and
- the presence of any introduced or pest plants.

Macrophytes with a submerged growth form predominantly grow beneath the surface of the water, although flowers may protrude through the water surface, and some leaves may float on the water surface (Sainty & Jacobs 2003).

Macrophytes with a floating growth can be either free-floating or rooted (Sainty & Jacobs 2003). Free-floating species are usually not attached to the substrate, whereas rooted species are attached to the substrate and normally have at least the mature leaves floating on the water surface (Sainty & Jacobs 2003).

Macrophytes with an emergent growth form are rooted in the substrate with stems, flowers and most of the mature leaves projecting above the water surface (Sainty & Jacobs 2003).

Aquatic flora was assessed along a 100 m reach at each site. The following was recorded for each site:

- the presence of all native and exotic macrophytes, and their form, and
- the percent cover of each species at each site.

Percent cover refers to the area of substrate (bed or bank) covered by vegetation. Due to the physical overlap of emergent, floating and submerged growth forms, total percent cover could exceed 100%.

Photographs of macrophytes were taken at each site and species were identified in the field, where practical. Representative samples of indefinite identifications were collected and pressed for later identification in the laboratory. The *Census of Queensland Flora 2007* (Queensland Herbarium 2007) was used to classify macrophytes as native or exotic.

3.4.2 A Regional and Ecological Perspective

The macrophytes of the streams and creeks in the Comet, Upper Dawson and Condamine – Upper Balonne Catchments were described through literature review, where possible, to provide a regional context for the condition of the creeks in the CSG Fields.

3.5 Aquatic Macroinvertebrate Communities

3.5.1 Of the CSG Fields

Sample Collection

A standard AusRivAS macroinvertebrate sample was collected from a 10 m stretch of each aquatic habitat found at each site. Each site had edge and bed (pool / run) habitats; riffle habitats were only present on the Dawson River (Site 16) and Injune Creek (Site 20). Sampling methodology followed the procedures set out in the Queensland AusRivAS sampling manual (DNRM 2001). A standard triangular-framed, cone-shaped net with 250 µm mesh was used to collect all samples.

Sample Processing

Samples were frozen and returned to frc environmental's Brisbane benthic laboratory where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AusRivAS standards and those described in Chessman (2003).

Data Analysis

A number of indices have been developed for freshwater macroinvertebrate communities to provide an indication of ecosystem health, as described in Appendix B. At each site, taxonomic richness, PET richness and Signal 2 scores were calculated. These indices have been used to provide an indication of the current ecological health of creeks in the CSG Fields, and to compare the health of these creeks to other waterways in the Catchments.

3.5.2 A Regional and Ecological Perspective

The macroinvertebrate communities of the Comet, Upper Dawson and Condamine – Upper Balonne Catchments were described through literature review to provide a regional context for the condition of the creeks in the CSG Fields. The Department of Natural Resources & Water (DNRW) has previously undertaken macroinvertebrate surveys in the same Catchments as the waterways in the CSG Fields. To provide for a regional overview, macroinvertebrate data was obtained for the DNRW sites listed in Table 3.3.

Table 3.3 DNRW Reference Monitoring Sites in the Condamine – Upper Balonne, Upper Dawson and Comet Catchments.

Site	Waterway	Catchment
1303003	Eurobah Creek at Peekadoo	Upper Dawson
130302A	Dawson River at Taroom	Upper Dawson
1303211	Dawson River at Baroondah Crossing	Upper Dawson
130322A	Dawson River at Beckers	Upper Dawson
1305001	Brown River at Lake Nuga Nuga	Comet
1305002	Comet River at Rolleston	Comet
1305003	Brown River at Clematis Junction	Comet
1305004	Comet River at Springsure Road	Comet
1305027	Brown River at Arcadia	Comet
130504A	Comet River at ANTD 17.2 Km	Comet

Site	Waterway	Catchment
130506A	Comet River at The Lake	Comet
4222059	Dogwood Creek at Paradise Crossing	Condamine – Upper Balonne
4222061	Bungil Creek South of Roma	Condamine – Upper Balonne
422210A	Bungil Creek at Tabers	Condamine – Upper Balonne
422213A	Balonne River at Weribone	Condamine – Upper Balonne
422219A	Yuleba Creek at Forestry Station	Condamine – Upper Balonne

In order to use the macroinvertebrate communities as an indicator of the likely health / condition of the DNRW sites, taxonomic richness, PET richness and Signal 2 scores were calculated.

3.6 Fish Communities

3.6.1 Of the CSG Fields

Sample Collection

Fish communities were surveyed using a combination of backpack electrofishing, seine and set nets, baited traps and dip nets. Electrofishing was the preferred method and was attempted at all sites where conditions were appropriate.

Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher. Field sampling followed the methods used in the south-east Queensland Ecological Health Monitoring Program (EHMP) (EHMP 2007), adapted where appropriate to suit local conditions. All available habitat units were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*. Sampling effort is presented in Table 3.4.

At each site, the species present, the abundance of each species by life history stage (juvenile, intermediate, adult) and the apparent health of individuals were recorded. Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification.

The sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approval No. CA 2006/03/106 issued to frc environmental (Appendix C).

Data Analysis

For each site, the taxonomic richness, total abundance, abundance of rare and threatened species, abundance of exotic species was determined. The relative abundance of different life history stages was discussed.

Table 3.4 Fish survey effort at each site.

Site	Method	Date	Time In	Time Out	Settings	Effort
1	Electrofishing	26/9/08	10:00	11:00	350-400 V, 30 Hz, 12%	494 s
2	Electrofishing	27/9/08	9:00	10:00	370 V, 30 Hz, 12%	512 s
3	Electrofishing	24/9/08	16:10	16:50	350 V, 30 Hz, 12%	520 s
4	Electrofishing	24/9/08	13:30	14:20	280 V, 30 Hz, 12%	499 s
5	Electrofishing	25/9/08	9:50	10:25	280 V, 30 Hz, 12%	409 s
6	Nets & Traps	23/9/08	NA	NA	NA	NA
7	Electrofishing	23/9/08	11:20	12:20	270 V, 30 Hz, 12%	640 s
8	Electrofishing	24/9/08	10:40	11:20	250 V, 30 Hz, 12%	540 s
9	Electrofishing	26/9/08	13:15	14:00	430 V, 30 Hz, 12%	430 s
10	Electrofishing	25/9/08	12:00	12:45	350 V, 30 Hz, 12%	430 s
11	Electrofishing	25/9/08	15:15	15:45	300 V, 30 Hz, 12%	426 s
12	Traps	30/9/08	NA	NA	NA	NA
13	Electrofishing	1/10/08	9:00	9:40	320 V, 30 Hz, 12%	584 s
14	Electrofishing	1/10/08	11:00	12:00	420 V, 30 Hz, 12%	466 s
15	Electrofishing	30/9/08	13:50	14:50	310 V, 30 Hz, 12%	556 s
16	Electrofishing	29/9/08	14:00	15:00	300 V, 30Hz 12 %	525 s
17	Electrofishing	27/9/08	13:00	13:55	400 V, 30 Hz, 12%	629 s
18	Electrofishing	28/9/08	13:15	14:15	350 V, 30% 12 Hz	505 s
19	Electrofishing	28/9/08	9:45	10:10	350 V, 30 Hz, 12%	329 s
20	Electrofishing	28/9/08	16:40	17:30	300 V, 30Hz 12 %	533 s
21	Electrofishing	29/9/08	10:15	11:00	380 V, 30 Hz, 12%	555 s
22	Traps & Nets	7/9/08	NA	NA	NA	NA
23	Electrofishing	2/10/08	12:10	13:00	315 V, 30Hz 12 %	579 s
24	Nets	6/10/08	NA	NA	NA	NA
25	Electrofishing	7/10/08	11:50	12:40	280 V, 30Hz 12 %	567
26	Electrofishing	8/10/08	13:30	14:15	260 V, 30Hz 12 %	818
27	Electrofishing	8/10/08	11:20	12:15	285 V, 30Hz 12 %	645
28	Dry Site	8/10/08	NA	NA	NA	NA
29	Dry Site	9/10/08	NA	NA	NA	NA
30	Traps	9/10/08	NA	NA	NA	NA
31	Dry Site	9/10/08	NA	NA	NA	NA
32	Dry Site	9/10/08	NA	NA	NA	NA

3.6.2 A Regional and Ecological Perspective

The fish communities of the Comet, Upper Dawson and the Condamine – Upper Balonne Catchments were described through literature to provide a regional context for the condition of the creeks in the CSG Fields. The most recent fish surveys in the Comet, Upper Dawson and Condamine – Upper Balonne Catchments have been conducted by the Department of Primary Industries & Fisheries (DPI&F) (Berghuis & Long 1999; DPI&F 2002). The DPI&F sampled seven sites along the Condamine River between 2000 and 2001. They also sampled two sites on the Dawson River, two sites on the Nogoa River and two sites on the Mackenzie River in 1999. The DPI&F surveyed the Mackenzie River near the Bedford Weir in 1997 (DPI 1997).

3.7 Turtle Communities

3.7.1 Of the CSG Fields

Sample Collection

Turtles were surveyed using purpose built cathedral traps that comply with current best practice EPA protocols. Five baited traps were set at each site that supported water and left to soak for a minimum of four hours.

At each site, the species present, the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded.

The sampling of turtles was conducted under Scientific Services Permit No. WISP05080608 and Animal Ethics Approval No. CA 2006/03/106 issued to frc environmental (Appendix C).

Data Analysis

For each site, the taxonomic richness, total abundance, abundance of rare and threatened species, abundance of exotic species, and the abundance of each life history stage was determined.

3.7.2 A Regional and Ecological Perspective

The turtle communities of the Comet, Upper Dawson and the Condamine – Upper Balonne Catchments were described through literature to provide a regional context for the condition of the creeks in the CSG Fields. The likely presence of turtles was described through database searches, specifically: the Commonwealth *Protected Matters Search Tool* (DEWHA 2008a); and the Queensland *Wildlife Online* database (EPA 2007b, 2008).

3.8 Artesian Spring Communities

The aquatic communities of artesian spring communities along the upper Dawson River were surveyed using a range of methods. At each spring site, habitat descriptions and observations were recorded, and photographs taken. The broad habitat type, channel pattern, rate of discharge and riparian cover were described, and the presence of any weeds or cattle damage was noted. The conditions of each spring site are presented in Appendix D.

Water quality was measured at each site using a TPS 90 FLMV water quality meter (See Section 3.3).

Mound spring communities support a number of species that are listed as threatened under the EPBC Act, the NCWR and the IUCN Red List (See Table 2.1). Our field surveys recorded listed species; specifically aquatic macrophytes and snails.

Aquatic macrophytes were surveyed at each site, using the methods outlined in Section 3.3.

Aquatic snails were also surveyed at each site using a combination of methods, which included: dip net sampling (using a standard triangular-framed, cone-shaped net with 250 μm mesh, as per Section 3.5) and visually searching though submerged vegetation and damp leaf litter for specimens. Searches through submerged vegetation were targeted at detecting *Jardinella* spp.; searches through damp leaf litter targeted boggomoss snails (*Adclarkia dawsonensis*) and were concentrated at the bases of sandpaper figs (*Ficus* spp.), following Stanisic (2008).

Fish communities were assessed visually; the presence, species composition and abundance of fish were recorded at all sites. The presence of any other obvious aquatic flora or fauna, including turtles, frogs and snakes, was also noted.

3.9 Other Aquatic Vertebrates

The relative abundance of other aquatic and semi-aquatic vertebrates, such as frogs, was recorded at each site. The likely presence of other aquatic vertebrates in the study area and throughout the region was described through literature review and database searches, specifically: the Commonwealth *Protected Matters Search Tool* (DEWHA 2008a); and the Queensland *Wildlife Online* database (EPA 2007b, 2008).

3.10 Limitations

The waterways in the study area are ephemeral, and are dry for much of the year. Our field data is based on a single, dry-season survey. To account for the expected high temporal variability in community structure (Smith et al. 2004), a further survey event is required to adequately assess and describe seasonal variation in the aquatic communities of the study area.

Water depth at the time of survey prevented the adequate assessment of fish communities at eleven of the watercourse sites; these were Wallumbilla Creek (sites 4 & 10), Yuleba Creek (site 5), Tchanning Creek (site 6) and Bony Creek (site 9) in the Condamine – Upper Balonne Catchment, the Dawson River (sites 12 & 16), Baffle Creek (site 18) and Lake Nuga Nuga (site 22) in the Upper Dawson Catchment, and Consuelo Creek (site 26) and the Comet River (site 30) in the Comet Catchment. Backpack electrofishing is not an effective or safe method for sampling fish in waters depths in excess of 0.7 m. A combination of trapping and netting was conducted at these deeper sites, however the sheer volume of water present at these locations prevented the representative sampling of fish communities.

The field survey of artesian springs along the upper Dawson River was designed to provide an assessment of the relative condition of each spring, and was limited to a description of the: broad habitat type, channel pattern, rate of discharge, riparian cover, presence of weeds, and cattle damage. This study did not seek to provide a comprehensive description of the aquatic flora and fauna present at these springs, however, all aquatic fauna that was encountered was identified and enumerated.

The assessment of impacts is based on conceptual and preliminary information developed for the Project.

4 Existing Environment

4.1 Aquatic Habitat

4.1.1 Of the CSG Fields

The watercourse sites surveyed within the CSG Fields typically had poor to moderate Habitat Bioassessment Program assessment scores (Figure 4.1 & Figure 4.2). Generally, these low scores were related to moderate to extensive bank erosion, low habitat variability and substrates dominated by finer sediments such as sand and silt. Watercourses in the Upper Dawson Catchment typically supported the best aquatic habitat, and therefore received the highest habitat bioassessment scores. This reflected the presence of flowing water, a greater diversity of instream habitat and the occurrence of runs and riffles at sites on the Dawson River (Sites 16) and Injune Creek (Site 20).

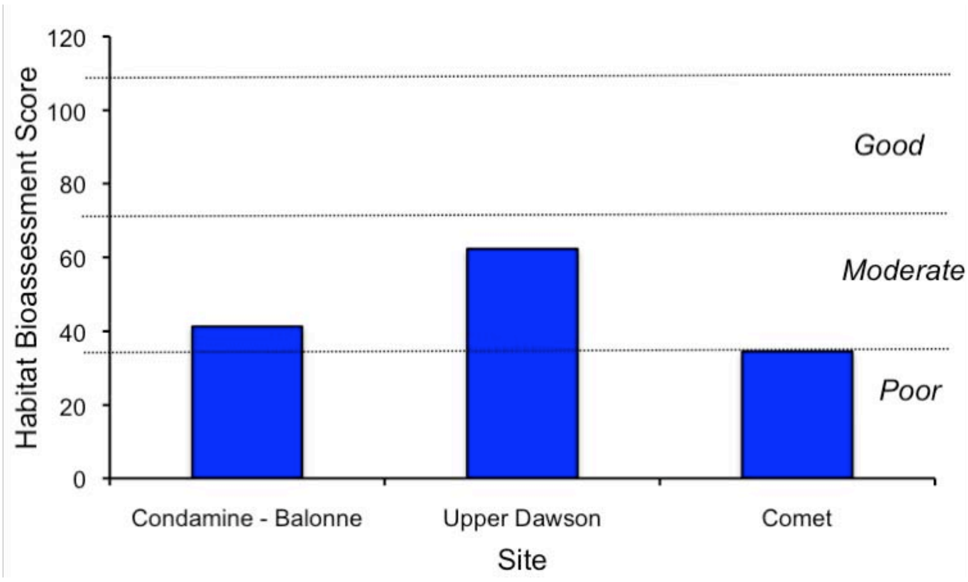


Figure 4.1 Mean Habitat Bioassessment Scores for watercourse sites in the: Condamine – Upper Balonne, Upper Dawson and Comet Catchments.

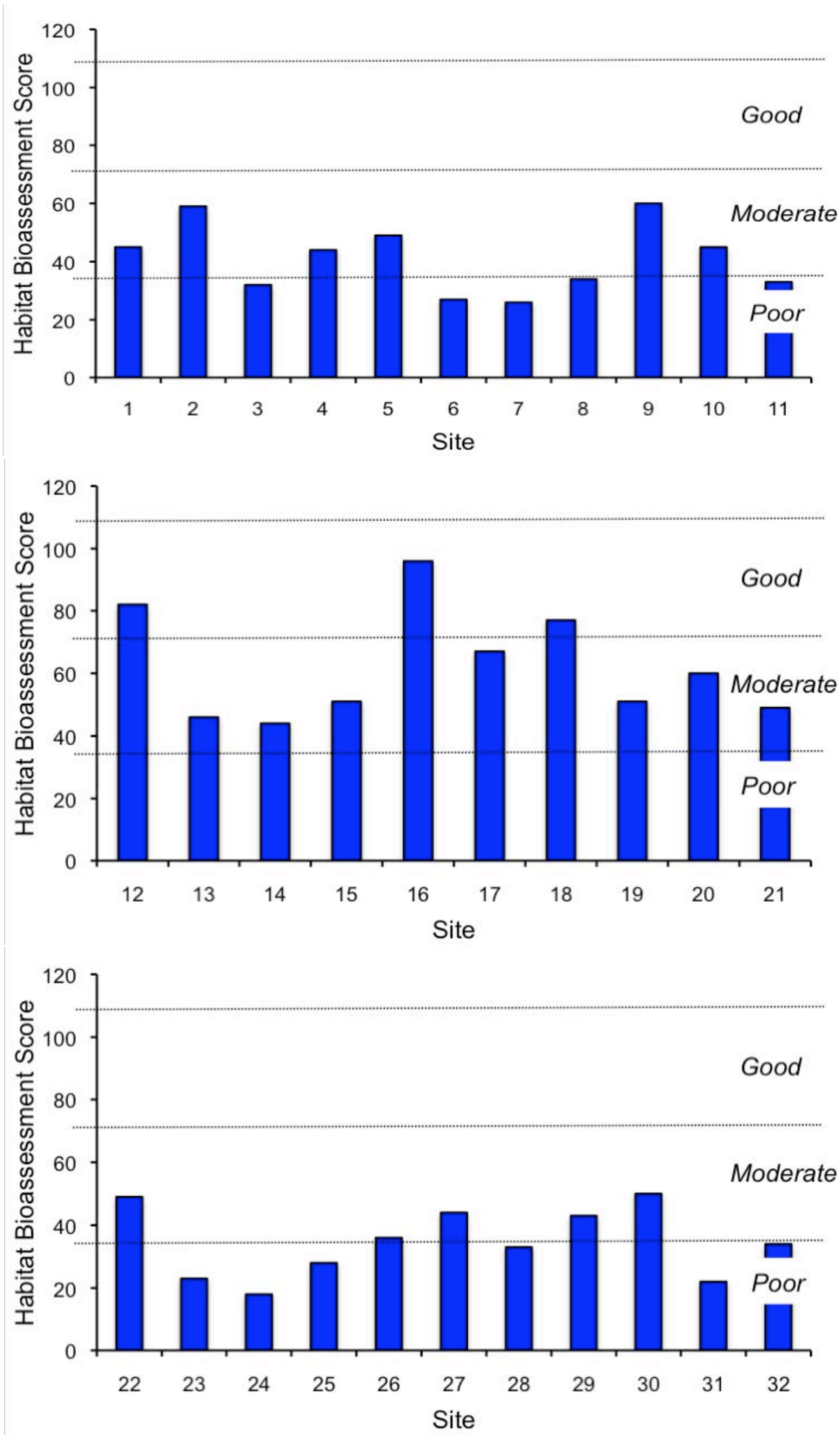


Figure 4.2 Habitat Bioassessment Scores for watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

Reach Environs

Overall disturbance of the reach environs of the creeks surveyed ranged from poor at sites adjacent to grazing land, to good at sites adjacent to forested areas. Pasture and both grazed and un-grazed forests are the dominant land uses surrounding the creeks of the CSG Fields and in the broader area.

There has been some riparian vegetation clearing across the study area, particularly at sites in the Condamine – Upper Balonne Catchment (Bungeworgorai, Yuleba and Bony Creeks) and at Bungaban and Roche Creeks in the Upper Dawson Catchment, although large trees still grow on the creek banks at many sites (and in particular at sites on higher order streams).

Erosion at road crossings was a major form of disturbance at many sites across the CSG Fields. Road crossings were a mix of dirt crossings without culverts, dirt crossings with pipe culverts, concrete crossings with culverts, and bridges. Bridge crossings were present at the fifteen, including: Bungil, Blyth, Yuleba, Bony and Wallumbilla Creeks in the Condamine – Upper Balonne Catchment; Roche, Hutton and Injune Creeks and the Dawson River in the Upper Dawson Catchment; and Carnarvon, Consuelo and Planet Creeks and the Brown and Comet Rivers in the Comet Catchment.

Concrete crossings with culverts were present at Bungeworgorai, Wallumbilla and Yuleba Creeks in the Condamine – Upper Balonne Catchment; Kinnoul Creek and the Dawson River in the Upper Dawson Catchment; and Clemantis and Humboldt Creeks in the Comet Catchment. Bungaban Creek in the Upper Dawson Catchment and Minerva Orion Creeks in the Comet Catchment were crossed by bitumen roads without culverts. Dirt crossings were present at Tchanning, Dulacca and Yalebone Creeks in the Condamine – Upper Balonne Catchment; and Baffle and Commissioner Creeks in the Upper Dawson Catchment.

Road crossings have the potential to cause alterations of flow and may prevent or restrict fish and turtle passage in some instances. Most of the dirt crossings in the study area were not built up and would only restrict aquatic fauna passage during very low flows (Figure 4.3). Similarly, box culverts in the study area are likely to allow for reasonable passage of aquatic fauna, but accretion and snagging upstream of culverts, is likely to restrict passage in Bungeworgorai and Wallumbilla Creeks in the Condamine – Upper Balonne Catchment (Figure 4.4). Bridge crossings in the study area are unlikely to restrict the movement of aquatic fauna, despite the presence of some debris around the pylons (Figure 4.5).

Figure 4.3

The dirt crossing at Commissioner Creek (Site 21) forms a physical barrier to water flows and aquatic fauna passage during periods of very low flow.

Figure 4.4

Obstructions upstream of the box culverts on Wallumbilla Creek (Site 4) are likely to restrict the passage of aquatic fauna.

Figure 4.5

The bridge pylons at a crossing on the Comet River (Site 30) are unlikely to restrict aquatic fauna movement.

Riparian Vegetation

Across the study area, riparian zones were generally 10 – 30 m wide. However, riparian vegetation was largely cleared from Yuleba Creek in the Condamine – Upper Balonne Catchment, and Bungaban, Roche, Kinnoul and Commissioner Creeks in the Upper Dawson Catchment (Figure 4.6 & Figure 4.7). Grasses typically dominated the riparian zone of the creeks, although shrubs and trees also grew at most sites. Eucalypts, callistemons, cypress pines, acacias and casuarinas dominated forested areas. Riparian vegetation throughout the study area was dominated by native species, although exotic grasses and some weeds were found. Common riparian weeds included: Mayne's pest (*Verbena tenuisecta*), prickly poppy (*Argemone ochroleuca*), fireweed (*Senecio lautus*) and crownbeard (*Verbesina encelioides*), which were present at the majority of sites surveyed. Dark blue snakeweed (*Stachytarpheta urticifolia*), cobblers' pegs (*Bidens pilosa*), and nagoora burr (*Xanthium pungens*) were present at sites in the Comet Catchment. Parthenium weed (*Parthenium hysterophorus*), a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002* and a Weed of National Significance, was noted at the Comet River (Site 30) and Minerva Creek (Site 31) in the Comet Catchment.

Figure 4.6

Largely cleared riparian zone atop an erosion scarp at Yuleba Creek (Site 8).

Figure 4.7

Pasture grass growing right to the bank of Kinnoul Creek (Site 15).

Bank Stability

There was considerable bank erosion at many sites in the study area. Vertical banks were common and appeared to be the result of water scouring during periods of high flow. Despite the steep banks, bank stability was often maintained by a relatively high cover of bank vegetation and by the root systems of larger trees (Figure 4.8). Bank stability was particularly low at: Blyth (Site 3), Tchanning (Site 6) and Yuleba (Site 8) creeks in the Condamine – Upper Balonne Catchment; and the Brown River (Site 23) in the Comet Catchment.

Figure 4.8

Tree roots stabilised creek banks at many sites.

Bed and Bar Stability

Overall, streambeds throughout the study area were moderately stable, with evidence of scouring on outside meanders, downstream of obstructions and along roadside drainage channels. Larger particles were embedded in fine sediments where eroding banks had deposited silt and sand into the streambed. Streambeds were sandy at a number of sites (refer to Appendix A for the sediment composition at each site).

Channel Diversity

Channel diversity was extremely low across the study area, and isolated pools were the dominant habitat category. Bends and changes in water depth are likely to provide some channel diversity during periods of flow. Run and riffle habitat was present on the Dawson River (Site 16) and Injune Creek (Site 20) in the Upper Dawson Catchment.

Aquatic Habitat

The condition of aquatic habitats in the study areas was quite variable, but some physical aquatic habitat was found at most of the sites surveyed. Habitat was generally in the form of small woody debris, fallen logs and tree roots (Figure 4.9). Cobbles, boulders, overhanging vegetation and instream vegetation were also observed, but seldom inundated, at the time of survey. These features would provide in-stream habitat during times of flow or when water levels are higher. At sites surveyed in higher order (i.e. larger) creeks, there was generally greater habitat availability, as there was more water present and large trees on the banks provided tree roots and fallen branches / logs as habitat.

Figure 4.9

Overhanging vegetation, branch piles, and undercut banks at Hutton Creek (Site 17).

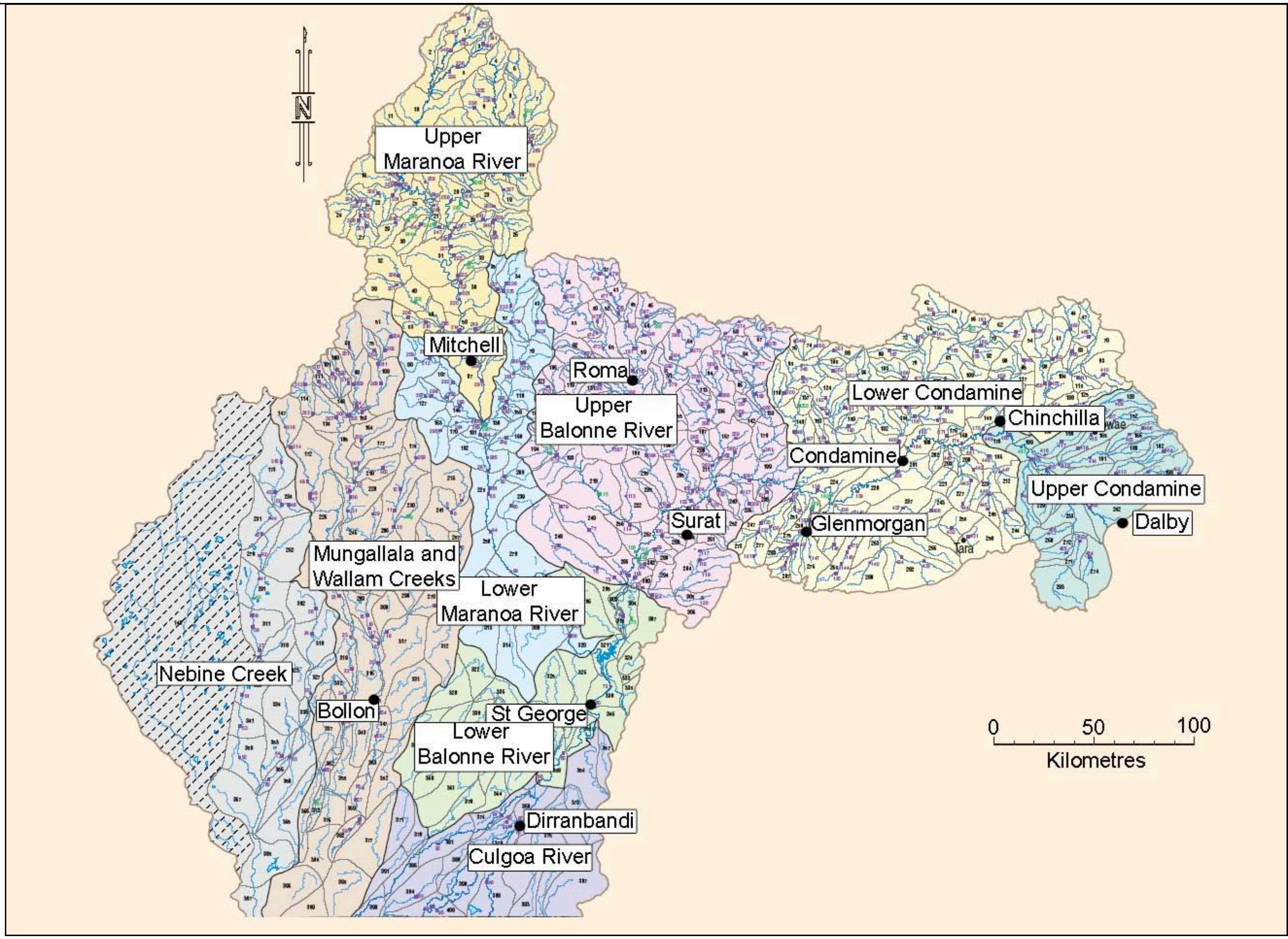
Watercourses in the Upper Dawson Catchment typically supported the greatest diversity of aquatic habitat, which included instream boulders and cobbles, fallen logs, and tree roots.

4.1.2 A Regional and Ecological Perspective

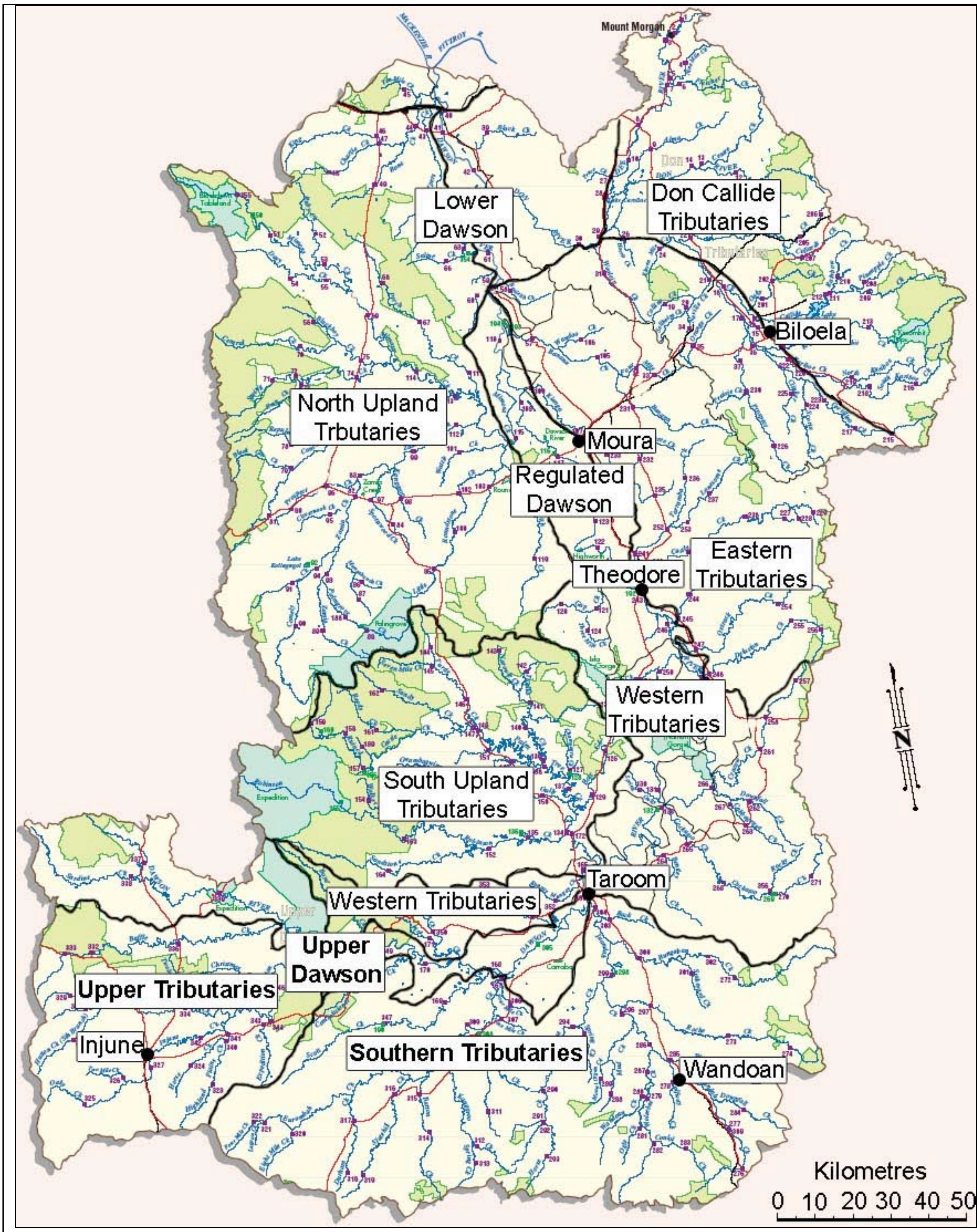
The following description of the aquatic habitat of the region is a summary of the *State of the Rivers* report for the Condamine and Upper Balonne Sub-catchments of the Maranoa, Balonne and Lower Condamine System (Van Manen 2001) (Figure 4.10); the Upper Dawson, Upper Tributaries and Southern Tributaries Sub-catchments of the Dawson River (Telfer 1995) (Figure 4.11); and the Eastern and Western Tributaries Sub-catchments of the Comet River (Henderson 2000) (Figure 4.12). The area of each catchment and sub-catchment is presented in Table 4.1.

Table 4.1 Area of each of the catchments and sub-catchments that encompass the CSG Fields (Telfer 1995, Henderson 2000, Van Manen 2001).

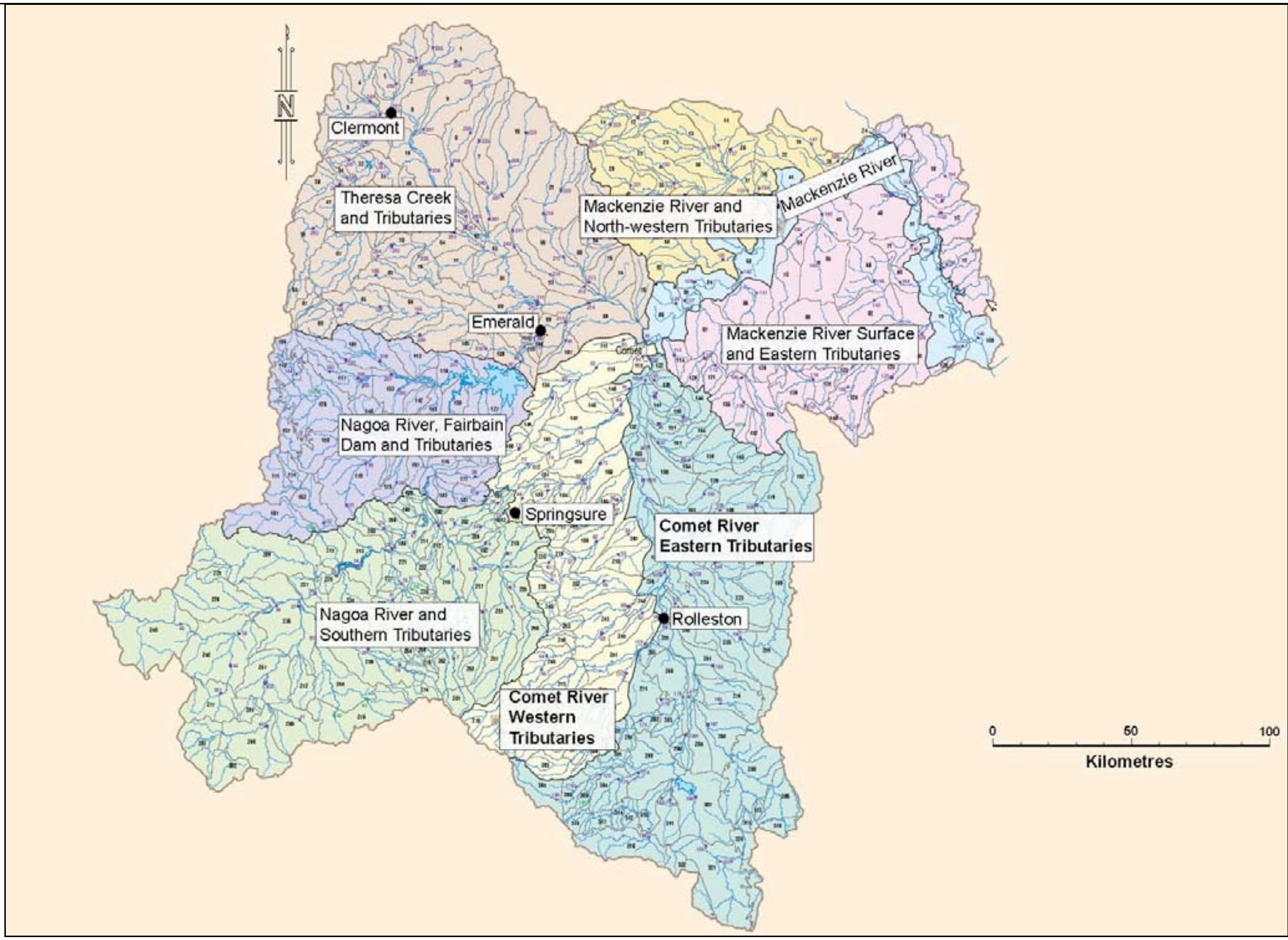
Catchment / Sub-catchment	**Area (km^2)**	**Percentage of Catchment (%)**
Maranoa, Balonne and Lower Condamine	112,823	
Condamine	18,131	16.1
Upper Balonne	17,479	15.5
Dawson	50,800	
Upper Dawson	2,714	5.3
Upper Tributaries	3,784	7.4
Southern Tributaries	8,689	17.1
Comet	17,295	
Eastern Tributaries	10,821	62.6
Western Tributaries	6,474	37.4



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 4.10 The Maranoa, Balonne and Condamine River Catchments.	
	Adapted from Van Manen 2001	December 2008



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 4.11 The Dawson River Catchment.	
	Adapted from Telfer 1995	December 2008



	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment
frc environmental deep thinking. science.	Figure 4.12 The Comet, Nogoa and Mackenzie River Catchments.
	Adapted from Henderson 2000 | December 2008

Condamine – Upper Balonne Catchment

Reach Environs

The Condamine Sub-catchment (downstream of Chinchilla) covers an area of 18,131 km^2; the Upper Balonne Sub-catchment covers an area of 17,479 km^2 (Figure 4.10). The Condamine Sub-catchment supports approximately 3,636 km of streams; approximately 61% of these reach environs were in good or very good condition. The Upper Balonne Sub-catchment supports approximately 4,031 km of streams; approximately 38% of these reach environs were in good or very good condition.

Of the sites surveyed in the Condamine Sub-catchment: 29% had low disturbance (intact vegetation on both sides of the stream, with minor disturbance from introduced species), 26% were moderately disturbed (cleared on one side of the stream, but native vegetation on the other side undisturbed), 45% were highly to extremely disturbed (vegetation on one side of the stream was completed cleared, and vegetation on the other side was highly disturbed or had a significant weed presence). In the Upper Balonne Sub-catchment: 8% of sites had low disturbance, 34% were moderately disturbed, and 53% were highly or very highly disturbed.

Most of the land adjacent to *State of the Rivers* sites in both Sub-catchments was used for cattle grazing, predominantly on thinned or cleared native vegetation. Other disturbances in the sub-catchments included: bridges, culverts, fords, cultivation and forestry activities. Many of the sites surveyed in the CSG Fields were in a similar condition to those assessed in the *State of the Rivers* program, with disturbance higher at sites adjacent to grazing lands than sites adjacent to State forest.

Bank Stability

Stream banks at 85% of sites surveyed in the Condamine Sub-catchment were rated as being stable or very stable; 58% of stream banks in the Upper Balonne Sub-catchment were rated as being in a stable to very stable condition. Erosion was noted along the banks at the majority of sites, with some aggradation at bends and obstacles. Stock access, scouring from water flows and clearing of vegetation negatively affected bank stability throughout the sub-catchments. Similar impacts were seen throughout the CSG Fields.

Bed and Bar Stability

Streambeds were rated as stable or very stable at 87% of the sites surveyed in the Condamine Sub-catchment and 79% of the sites in the Upper Balonne Sub-catchment. Bars had formed as mid-channel islands, around obstructions and along the edge of the streambed.

Factors reducing stream bed stability throughout both sub-catchments included agricultural and grazing practices, bank erosion and bed deepening; while vegetation, fallen trees, rock outcrops and man-made structures provided stream bed stabilisation. Bed stability in the current study area had been affected by similar factors.

Channel Diversity and Habitat Types

Channels across both the Condamine and Upper Balonne Sub-catchments lacked diversity (diversity ratings ranged from low to moderate). The average depths of pools, runs and riffles throughout both sub-catchments (measured from the watermark) were 0.8, 0.6 and 0.4 m, respectively. Average widths of pools, runs and riffles were 8.85, 8.86 and 5.8 m, respectively. Pools within the CSG Fields were slightly shallower and narrower than the average size of pools across both sub-catchments. Riffles and runs were not recorded in these sub-catchments, but may be present during periods of higher flow.

Sediments in the upper banks and streambeds varied from boulders to fine silt, lower banks were composed of sand and fine silt. The sediments of creeks in the CSG Fields had a similar composition (refer to Appendix A for the sediment composition at each survey site).

Riparian Vegetation

Across both sub-catchments, riparian vegetation included trees, shrubs, vines, rushes, grasses, and mosses. The most dominant structural types were grasses (65 & 70% cover respectively), trees 10 – 30 m (37 & 36% cover respectively) and trees <10 m (27 & 15% cover respectively). Eucalypt woodlands and cypress pine forests were the dominant vegetation communities. Native species recorded included: *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Casuarina* spp. and *Melaleuca* spp. Riparian vegetation across the CSG Fields, was also dominated by grasses, but almost always included eucalypt and acacia trees. *Callistemon* spp. trees were relatively common at a number of the sites surveyed.

Most riparian zones in the sub-catchments were in poor or very poor condition (68% of the Condamine and 88% of the Upper Balonne Sub-catchments respectively), due to agricultural clearing and grazing. Weed species were recorded from 88% of sites; these were mostly exotic grasses and herbs, Mayne's pest (*Verbena tenuisecta*) and prickly pear (*Opuntia* spp.). Riparian zones within the CSG Fields were generally in poor to very poor condition and supported the same weed species.

Aquatic Habitat

Across both sub-catchments, most aquatic habitats were rated as poor or very poor (91% of the Condamine and 69% of the Upper Balonne respectively). Stream cover was provided by forest canopy (identified at 97% of streams), vegetation overhang (52%), root overhang (36%) and bank overhang (6%). Logs, branches, leaves, twigs and tree roots, provided in-stream habitat. Aquatic habitat was also poor in the CSG Fields, although there was moderate aquatic habitat at some higher stream order sites, such as the Dawson and lower Comet Rivers.

Conservation Values

Conservation values were poor or very poor at 16% of sites in the Condamine Sub-catchment and 21% of sites in the Upper Balonne Sub-catchment, moderate at 23 and 29% of sites respectively and good to very good at 61 and 50% of sites respectively.

Overall, 1% of both sub-catchments were in very poor condition (ratings for most categories were very low, and the bed and bank habitats were very unstable); 22% of the Condamine Sub-catchment and 35% of the Upper Balonne Sub-catchment was in poor condition (ratings for most categories were low, and the bed and bank habitats were unstable); 55% and 57% respectively, was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable) and 22% and 7% respectively, was in good condition (ratings for most categories were high, and the bed and bank habitats were stable. Generally, the aquatic habitats of sites in the CSG Fields were in moderate condition.

The Upper Dawson Catchment

Reach Environs

The Upper Dawson Sub-catchment covers an area of 2,714 km^2; the Upper Tributaries Sub-catchment covers an area of 3,784 km^2; the Southern Tributaries Sub-catchment covers 8,689 km^2 (Figure 4.11). Respectively, the sub-catchments support approximately 716, 912 and 2,258 km of streams. The majority of streams in the Upper Dawson Sub-catchment were in a moderate to good condition, streams in the Upper Tributaries Sub-catchment range from poor to good, whilst streams in the Southern Tributaries Sub-catchment were typically in poor to moderate condition.

Streams in the Upper Dawson were mainly highly (50%) or moderately (25%) disturbed; streams in the Upper Tributaries were either very highly (30%) or highly (40%) disturbed; streams in the Southern Tributaries were either extremely (15%) or highly (43%) disturbed. Much of the land adjacent to the sites surveyed in the *State of the Rivers* assessment had been cleared, and was covered in native pasture for cattle grazing. Other disturbances included bridges, culverts, fords and forestry activities. Overall, it appears that many of the sites within the CSG Fields were in a similar condition. Sites within the Southern and Upper Tributaries Sub-catchments were typically in poorer condition than those in the Upper Dawson Sub-catchment.

Bank Stability

Most stream banks in the Upper Dawson, Upper Tributaries and Southern Tributaries Sub-catchments were rated as stable, though most sites were affected to some degree by erosive processes. Eroding banks were observed at all sites in the Upper Dawson and Upper Tributaries Sub-catchments and at 96% of sites in the Southern Tributaries Sub-catchment. The presence of grazing stock, land clearing, man-made structures, flood scouring and eroded walking tracks had negatively affected bank stability throughout the sub-catchments. Similar impacts were seen throughout the CSG Fields.

Bed and Bar Stability

Bed aggradations and erosion throughout the sub-catchments was indicative of dynamic streams. Bars were present at 63%, 45% 46% of the sites in Upper Dawson, Upper Tributaries and Southern Tributaries Sub-catchments respectively. Irregular and alternate bars and high flow deposits were also common. A similar pattern of sediment deposition was seen throughout the CSG Fields.

Factors reducing streambed stability throughout the sub-catchments included the presence of stock, bank erosion and bed deepening, while fallen trees, rock outcrops and man-made structures provided streambed stabilisation. These factors had also affected bed stability across the CSG Fields.

Channel Diversity and Habitat Types

Channels across the sub-catchments lacked diversity (diversity ratings ranged from very low to moderate). The average depths of pools, runs and riffles (measured from the watermark) were: 1.4, 0.4 and 0.6 m, respectively in the Upper Dawson; 1.7, 0.5 and 0.2 m respectively in the Upper Tributaries; and 1.0, 0.5 and 0.1 m, respectively in the Southern Tributaries Sub-catchments. Average widths of pools, runs and riffles were: 14.2, 6.9 and 8.8 m in the Upper Dawson; 11.9, 7.2 and 7.9 m respectively in the Upper Tributaries; and 8.4, 8.5 and 7.4 m, respectively in the Southern Tributaries Sub-catchments. Pools within the CSG Fields were variable in size and depth, but were relatively consistent with pools across the sub-catchments; riffles were only recorded on the Dawson River and Injune Creek. Riffles on the Dawson River were typical of the sub-catchment; the riffle on Injune Creek was considerably narrower and shallower.

Sediments in the upper banks and streambeds varied from boulders to fine silt, and lower banks were composed of sand and fine silt. Organic matter made up between 5 – 27.5% of the sediment in pools, runs and riffle habitats. Creeks is the CSG Fields had a similar sediment composition (refer to Appendix A for the sediment composition at each survey site).

Riparian Vegetation

Across the sub-catchments, riparian vegetation included trees, shrubs, vines, rushes, grasses, and mosses. The most dominant structural types were grasses, rushes and sedges, small (<10 m) and medium sized trees (10 – 30 m). Native species included *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Melaleuca* spp., *Brigalow* spp. and *Callistemon* spp. Riparian vegetation and across the CSG Fields was also dominated by grasses and small and medium sized trees.

Most of the riparian zones in the sub-catchments were in poor condition, due to agricultural clearing and grazing. The presence of weeds was relatively variable across the sub-catchments; weeds were recorded at between 15% of sites in the Upper Dawson and 92% of sites in the Southern Tributaries Sub-catchments. Weeds comprised an average of between 7% and 23% of the vegetation at sites surveyed across the three sub-catchments. These were mostly burrs, pastures grasses, milkweeds, Mexican poppies, thistles, ragweeds, Rhodes grass, buffel grass, green panic and prickly acacia. Riparian zones within the CSG Fields were also generally in poor to very poor condition and supported several of the same weed species.

Aquatic Habitat

Condition ratings for aquatic habitats in the sub-catchments were: mostly good to very good (52%) in the Upper Dawson; very poor to good in the Upper Tributaries; and poor to very poor in the Southern Tributaries (69%). Logs, branches and leaves and twigs provided instream cover in the three sub-catchments. Stream cover was provided by forest canopy, vegetation overhang, root overhang and bank overhang. Telfer (1995) suggested that good riparian cover in the Upper Dawson Sub-catchment was the major factor in the provision of instream habitat in this sub-catchment. Conversely, the poor riparian cover in the Southern Tributaries was believed to have reduced the supply of vegetative debris, resulting in poor aquatic habitat. Aquatic habitat was poor at many sites in the CSG Fields, although there was a moderate amount of aquatic habitat at some of the larger waterways, such as the Dawson River.

Conservation Values

Approximately 46% of sites in the Upper Dawson Sub-catchment were regarded to be of very high conservation value; 29% were identified to be of high conservation merit. Five percent of sites in the Upper Tributaries Sub-catchment were identified to be of very high conservation values; 22% of sites were deemed to be of both high and moderate value. 40 – 46% of sites in the Southern Tributaries Sub-catchment were deemed to be of low conservation value for aquatic habitat, riparian habitat or as wildlife corridors.

Overall, 37% of the Upper Dawson Sub-catchment was in very good condition (ratings for most categories were very high, and the bed and bank habitats were stable); 20% was in good condition (ratings for most categories were high, and the bed and bank habitats were stable) and 43% was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable). 14% of the Upper Tributaries Sub-catchment was in good condition; 82% was in moderate condition and 4% was in poor condition (ratings for most categories were low, and the bed and bank habitats were unstable). 7% of the Southern Tributaries Sub-catchment was in good condition; 23% was in moderate condition, 63% was in poor condition and 7% of the sub-catchments was in very poor condition (ratings for most categories were very low, and the bed and bank habitats were very unstable). Generally, the aquatic habitats of the sites within the CSG Fields ranged from poor to good condition. Sites within the Southern Tributaries Sub-catchments were typically in poorer condition than those in the Upper Dawson Sub-catchment.

Comet Catchment

Reach Environs

The Eastern Tributaries Sub-catchment covers an area of 10,821 km^2; the Western Tributaries Sub-catchment covers an area of 6,474 km^2 (Figure 4.12). The Eastern and Western Tributaries sub-catchments contain approximately 2,820 km and 2,001 km of streams, respectively. In the Eastern Sub-catchment, 84% of streams were rated as very good, 13% as poor and only 3% as very poor. In the Western Sub-catchment, 86% of streams were rated as moderate to very good, and 14% are rated as poor to very poor.

Despite these good ratings, 60% of streams in the Eastern and 52% of streams in the Western Sub-catchments were subject to high, very high or extreme disturbance. The most common form of disturbance was grazing with some influence from man-made structures such as ford, culverts, roads and water extraction infrastructure. Many of the sites within the CSG Fields were in a similar condition.

Bank Stability

Stream banks were largely rated as either stable or very stable in both the Eastern (68%) and Western (87%)Tributaries sub-catchments. Erosion was widespread throughout both sub-catchments and occurred at bends, obstacles and seepage points. Erosion was observed at 63% of sites in the Eastern Tributaries and 55% of sites in the Western Tributaries Sub-catchments. Aggradations were prominent at bends and obstacles at 18% of sites in the Eastern Tributaries and 10% of sites in the Western Tributaries Sub-catchments. The major factor influencing stability was judged to be the presence of stock in the riparian zone; although runoff, water flow and clearing of vegetation were also common factors. Similar impacts were seen throughout the CSG Fields.

Bed and Bar Stability

The condition of streambeds in both sub-catchments ranged from stable to unstable. Erosion was the dominant process acting on streambeds, and affected 58% of streams in the Eastern Tributaries and 32% of streams in the Western Tributaries Sub-catchments. Aggradation was the dominant streambed process at 7% of sites in the Eastern Tributaries and 24% of sites in the Western Tributaries. Bars were present at 26% of sites in the Eastern Tributaries and 33% of sites in the Western Tributaries. Bars occurred at alternate locations, points, with encroaching vegetation and as islands. Other factors that increased bed stability included the presence of vegetation, fallen trees and rocky outcrops; erosion and bed deepening reduced bed stability.

Channel Diversity and Habitat Types

Channel habitat diversity was low or very low in both the Eastern Tributaries (99% of sites) and Western Tributaries (98% of sites) Sub-catchments. Pools and runs were most prevalent habitat types in both sub-catchments, with runs being the most observed habitat type. The average depths of pools, runs and riffles were: 1.0, 1.0 and 0.1 m, respectively in the Eastern Tributaries and 2.0, 0.5 and 0.3 m, respectively in the Western Tributaries Sub-catchments. Average widths of pools, runs and riffles were: 8.7, 6.6 and 5.6 m, respectively in the Eastern Tributaries and 8.8, 6.0 and 18.0 m in the Western Tributaries Sub-catchments. Pools were the dominant habitat type observed in the CSG Fields; pool dimensions were variable between sites, but generally corresponded to the ranges typical of both sub-catchments.

Pools across the sub-catchments were mainly made up of silt, while runs had some silt and some sand, and riffles were comprised mostly of larger particles. Organic matter made up between 5 and 26% of streambed sediment in pools, runs and riffles. Streams in the CSG Fields had a similar sediment composition (refer to Appendix A for the sediment composition at each survey site).

Riparian Vegetation

Across both the Eastern and Western Tributaries Sub-catchments, riparian vegetation included grasses, medium sized trees (10 – 30 m), small trees (<10 m), shrubs, and rushes. Native species that were common in the riparian zone included: *Eucalyptus* spp., Kangaroo Grass (*Themeda triandra*), *Melaleuca* spp., *Lomandra* spp., *Acacia* spp., *Casuarina* spp. and Brigalow (*Acacia harpophylla*). Across the CSG Fields, riparian vegetation was also dominated by grasses, but included fewer shrubs than other sites in the sub-catchments.

The majority of the riparian zones across the Eastern Tributaries sub-catchment were in very poor to moderate condition (72% of sites), whereas riparian vegetation in the Western Tributaries Sub-catchment was largely rated as good to very good (63% of stream length). Exotic grasses were recorded at 73% of sites. Exotic plants commonly observed were green panic (*Panicum maximum*), noogoora burr (*Xanthium pungens*) and parthenium (*Parthenium hysterophorus*). These species were present in the CSG Fields.

Aquatic Habitat

Aquatic habitat was rated as being in poor or very poor condition at the majority of sites in both the Eastern (73%) and Western (59%) Tributaries sub-catchments. Logs, branches, leaves and twigs and tree roots were the most widespread forms of instream habitat. The riparian canopy and overhanging vegetation provided aerial cover, though Telfer (1995) suggested that poor riparian vegetation reduced the supply of vegetative debris, resulting in poor aquatic habitat. Aquatic habitat was also poor at most sites in the CSG Fields, although the larger streams, such as the lower Comet River, supported a moderate amount of aquatic habitat.

Conservation Values

The conservation value of 28% of sites in the Eastern Tributaries and 31% of sites in the Western Tributaries was deemed to be high; 28% of sites in the Eastern Tributaries and 34% of sites in the Western Tributaries were considered to be of moderate conservation value. Overall, streams in the Comet Catchment were regarded to be in moderate to poor condition, with 54% of stream in the Eastern Tributaries Sub-catchment rated as poor (ratings for most categories were very low, and the bed and bank habitats were very unstable), and 36% as moderate (ratings for most categories were moderate, and the bed and bank habitats were moderately stable). Similarly, 27% of streams in the Western Tributaries Sub-catchment were regarded to be in poor condition; 71% were considered to be in moderate condition. Generally, the aquatic habitats of the sites in the CSG Fields were considered to be in a poor to moderate condition.

4.1.3 Summary

Watercourses of the CSG Fields are located in the Condamine and Upper Balonne Sub-catchments of the Maranoa, Balonne and Lower Condamine System, the Upper Dawson, Upper Tributaries and Southern Tributaries Sub-catchments of the Dawson River, and the Eastern and Western Tributaries Sub-catchments of the Comet River.

The watercourse sites surveyed within the CSG Fields were typically given poor to moderate Habitat Bioassessment Program assessment scores, reflecting moderate to extensive bank erosion, low habitat variability and substrates dominated by finer sediments.

Overall, the reach environs of the creeks surveyed had been moderately affected by human activities. Grazed pastures and grazed and un-grazed forests were the dominant adjoining land uses. There had been some clearing of riparian vegetation, although large trees still grew on the creek banks at many sites. Erosion at road crossings was a major form of disturbance at many sites. Several road crossings in the CSG Fields were likely to cause alterations of flow and restrict aquatic fauna passage under particular flow regimes.

Similar impacts were observed across the study area, although the extent of disturbance was lower in the Upper Dawson catchment.

Riparian zones in the CSG Fields were in poor condition and were considered to be characteristic of the region. Riparian zones were generally 10 – 30 m wide and dominated by grasses. Riparian vegetation was dominated by native species, although exotic species were found at all sites. Erosion was prominent in waterways throughout the region; some bank erosion had occurred at most sites in the CSG Fields.

Streambeds in the CSG Fields were relatively stable; however, there was scouring outside meanders, downstream of obstructions and along roadside drainage channels. Bars were a common feature of the streambeds in the region. Channel diversity was generally low; isolated pools were the dominant habitat category observed. Pool habitats in the CSG Field were typically representative of those in the greater sub-catchments.

Sites in the CSG Fields supported some physical aquatic habitat. Instream habitat was provided by small woody debris, fallen logs and tree roots. Diversity was highest at sites with a higher cover of riparian trees and a higher cover of overhanging vegetation.

4.2 Water Quality

4.2.1 Of the CSG Fields

Water Temperature

Water temperature varied between 16.4 °C at Bungil Creek (Site 2) and 30.8 °C at Carnarvon Creek (Site 24). The Condamine – Upper Balonne Catchment had the lowest average temperature (19.8 °C), followed by the Upper Dawson Catchment (22.6 °C) and the Comet Catchment (26.4 °C) (Figure 4.13), reflecting the latitude of the Catchments. Water temperature was also affected by the time of day (i.e. sites visited in the morning were typically cooler than those visited later in the day) and the ambient weather conditions. There are no guidelines available for water temperature (ANZECC & ARMCANZ 2000; EPA 2007a).

Dissolved Oxygen

Dissolved oxygen (DO) levels were outside the ANZECC & ARMCANZ (2000) range at all sites in the Condamine – Upper Balonne Catchment, and outside the QWQG range at all sites in the Upper Dawson and Comet Catchments (Figure 4.14). All sites except Carnarvon Creek (Site 24) had low levels of dissolved oxygen. Carnarvon Creek was extremely hyperoxic (139% saturation), a likely reflection of the high abundance of filamentous algae in senescing pools at this location. Algal photosynthesis provides oxygen to the water column during the day; in contrast, algal respiration removes oxygen from the water column at night.

The low level of dissolved oxygen at many sites is likely to be related to the lack of water movement and mixing at many sites.

pH

pH tended to be neutral to slightly acidic (< 7) across most sites within the Condamine – Upper Balonne Catchment, with pH below the national guideline range at Tchanning (Site 5), Wallumbilla (Site 10) and Yalebone (Site 11) Creeks (Figure 4.15). At most sites within the Upper Dawson Catchment, with the exception of Sites 16 and 21, pH was within the range of the QWQG (EPA 2007a). pH varied from neutral to basic in the Comet Catchment; exceeding the QWQG in the senescing pools in Carnarvon Creek (Site 24). The lowest pH was 5.94 at Tchanning Creek (Site 6) in the Condamine – Upper Balonne Catchment; the highest pH of 8.84 occurred at Carnarvon Creek (Site 24) in the Comet Catchment. Differences in pH between catchments may reflect differences in local geomorphology; for example, much of the spring water that feeds the Upper Dawson River is relatively acidic.

Electrical Conductivity

Conductivity ranged from 88.9 μS/cm at Injune Creek (Site 20) to 610 μS/cm at Consuelo Creek (Site 26) (Figure 4.16). Conductivity was lowest in the Condamine – Upper Balonne Catchment (mean of 157.9 μS/cm), followed by the Upper Dawson (mean of 239.39 μS/cm), and the Comet Catchments (mean of 318.3 μS/cm). Conductivity at all sites in the Condamine- Upper Balonne Catchment was below the national guideline upper limit. Conductivity was also below the QWQG upper limit at all sites in the Upper Dawson and Comet Catchments (EPA 2007a), except for the lower and mid Dawson River (Sites 12 and 16) and Consuelo Creek (Site 26). It should be noted that the QWQG value for conductivity is a preliminary guideline only (EPA 2007a).

Turbidity

Turbidity was very high across all three catchments, with a maximum reading of 1,537 NTU at Bungaban Creek (Site 13) in the Condamine – Upper Balonne Catchment. Consuelo Creek (Site 26) in the Comet Catchment was the only site with turbidity below guideline levels (Figure 4.17). The Comet Catchment was the least turbid (with a mean turbidity of 146 NTU), while the Condamine – Upper Balonne and the Upper Dawson Catchments were very turbid, with mean turbidity levels of 354 and 487 NTU, respectively (Figure 4.17).

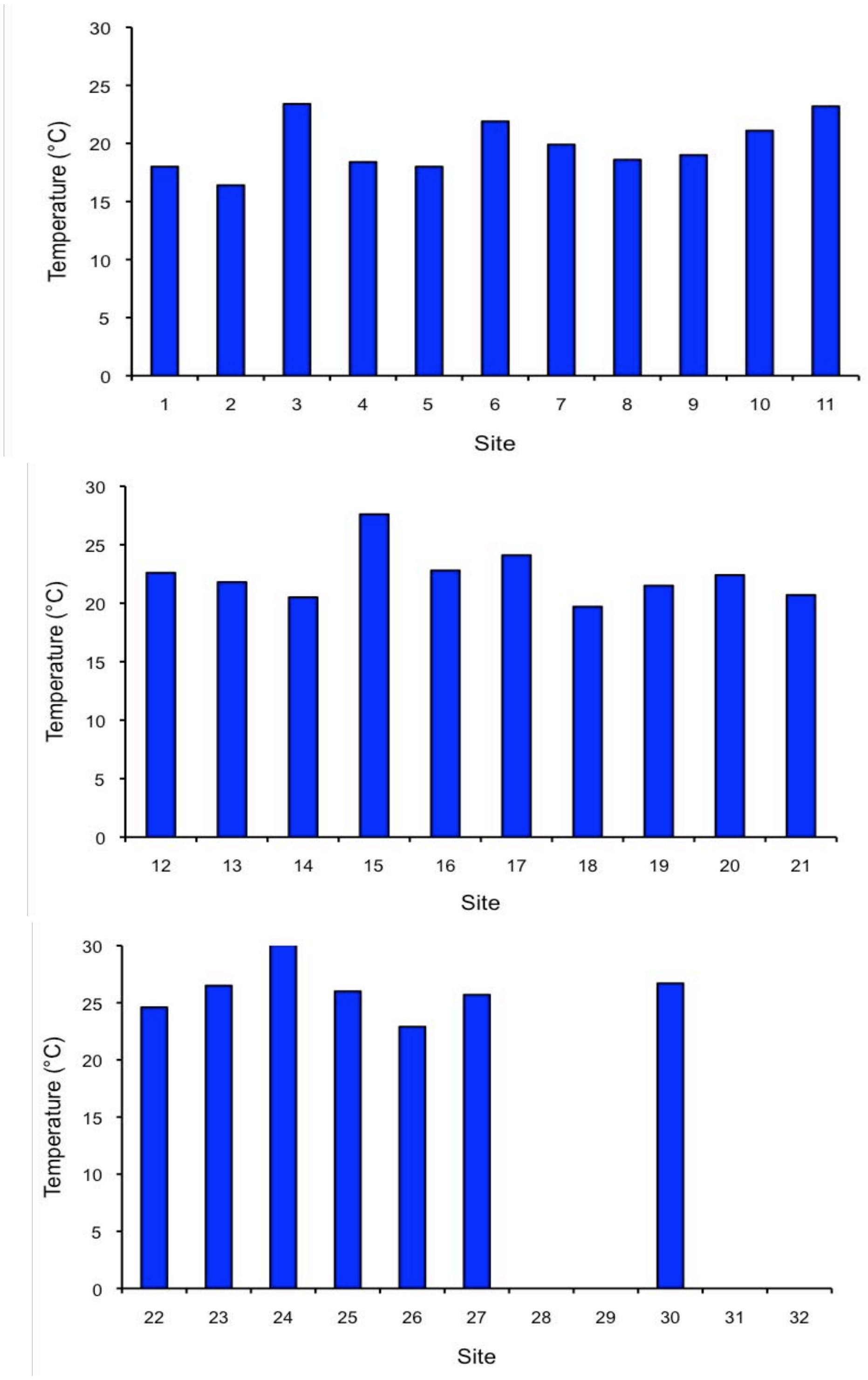


Figure 4.13 Water temperature at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet Catchments (Sites 22-32). Sites 28,29, 31, and 32 were dry.

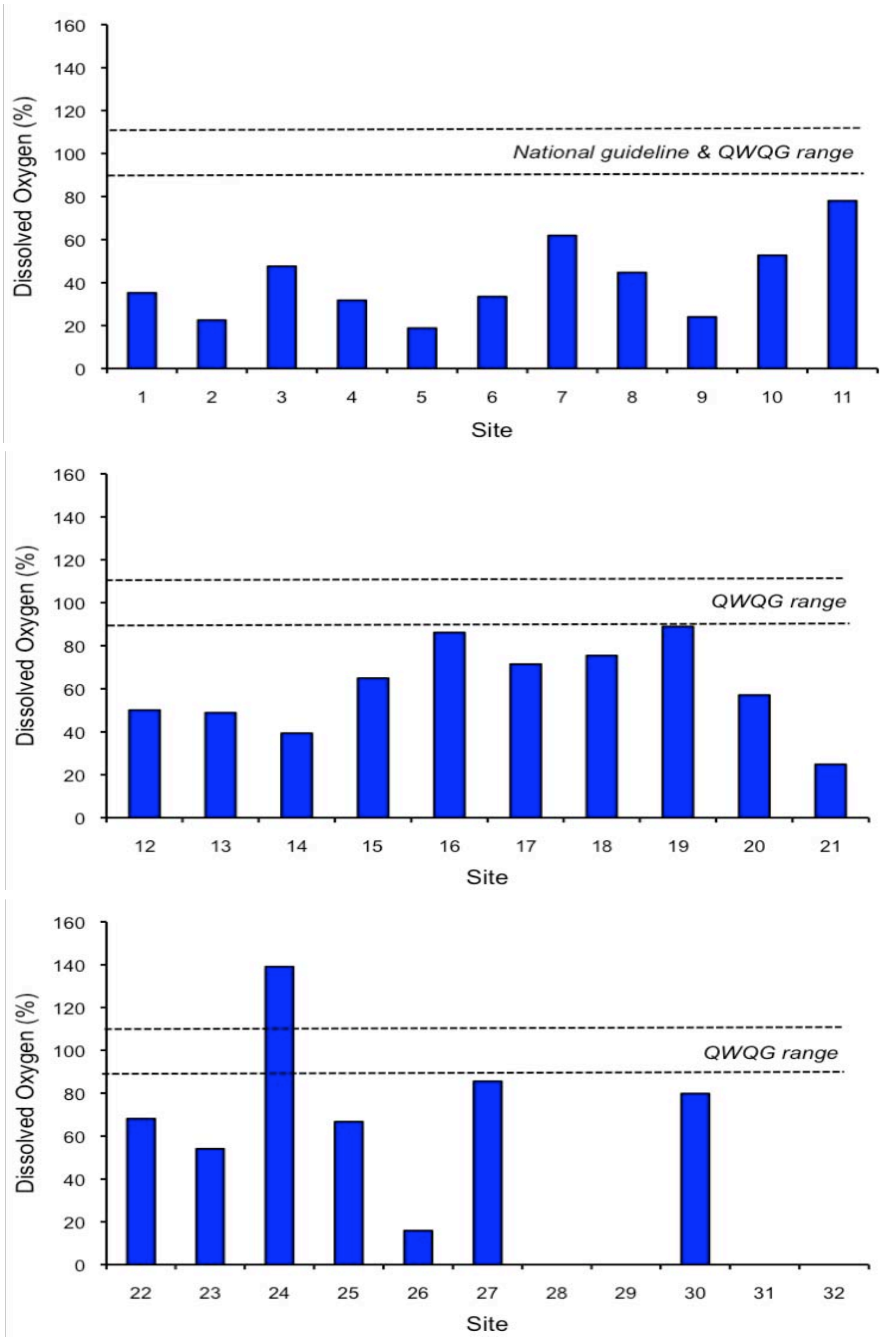


Figure 4.14 Dissolved oxygen (percent saturation) at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet Catchments (Sites 22-32). Sites 28,29, 31, and 32 were dry. Guidelines are based on QWQG (EPA 2007a) and the ANZECC & ARMCANZ (2000).

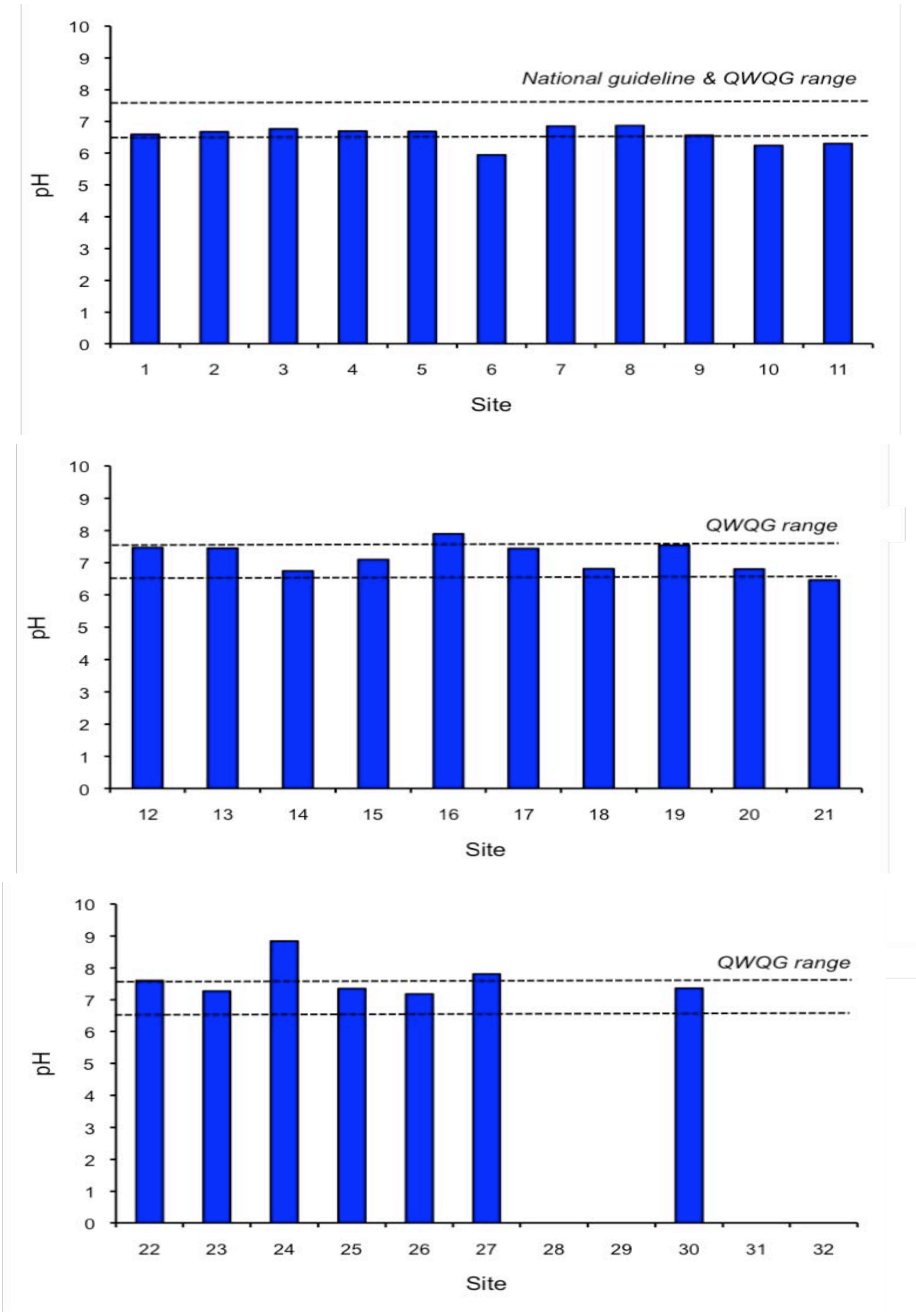


Figure 4.15 pH at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet Catchments (Sites 22-32). Sites 28,29, 31, and 32 were dry. Guidelines are based on QWQG (EPA 2007a) and the ANZECC & ARMCANZ (2000).

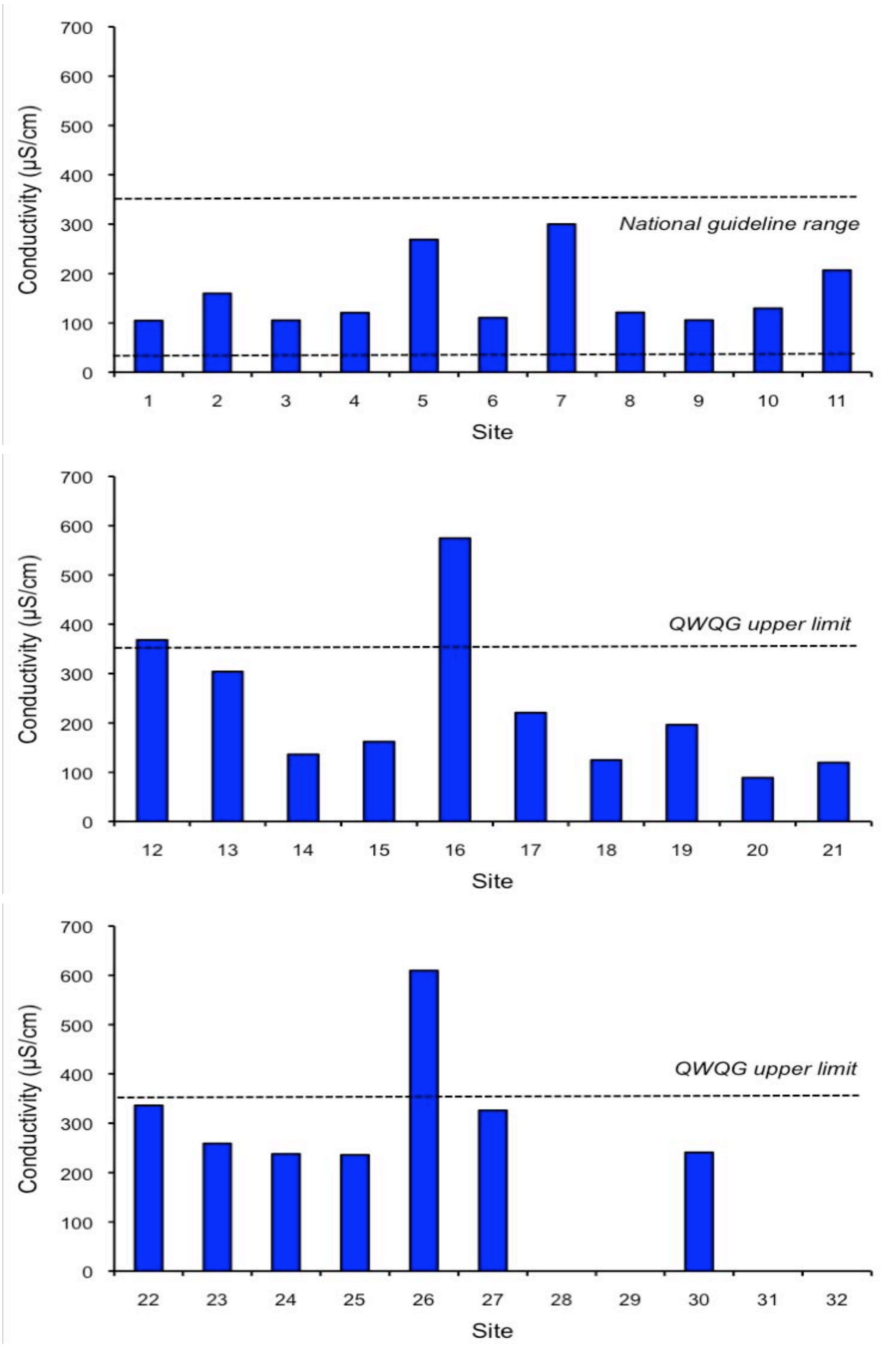


Figure 4.16 Electrical conductivity at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet Catchments (Sites 22-32). Sites 28,29, 31, and 32 were dry. Guidelines are based on QWQG (EPA 2007a) and the ANZECC & ARMCANZ (2000).

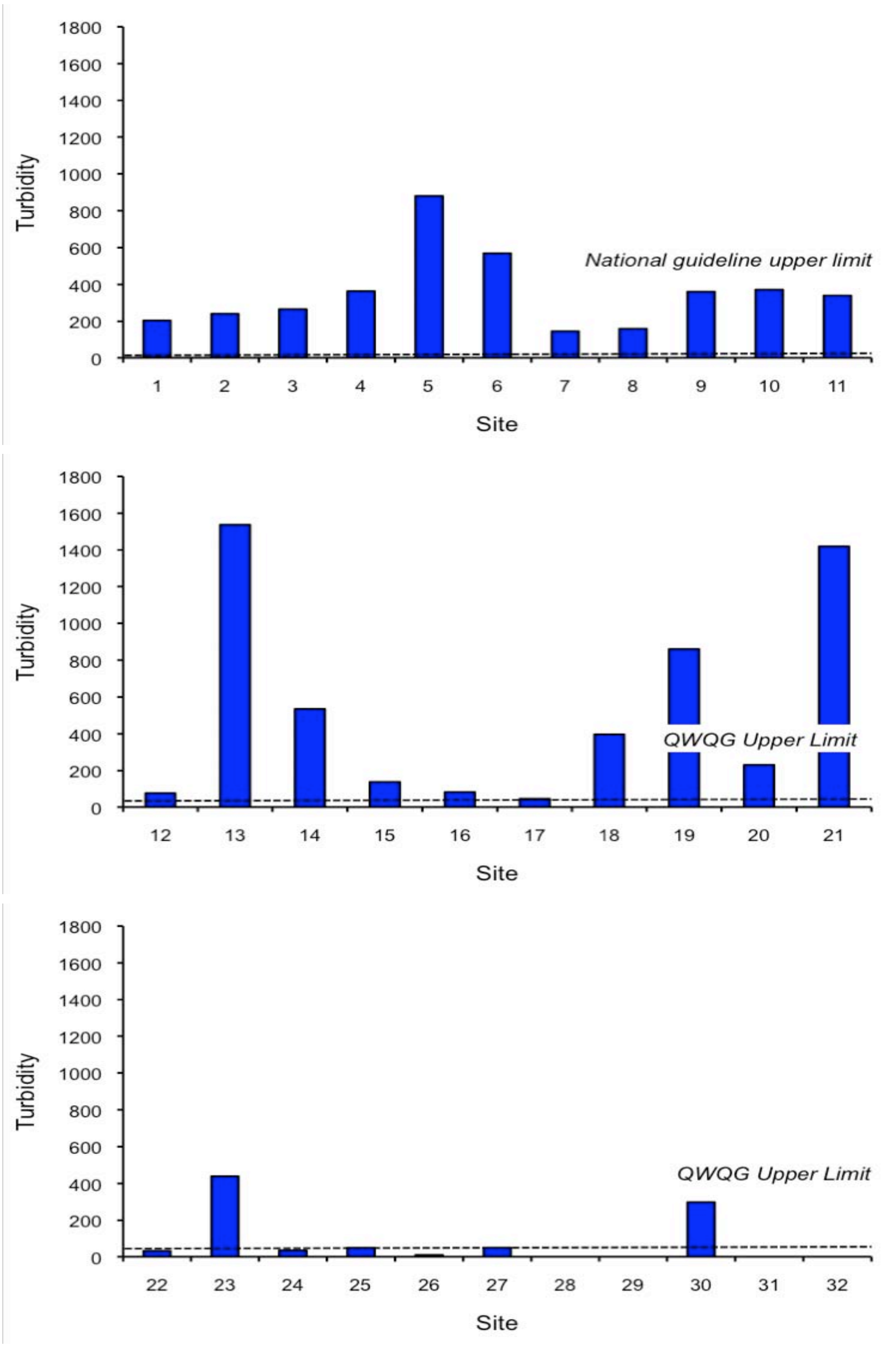


Figure 4.17 Turbidity at watercourse sites within in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet Catchments (Sites 22-32). Sites 28,29, 31, and 32 were dry. Guidelines are based on QWQG (EPA 2007a) and the ANZECC & ARMCANZ (2000).

4.2.2 A Regional and Ecological Perspective

Condamine – Upper Balonne Catchment

Generally, the Condamine – Upper Balonne system is characterised by high turbidity that exceeds guideline values (DEWHA 2007). The highest turbidities actually occur in the less intensively cultivated lower reaches of the catchment, which indicates that the natural soil type of the region may be the cause of high turbidity recordings (DEWHA 2007). However, vegetation clearing and cattle grazing are known to cause erosion, and are likely to contribute to high turbidity (DEWHA 2007). No significant increases in turbidity have been reported in the Condamine – Upper Balonne Catchment over the last decade; however, turbidity levels generally increase with distance downstream (DEWHA 2007).

Agriculture in the Condamine – Upper Balonne Catchment has a strong reliance on the use of pesticides and fertilisers. The herbicide atrazine can persist in both soil and water for long periods of time. Low levels of atrazine residues have been consistently detected in the aquatic environment, especially close to cropping lands (CA 2004). High surface water concentrations of atrazine and endosulfan have been recorded in up to 91% of samples from some weirs in the Uplands and the Upper Floodplain of the catchment (CA 2004).

Upper Dawson Catchment

Agricultural land use dominates the Dawson River Catchment; 77% of the area is grazed, 12% is State forest, 7% is cropped, and 3% is national park (EPA 2001). Within the Dawson River Catchment there are eight sub-catchments, which vary in their aggregate emission rates of nitrogen and phosphorus. In comparison with other Dawson River Sub-catchments, the upper Dawson River Sub-catchment is a moderate emitter of nitrogen and a light emitter of phosphorus (EPA 2001). Total nitrogen emitted from this Sub-catchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001).

Grazing lands are the primary source of both nitrogen and phosphorus in the Dawson Basin (43 and 80%, respectively) (Joo et al. 2000). For nitrogen, the next biggest source is from State forests (39%), then cropping (9%) (Joo et al. 2000). For phosphorus, cropping is the second largest source, contributing 12% of the total, and State forests are the source of 4% of total phosphorus (Joo et al. 2000).

Comet Catchment

Cropping dominates land usage in the Comet Catchment and grazing is common on the higher ground. Only 12% of the Catchment is National Park, and 9% is State Forest (Henderson 2000). Levels of turbidity and suspended solids are very high, as are nutrient concentrations. Total N and P levels in runoff from cropping are very high (Noble & Rummenie 1996; Henderson 2000), resulting in high cyanobacteria (blue-green algae) densities throughout the catchment at times of low flow (Fabbro et al. 1996; Henderson 2000). However, high turbidity (which limits light penetration) limits the growth of cyanobacteria (Henderson 2000). The widespread distribution of herbicides in surface waters of the catchment is a matter of local concern (Noble & Rummenie 1996; Henderson 2000).

Immediately downstream of the Catchment, the waters of the Mackenzie River received a report card score of 'D' (poor) for waters above the Isaac River confluence (Meecham 2003). Water quality in this catchment is threatened by:

- increased chemical loads associated with irrigation and grazing
- flow regulation reducing availability of aquatic habitat, and
- increased sediment runoff associated with interactions between grazing, fire, drought and rainfall (Meecham 2003).

These factors are also likely to have a major influence on water quality within the Comet Catchment.

Central Queensland

Overall, Central Queensland's water quality is of moderate condition but there are a number of issues that will be problematic unless they are remedied. Key issues include (Meecham 2003):

- erosion and runoff increasing sedimentation, nutrient, pesticide and herbicide levels;
- toxic blue-green algae blooms in still waters;
- contamination or pollution in industrial and mining areas;
- rising salinity;
- poor riparian vegetation cover; and
- changes to river flows.

4.2.3 Summary

Dissolved oxygen concentrations were outside the guideline ranges at all sites; all sites except Carnarvon Creek (Site 24) had low levels of dissolved oxygen, whereas Carnarvon Creek was extremely hyperoxic. Low DO concentrations were probably related to the extremely high turbidity experienced at most sites, a high biological oxygen demand and the low mixing of the waters. The high DO concentrations at Carnarvon are likely to reflect the abundance of filamentous algae in senescing pools at this location.

Turbidity was high throughout the study area and was probably related to sediment-laden runoff associated with clearing of riparian vegetation and erosion of steep banks. High turbidity is characteristic of all three catchments, and of the greater central Queensland region. Due to surrounding land uses, waterways within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants. By their nature, ephemeral streams such as those in the study area are commonly subject to a range of severe (natural) stresses, and as such the water quality of the creeks within the study area may be characterised by elevated turbidity, salinity and nutrient enrichment (Chessman, B. [Centre for Natural Resources NSW] pers. comm. 2003, 21 October).

4.3 Aquatic Flora

4.3.1 Of the CSG Fields

Aquatic vegetation provides physical structure for use by aquatic fauna (e.g. as a refuge habitat, or a substrate for fish to lay eggs upon), as well as a food source for herbivorous fauna and detritivores. The diversity of aquatic macrophytes was relatively low, with only 21 species recorded across the entire study area. The Upper Dawson Catchment supported the greatest number of aquatic macrophytes (16), followed by the Comet (15) and the Condamine – Upper Balonne (12) Catchments (Table 4.2 to Table 4.4). The cover of aquatic macrophytes varied greatly across sites (from 0 to 66.5% at each site).

The composition of macrophyte communities varied greatly across the study area, though common rush (*Juncus usitatus*) and mat rush (*Lomandra longifolia*) were common in the study area, being recorded at many sites (Table 4.2 to Table 4.4). The exotic macrophytes, reed sweetgrass (*Glyceria maxima*) and curled dock (*Rumex crispus*), were recorded at sites in the Upper Dawson and Comet Catchments (Table 4.2 to Table 4.4).

Figure 4.18

Mat rush (*Lomandra longifolia*) grew at many of the sites in each of the three Catchments.

Figure 4.19

Common rush (*Juncus usitatus*) was the most widespread macrophyte in the study area.

With the exception of the submerged macrophytes: red watermilfoil (*Myriophyllum verrucosum*), ribbon weed (*Vallisneria nana*), nardoo (*Marsilea drummondi*), and the floating wavy marshwort (*Nymphoides crenata*), found at Lake Nuga Nuga and Bony Creek, all macrophytes were of emergent growth form.

The limited cover of macrophytes, and in particular the lack of submerged species, is likely to be related to the largely ephemeral nature, and turbid conditions, of many of the waterways in the study area. Ephemeral waterways do not offer appropriate habitat for submerged macrophytes, as they are sensitive to desiccation and would die when ephemeral waterways become dry. Turbidity may not allow sufficient light penetration through the water column for the growth of macrophytes on the substrate. However it should be noted that high turbidity could also prevent observation of submerged macrophytes through the water column during surveys.

Table 4.2 Percent cover of all aquatic macrophytes at each site in the Condamine – Upper Balonne Catchment, listed by growth form.

GROWTH FORM / Family / *Latin name*	**Common name**	**Native Exotic**	**% Cover at Each Site**										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
EMERGENT													
Amaranthaceae													
Alternanthera denticulata	lesser joy-weed	Native									1		
Cyperaceae													
Cyperus difformis	dirty dora	Native	1			2					2	2	
Cyperus polystachyus	bunchy sedge	Native					2						
Eleocharis sphacelata	tall spike rush	Native											5
Graminae													
Echinochloa colona	awnless barnyard grass	Native	10	3								30	
Leptochloa digitata	umbrella canegrass	Native		1							12		
Phragmites australis	common reed	Native				5		1					
Juncaceae													
Juncus ursitatus	rush	Native	2	1		8	5	2				5	
Lomandraceae													
Lomandra longifolia	mat rush	Native			2	1	10	2	10				
Onagraceae													
Ludwigia peploides	ludwigia	Native										10	
Poaceae													
Cynodon dactylon	couch grass	Native										10	
SUBMERGED													
Marsileaceae													
Marsilea drummondi	nardoo	Native									1		
TOTAL			13	5	2	16	17	5	10	0	16	57	5

Table 4.3 Percent cover of all aquatic macrophytes at each site in the Upper Dawson Catchment, listed by growth form.

GROWTH FORM / Family / *Latin name*	Common name	Native Exotic	% Cover at Each Site									
			12	13	14	15	16	17	18	19	20	21
EMERGENT												
Amaranthaceae												
Alternanthera denticulata	lesser joy-weed	Native					0.5		1	1		1
Cyperacea												
Cyperus polystachyus	bunchy sedge	Native							1			
Eleocharis acuta	common spike-rush	Native					1	1	2			1
Graminae												
Echinochloa colona	awnless barnyard grass	Native	2	51	10	2	2		10		5	
Glyceria maxima	reed sweetgrass	Exotic	22									
Leptochloa digitata	umbrella canegrass	Native		5	5	15		5		2	20	
Phragmites australis	common reed	Native		10	5						10	
Juncaceae												
Juncus ursitatus	rush	Native	1	0.5	2	1	1	5	1	1	2	5
Lomandraceae												
Lomandra longifolia	mat rush	Native	5		15	2	5	25		3	20	
Onagraceae												
Ludwigia peploides	ludwigia	Native					8					
Poaceae												
Cynodon dactylon	couch grass	Native										10
Polygonaceae												
Persicaria attenuata	smartweed	Native	5									
Rumex crispus	curled dock	Exotic					3					
TOTAL			35	66.5	37	20	20.5	36	15	7	57	17

Table 4.4 Percent cover of all aquatic macrophytes at each site in the Comet Catchment, listed by growth form.

GROWTH FORM / Family / *Latin name*	**Common name**	**Native Exotic**	**% Cover at Each Site**										
			22	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
EMERGENT													
Cyperacea													
Cyperus difformis	umbrella sedge	Native					1	1		5			
Cyperus polystachyus	bunchy sedge	Native				1							
Eleocharis acuta	common spike-rush	Native						1					
Graminae													
Echinochloa colona	awnless barnyard grass	Native		5		3	5						
Glyceria maxima	reed sweetgrass	Exotic					3	1					
Leptochloa digitata	umbrella canegrass	Native		2						1		1	1
Phragmites australis	common reed	Native					2	2				5	
Pseudoraphis spinescens	spiny mudgrass	Native				2			2		1		
Juncaceae													
Juncus ursitatus	Rush	Native		1	0.5			1		2			
Lomandraceae													
Lomandra longifolia	mat rush	Native		2							0.5		
Poaceae													
Cynodon dactylon	couch grass	Native			3	3		10	2	5	2		2
Polygonaceae													
Persicaria attenuata	smartweed	Native				20	5	5					
Persicaria decipiens	slender knotweed	Native				1							
Rumex crispus	curled dock	Exotic			0.5								

GROWTH FORM / Family / *Latin name*	Common name	Native Exotic	% Cover at Each Site										
			22	23	24	25	26	27	28	29	30	31	32
SUBMERGED													
Haloragaceae													
Myriophyllum verrucosum	red watermilfoil	Native	8										
Hydrocharitaceae													
Vallisneria nana	ribbon weed	Native	5										
Marsileaceae													
Marsilea drummondi	nardoo	Native			1			1					
Menyanthaceae													
Nymphoides crenata	wavy marshwort	Native	2										
TOTAL			15	10	5	30	16	22	4	13	3.5	6	3

4.3.2 A Regional and Ecological Perspective

Very little information is available regarding aquatic macrophytes of the region.

Condamine – Upper Balonne Catchment

The depth of visibility was 0.1 m at many sites surveyed during the *State of the Rivers* assessment (Van Manen 2001), which meant that an assessment of aquatic vegetation could not be completed at 55% of the sites surveyed in this Catchment. However, at sites where aquatic vegetation was surveyed, submerged macrophytes were recorded at 38% of sites, including species such, native watermilfoil (*Myriophyllum* spp.), and hornwort (*Ceratophyllum demersum*) (Van Manen 2001). Floating vegetation was only recorded at 4% of the sites surveyed, and included swamp lilies (*Ottelia ovalifolia*), nardoo (*Marsilea mutica*) and *Azolla* spp. (Van Manen 2001).

Emergent vegetation was the most common form of macrophyte in the catchment, with common species including common reed (*Phragmites australis*), cumbungi (*Typha* spp.), water ribbons (*Triglochin procerum*) and the introduced weed species para grass (*Urochloa mutica*) (Van Manen 2001).

Upper Dawson Catchment

State of the Rivers (Telfer 1995) sites in the catchment were dry at the time of sampling (91%), and sites with water did not support aquatic macrophytes. frc environmental (2007) reported ten different species of macrophyte from seven sites, with richness ranging from 0 to 8 species at any one site. All aquatic macrophytes had an emergent growth form (there were no floating or submerged species).

Comet Catchment

The *State of the Rivers* Assessment (Henderson, 2000), rates the aquatic vegetation communities of the Comet Catchment mostly as very poor. This is likely to reflect the high turbidity levels at the time of survey, which prevented an accurate assessment at many sites; turbidity was considered too high to accurately estimate cover at 18% of sites. Aquatic vegetation that was recorded in the Comet Catchment included common reed (*Phragmites* australis), water fern (*Azolla* spp.) and *Blyxa* spp..

4.3.3 Temporal Variance in Macrophyte Communities

The aquatic macrophyte communities of the study area are not likely to vary considerably between seasons, though recruitment during spring may enhance (at least temporarily) the abundance of some species. Vegetative recruitment is likely to be most successful in the larger, more permanent waterways of the study area. Macrophytes are likely to be swept downstream or to die-off due to being submerged in turbid water during flood events in the wet season.

4.3.4 Summary

The diversity of aquatic macrophytes in the CSG Fields is relatively low. The composition and cover of these communities varies across the study area. The limited cover of macrophytes, and in particular the lack of submerged species, is likely to be related to the largely ephemeral nature, and turbid conditions, of many of the waterways in the study area. Larger waterways, such as the Dawson and Comet Rivers and Lake Nuga Nuga, support more permanent water and provide a more stable habitat for aquatic macrophytes, and are therefore likely to support more abundant and diverse communities.

No rare or threatened species of aquatic flora have been recorded from the waterways of the study area. Exotic macrophytes were recorded at sites in the Upper Dawson and Comet Catchments.

4.4 Aquatic Macroinvertebrate Communities

4.4.1 Of the Study Area

Taxonomic richness, PET richness, and SIGNAL 2 scores were calculated for all sites except for those that were dry, these were: Planet Creek, the Comet River, Minerva Creek and Orion Creek (sites 28, 29, 31, & 32) from the Comet Catchment. Non-biting midge larvae (sub-family Chironominae), diving beetles (family Dyticidae), water boatmen (family Corixidae) and water fleas (family Cladocera) dominated the invertebrate communities of the study area.

Richness

Taxonomic richness (the number of macroinvertebrate taxa, generally families, per sample) ranged from 0 to 17 in bed habitats and 6 to 18 in edge habitats across all sites surveyed. Within each site, richness was higher in edge habitats than bed habitats (Figure 4.20). Riffle habitats were only present at two sites in the Upper Dawson Catchment (Sites 16 & 20), which supported 10 and 7 taxa, respectively (Figure 4.20).

Richness was highest in the Comet Catchment, particularly in edge habitats, where greater than 14 taxa were typically recorded at each site. Mean richness in edge and bed habitats in the Comet Catchment was 15.7 and 9.7 taxa, respectively. The edge habitats of Carnarvon Creek (Site 24), Consuelo Creek (Site 26) and the Comet River (Site 27) had the highest richness of all edge habitats surveyed across the study area. Richness was particularly high (17 taxa) in bed habitats on the Comet River (Site 27).

Richness was typically lower at sites in the Upper Dawson Catchment (Figure 4.20). Mean richness in edge, bed and riffle habitats was 10.5, 5.4 and 8.5 taxa, respectively. Richness was highest in the edge habitat of Hutton Creek (Site 17) (15 taxa) and lowest in (in bed habitats on Commissioner Creek (Site 21) (2 taxa). Water depth prevented the survey of bed habitats on the lower Dawson and and Comet Rivers (Sites 12 and 30).

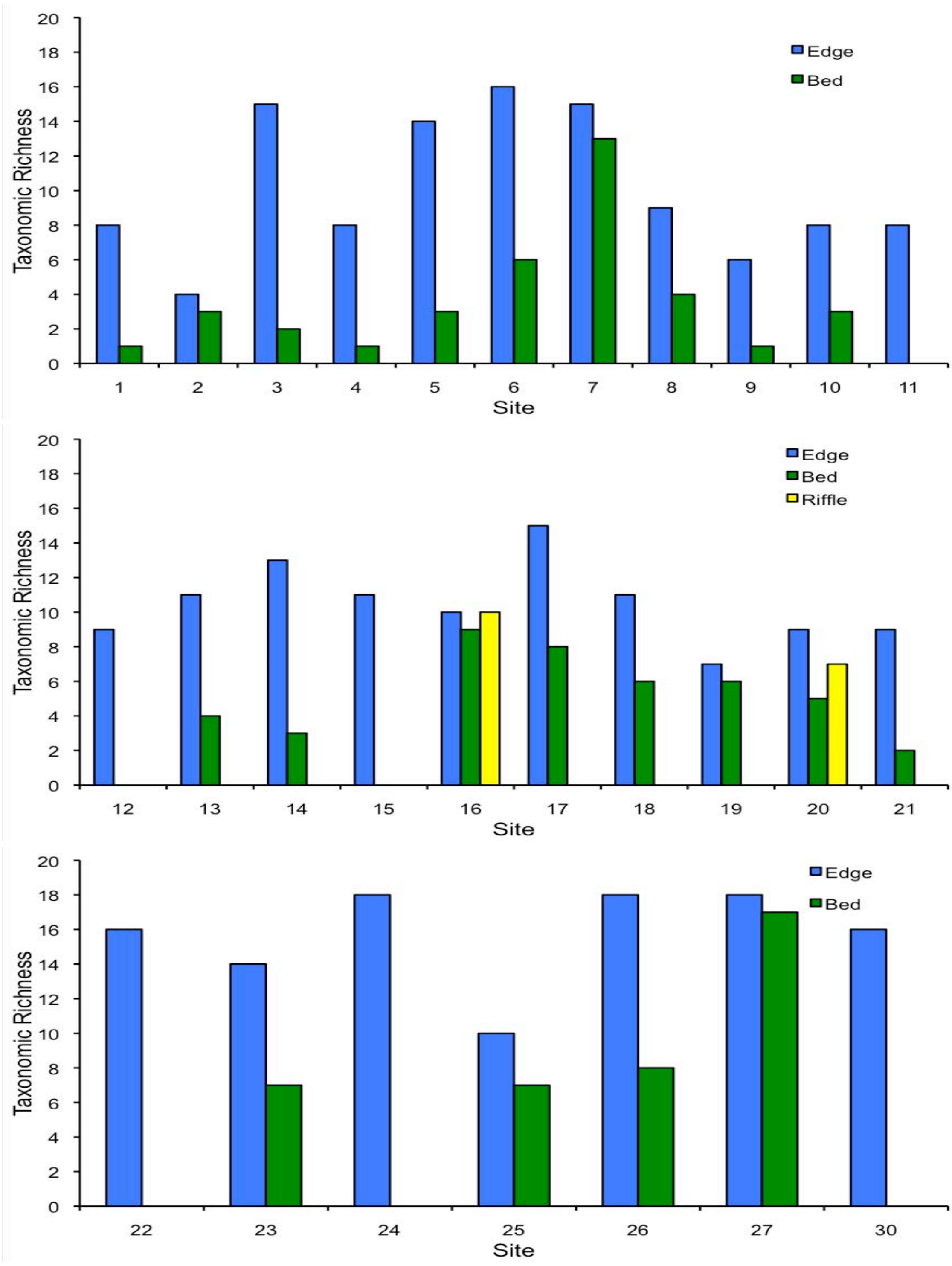


Figure 4.20 Taxonomic richness for watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

The Condamine – Upper Balonne Catchment supported the lowest richness of macroinvertebrates; mean richness in edge and bed habitats was 9.3 and 3.4 taxa, respectively (Figure 4.20). The richest communities in the catchments were sampled from edge habitats on Tchanning Creek (Site 6) and Dulacca Creek (Site 7), which both supported 15 invertebrate families. Richness was particularly low at edge habitats on Bungil (Site 2) and Bony (Site 9) Creeks and bed habitats on Bungeworgorai (Site 1), Blyth (Site 3), Wallumbilla (Site 4) and Bony (Site 9) Creeks.

PET Richness

In general, PET richness (a measure of pollution-sensitive invertebrate taxa richness) of <1 indicates degraded water or habitat quality, PET richness of 1 – 4 indicates moderate water / habitat quality, and PET richness of >4 indicates good water / habitat quality.

Similar to taxonomic richness, PET richness was typically highest in the Comet, followed by the Upper Dawson and then the Condamine – Upper Balonne Catchments (Figure 4.21). Mean PET richness for edge and bed habitats in the Comet Catchment were 2.28 and 1.0 families, respectively. Overall, these scores are indicative of moderate water / habitat quality. At least one PET family was collected from each site in the Comet Catchment; PET richness was highest in the edge habitat at Consuelo Creek (Site 26) (4 families).

PET richness was typically lower in the Upper Dawson Catchment (Figure 4.21); mean PET richness in edge, bed and riffle habitats was 1.36, 0.25 and 2.5 families, respectively, again indicative of moderate water / habitat quality. The Dawson River (Site 16) supported a relative abundance of PET families (4) in both edge and riffle habitats, which is indicative of relatively good water / habitat quality. No PET families were recorded from Baffle Creek (Site 18), the upper Dawson River (Site 19), and Commissioner Creek (Site 21), indicating locally degraded water and / or habitat quality.

The Condamine – Upper Balonne Catchment supported the lowest richness of PET families; mean PET richness in edge and bed habitats was 0.91 and 0.09 families, respectively, indicating degraded water and / or habitat quality (Figure 4.21). Bungeworgorai (Site 1) and Dulacca (Site 7) Creeks supported a moderate abundance of PET families (3 and 2 respectively), indicating the presence of moderate water / habitat quality at these locations. No PET families were recorded at Bungil (Site 2), Wallumbilla (Sites 4 and 10), and Yalebone (Site 11) Creeks.

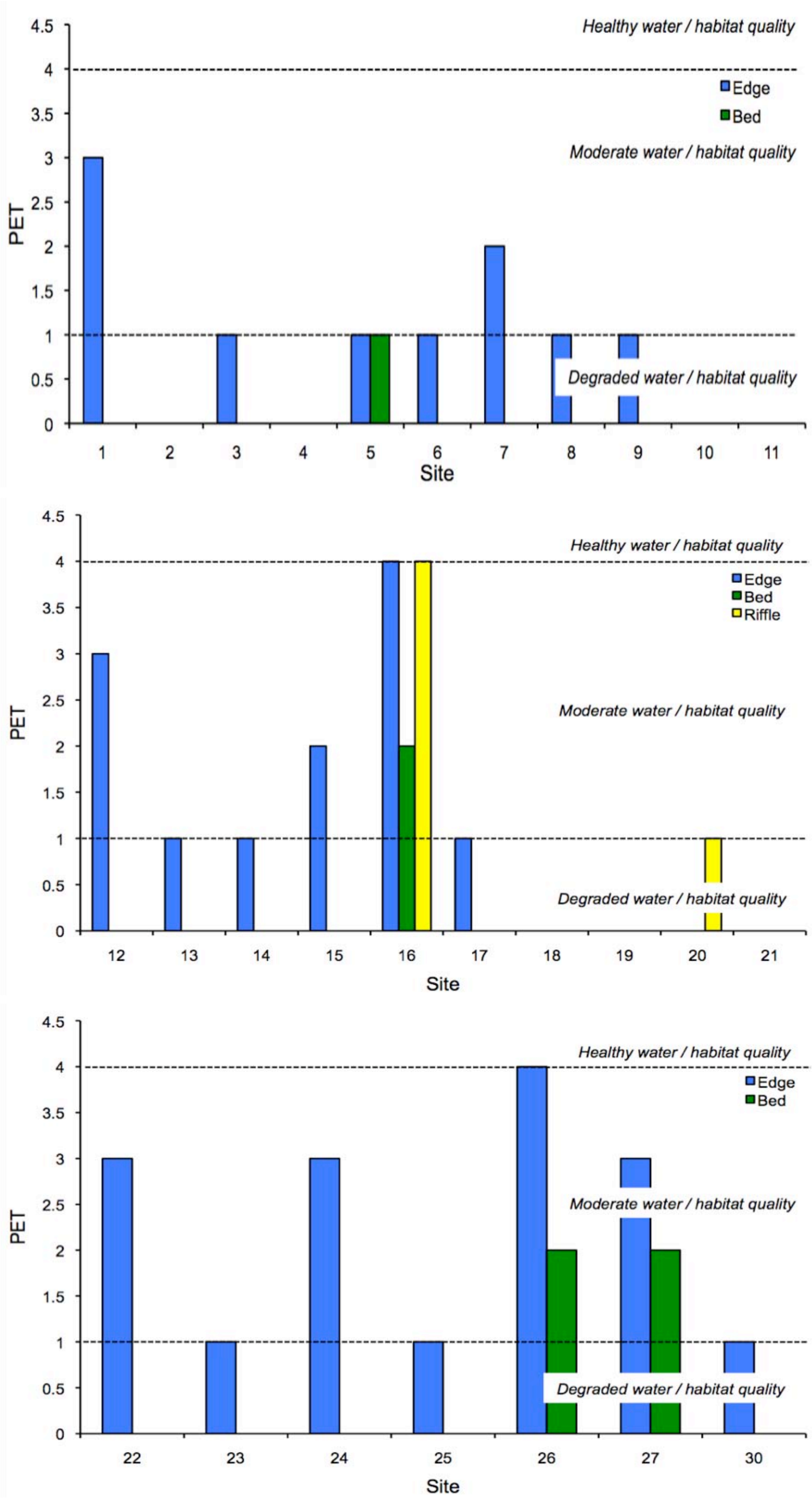


Figure 4.21 PET richness for watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

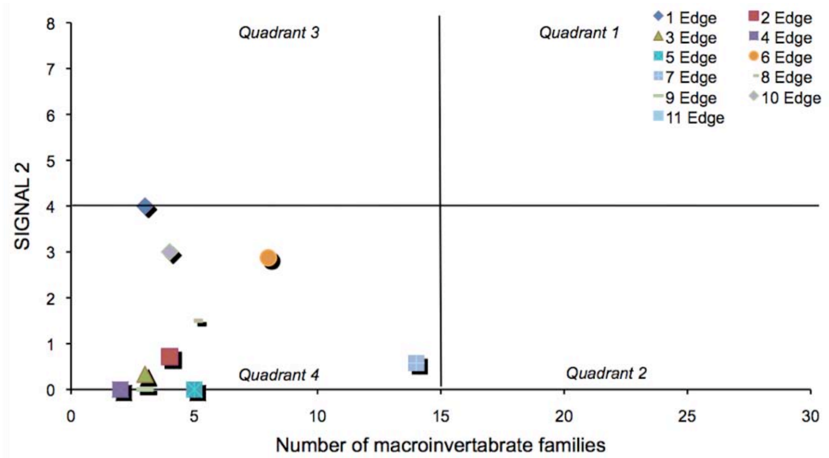
The low abundance of PET taxa at most sites may be due to the ephemeral or intermittent nature of these waterways. By their nature, ephemeral streams are commonly subject to a range of severe (natural) stresses, such as nutrient enrichment, turbidity and salinity (Chessman, B. [Centre for Natural Resources NSW] pers. comm. 2003, 21 October), and as a consequence, PET families are not commonly abundant in these environments.

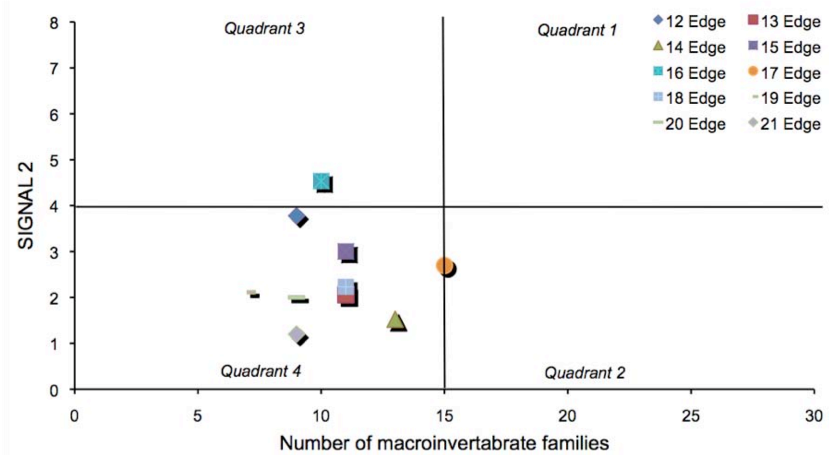
SIGNAL 2 / Family Bi-plots

The interpretation of SIGNAL 2 indices in conjunction with the number of macroinvertebrate families recorded, enables the simple characterisation of aquatic macroinvertebrate communities. Quadrant boundaries for the SIGNAL 2 / Family Bi-plot used for this study are interim suggested boundaries (Chessman 2001) for Australian freshwaters (excluding the Murray – Darling Basin and rivers east of the Great Dividing Range in Queensland). Recently, an alternative approach has been recommended, which includes boundary setting for each study (Chessman 2003). This technique would require considerable sampling (in effect calibration) within the region, which is beyond the scope of this study. Interpretation of the bi-plot with regard to quadrant boundaries should therefore be approached with caution.

Macroinvertebrate communities surveyed from bed, edge and riffle habitats throughout the study area generally ordinate into quadrant 4 of the SIGNAL 2 / Family Bi-plot (Figure 4.22), which indicates that these communities may be impacted by urban, industrial or agricultural pollution. However, there were some exceptions, including: edge habitats in the Comet River (Sites 27 and 30), Lake Nuga Nuga (site 22), Carnarvon Creek (Site 24), and Consuelo Creek (Site 26), and bed habitats in the Comet River (Site 27) in the Comet Catchment; edge habitats in the Upper Dawson Catchment; and bed habitats in Dulacca Creek (Site 7), which all fell within quadrat 2. Quadrat 2 can indicate the presence of high salinity or nutrient levels, but these sites are interpreted as being less impacted than other sites from the three catchments.

In addition, bed habitats from the Dawson River (Site 16) and Blyth Creek (Site 3), and edge habitats from Bungeworgorai Creek (Site 1) and the Dawson River (Site 16) had SIGNAL 2 bi-plot scores in quadrant 3, which is often indicative of toxic pollution or harsh physical conditions. In both cases, this may be reflective of the physical harshness of ephemeral or intermittent waterways in western Queensland, however it is possible that pollution from the road crossings (i.e. hydrocarbons) at these sites has contributed to the state of these macroinvertebrate communities at these locations.





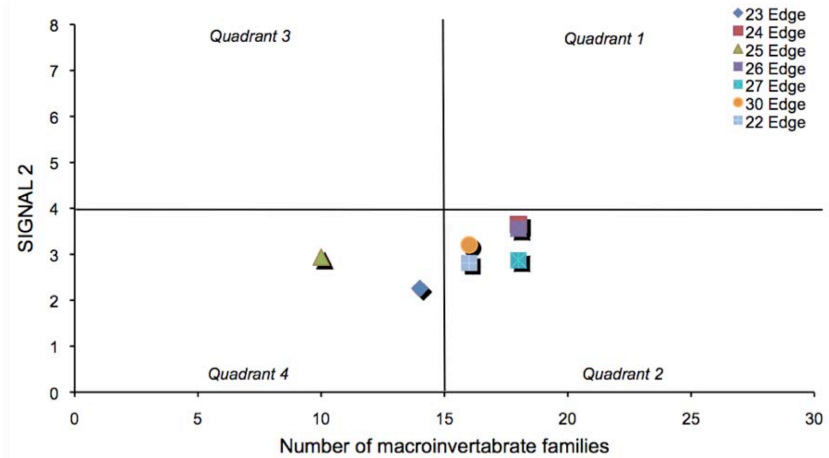


Figure 4.22 SIGNAL 2 / Family Bi-plot for edge habitats in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

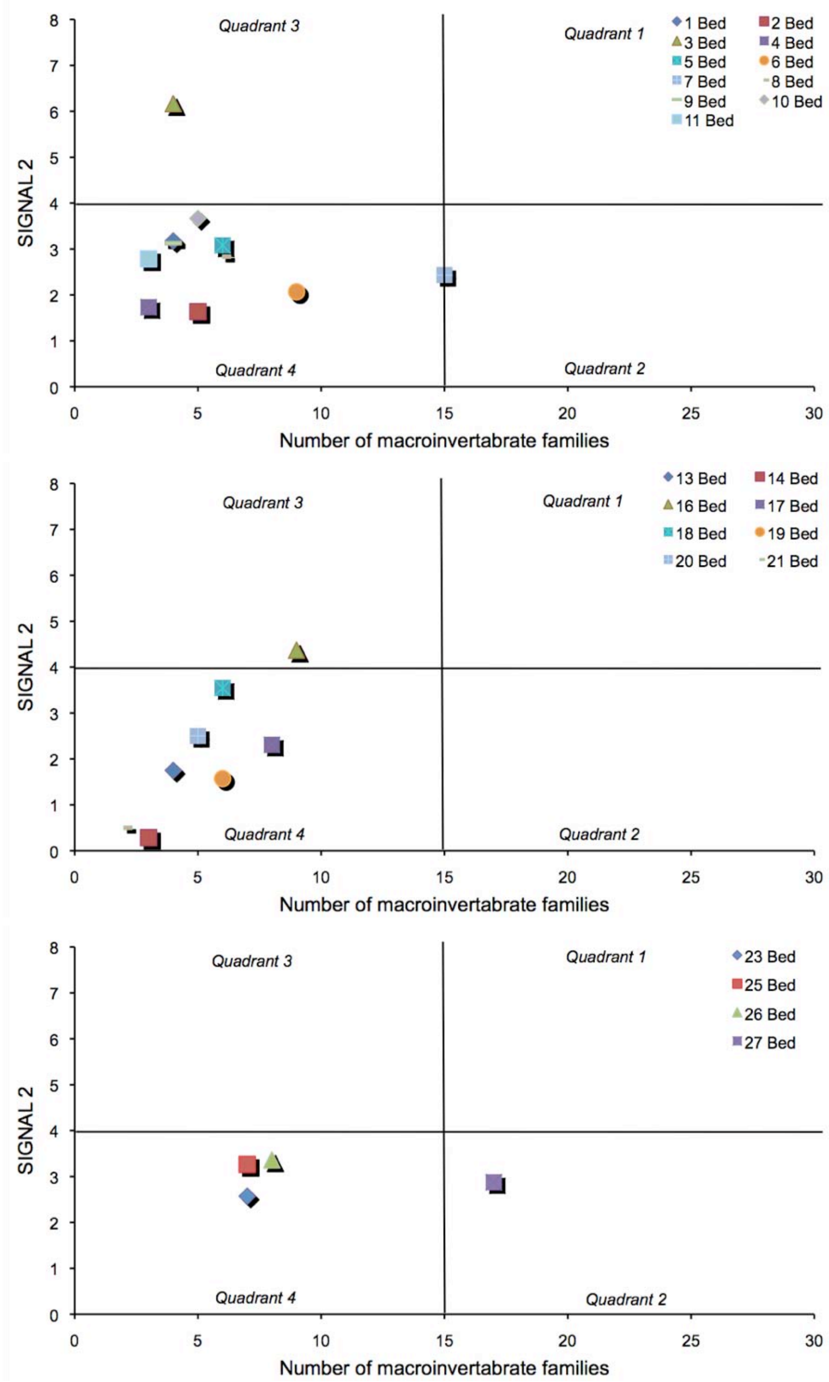


Figure 4.23 SIGNAL 2 / Family Bi-plot for bed habitats in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

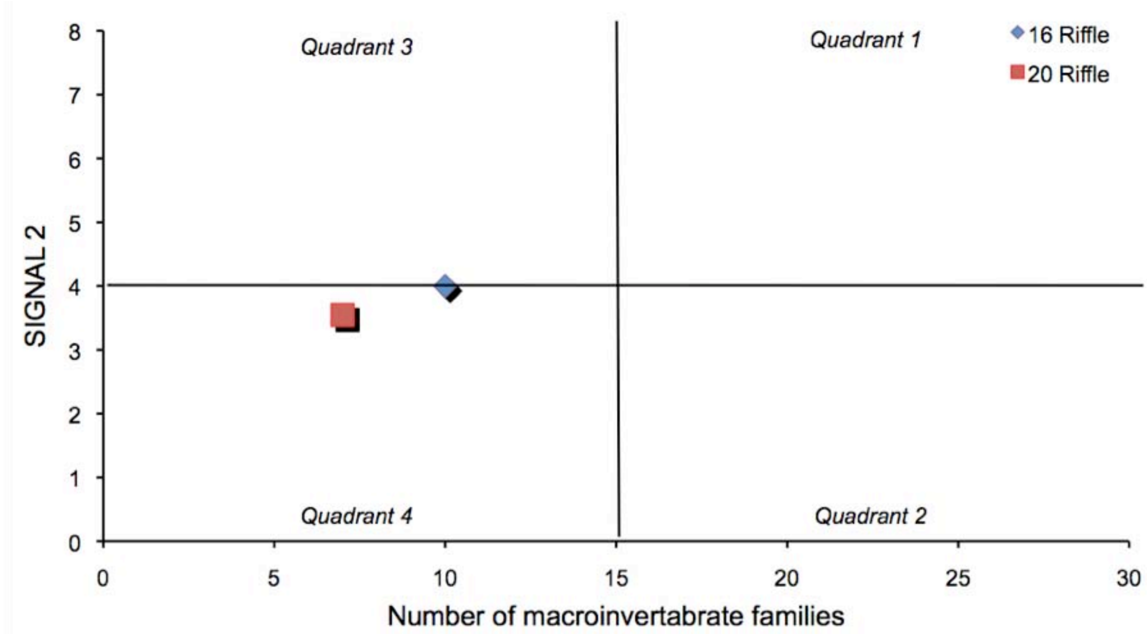


Figure 4.24 SIGNAL 2 / Family Bi-plot for riffle habitats in the Upper Dawson Catchment.

It is likely that the waterways of the study area are subject to agricultural pollution (e.g. nutrient enrichment) from the surrounding land uses. However, for ephemeral and intermittent waterways such as those in the study area, the interim boundaries for the SIGNAL 2 / Family Bi-plots may not adequately distinguish sites that are impacted by anthropogenic disturbance from those that are naturally impacted (B. Chessman [NSW Centre for Natural Resources], pers. comm. 2003, 21 October). It is recommended that only limited interpretation should be made of the absolute position of scores within the matrix.

4.4.2 Macrocrustacean Communities

An estimated 1,390 macrocrustaceans were captured across the three greater catchments. The Condamine – Upper Balonne and the Upper Dawson Catchments supported similar abundances of macrocrustaceans, with 630 and 660 animals collected, respectively (Figure 4.25). Substantially fewer macrocrustaceans (100) were collected from the Comet Catchment (Figure 4.25). The abundance of macrocrustaceans varied considerably between sites within each of the catchment. Mean abundance per site in the Condamine – Upper Balonne, Upper Dawson and Comet Catchments was 57, 66, and 9 animals, respectively. No macrocrustaceans were collected from the Dawson River (Site 12), Lake Nuga Nuga (Site 22) or the Comet River (Site 30).

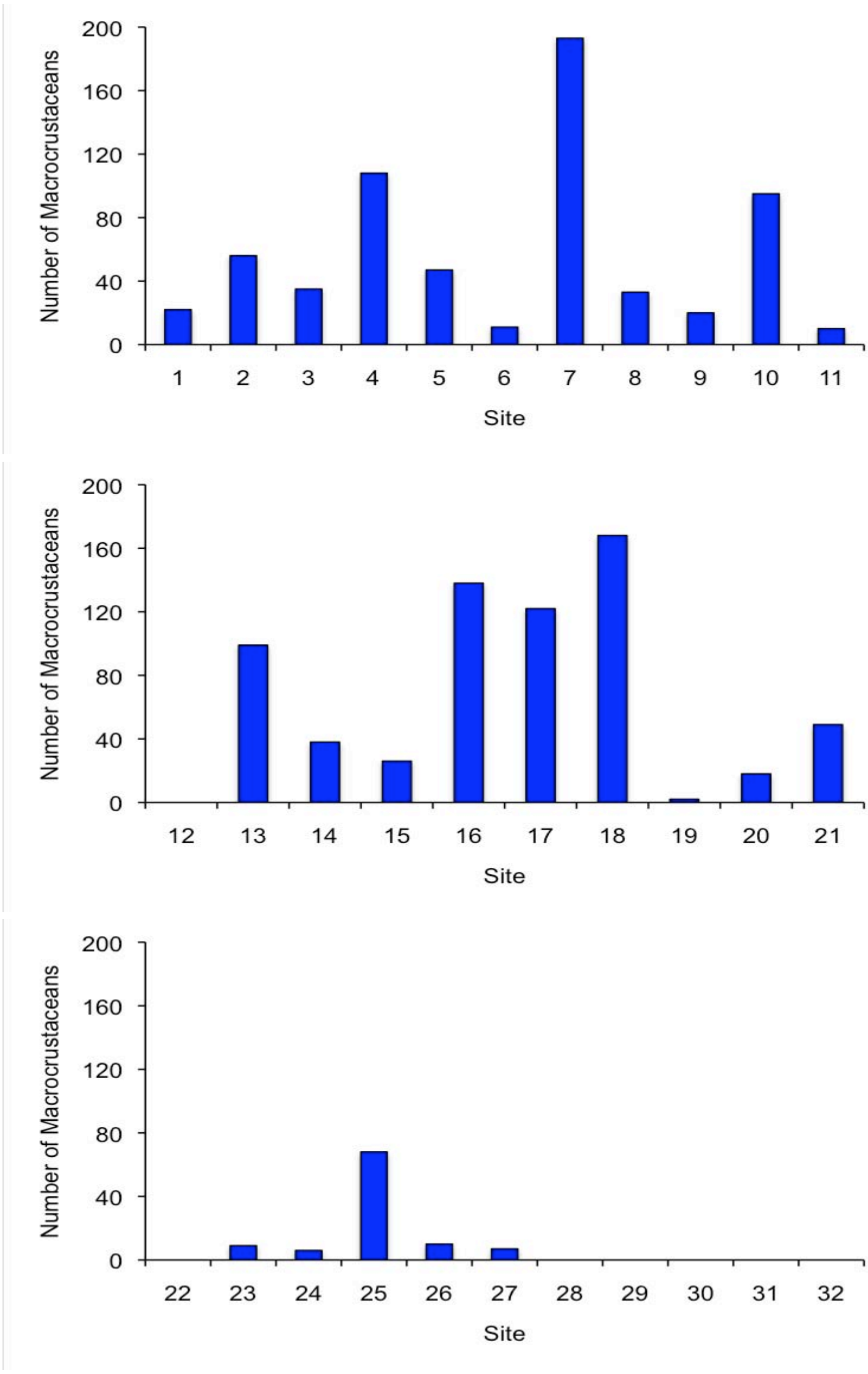


Figure 4.25 Macrocrustacean abundance at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

A total of six macrocrustacean taxa were captured across the three catchments; the Condamine – Upper Balonne, Upper Dawson and Comet Catchments supported 5, 3 and 4 taxa, respectively. (Table 4.5). Freshwater shrimp (*Paratya australis*) were the most common and abundant species (586 collected in total), followed by river prawns (*Macrobrachium* sp.) (433 collected) and yabbies (*Cherax destructor*) (323 collected).

Within the Condamine – Upper Balonne Catchment, Bungeworgorai (Site 1) and Blyth (Site 3) creeks supported the greatest richness of macrocrustaceans, each with 4 taxa. The mean richness of macrocrustaceans was 2.45 taxa per site.

In the Upper Dawson Catchment, Bungaban (Site 13) Hutton (Site 17), Baffle (Site 18), and Injune (Site 20) Creeks supported the greatest richness of macrocrustaceans, each with 3 taxa. Mean richness was lower than the Condamine – Upper Balonne catchment, at only 1.9 taxa per site.

In the Comet Catchment, the greatest number of macrocrustacean taxa was recorded from the Comet River (Site 27), which supported 3 taxa. The Comet Catchment supported the lowest mean richness of macrocrustaceans, at only 0.9 taxa per site.

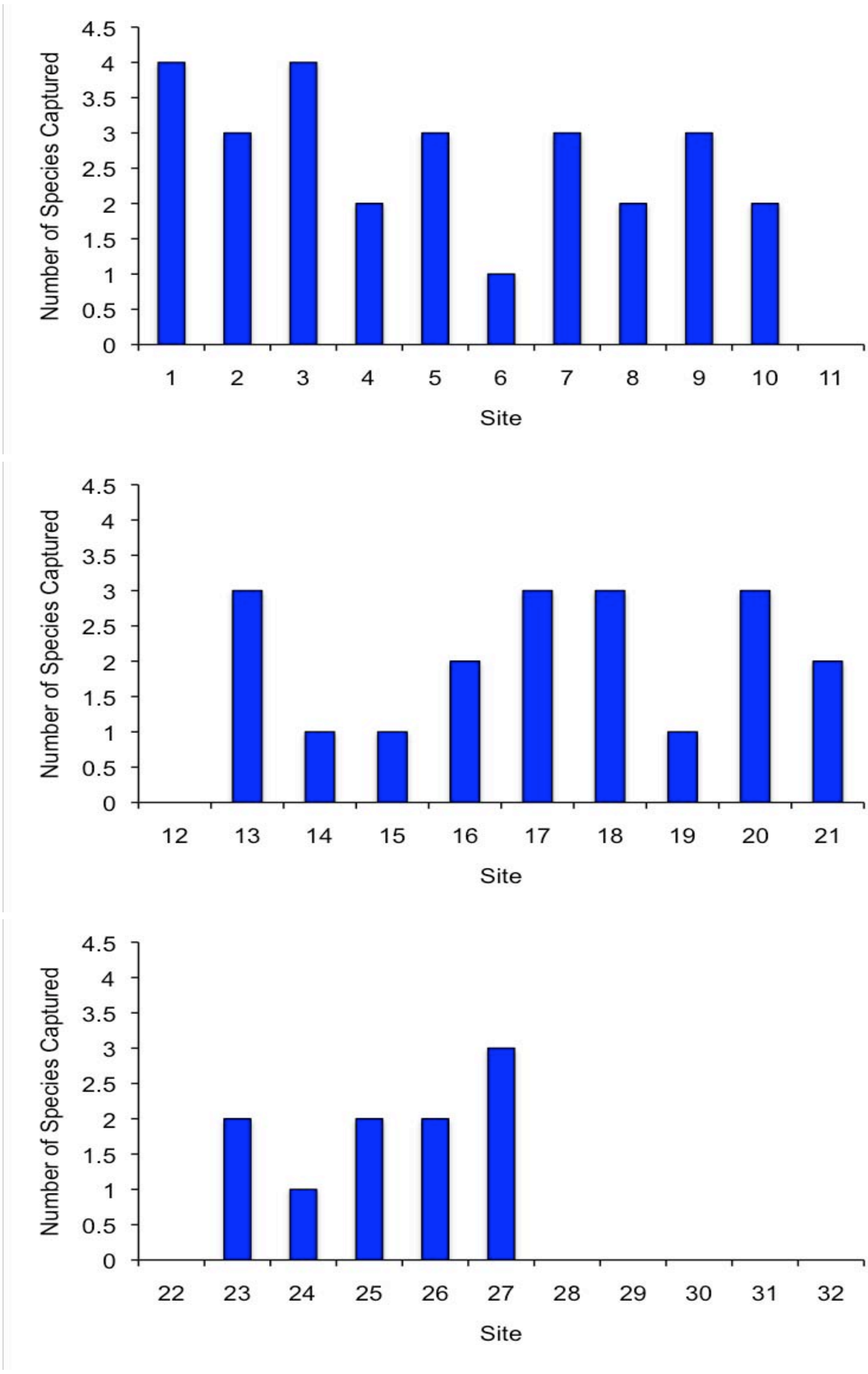


Figure 4.26 Richness of macrocrustaceans at watercourse sites in the: Condamine – Upper Balonne (Sites 1-11), Upper Dawson (Sites 12-21), and Comet (Sites 22-32) Catchments.

Table 4.5 Abundance of macrocrustaceans at each watercourse site in the Condamine – Upper Balonne, Upper Dawson, and Comet Catchments.

Family	**Latin name**	**Common Name**					**Site**					
Condamine – Upper Balonne			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Atyidae	*Paratya australis*	freshwater shrimp	1	2	8	105	43	11	134	10	1	79	8
Triopsidae	*Triops* sp.	seed shrimp	2		7								
Palaemonidae	*Macrobrachium* sp.	river prawn	8	1	6		2				1		
Parastacidae	*Cherax depressus*	orange fingered yabby							38				
Parastacidae	*Cherax destructor*	yabby	11	53	14	3	2		21	23	18	16	2
Total			***22***	***56***	***35***	***108***	***47***	***11***	***193***	***33***	***20***	***95***	***10***
Upper Dawson			**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Atyidae	*Paratya australis*	freshwater shrimp		16			10	90	64		3		
Palaemonidae	*Macrobrachium* sp.	river prawn		66		26	128	17	89		2	5	
Parastacidae	*Cherax destructor*	yabby		17	38			15	15	2	13	44	
Total			***0***	***99***	***38***	***26***	***138***	***122***	***168***	***2***	***18***	***49***	
Comet			**23**	**24**	**25**	**26**	**27**						
Atyidae	*Paratya australis*	freshwater shrimp					1						
Palaemonidae	*Macrobrachium* sp.	river prawn	1	6	62	9	4						
Parastacidae	*Cherax destructor*	yabby	8		6		2						
Sundathelphusidae	*Austrothelphusa* sp.	freshwater crab					1						
Total			***9***	***6***	***68***	***9***	***8***						

4.4.3 A Regional and Ecological Perspective

Macroinvertebrate Communities of the Condamine – Upper Balonne Catchment

Richness

DNRW sampled macroinvertebrates from the Condamine – Upper Balonne Catchment in the vicinity of the CSG Fields, between 1994 and 2004. This sampling included the survey of bed and edge habitats from: the Balonne River at Weribone (Site 422213A) between 1994 and 2004, Bungil Creek at Tabers (Site 422210A) in 1997, Bungil Creek south of Roma (4222061) in 1998 and Yuleba Creek at the Forestry Station (Site 422219A) in 1997 (Figure 4.27)[1]. During the DNRW surveys, the richness of macroinvertebrate communities varied over time and among locations, ranging from 16 to 26 in edge habitats and from 4 to 20 in bed habitats (Figure 4.27). The present study reported a slightly lower richness of macroinvertebrates from watercourses that cross the CSG Fields in the Condamine – Upper Balonne Catchment, with a mean of 9.3 and 3.4 families reported from edge and bed habitats, respectively.

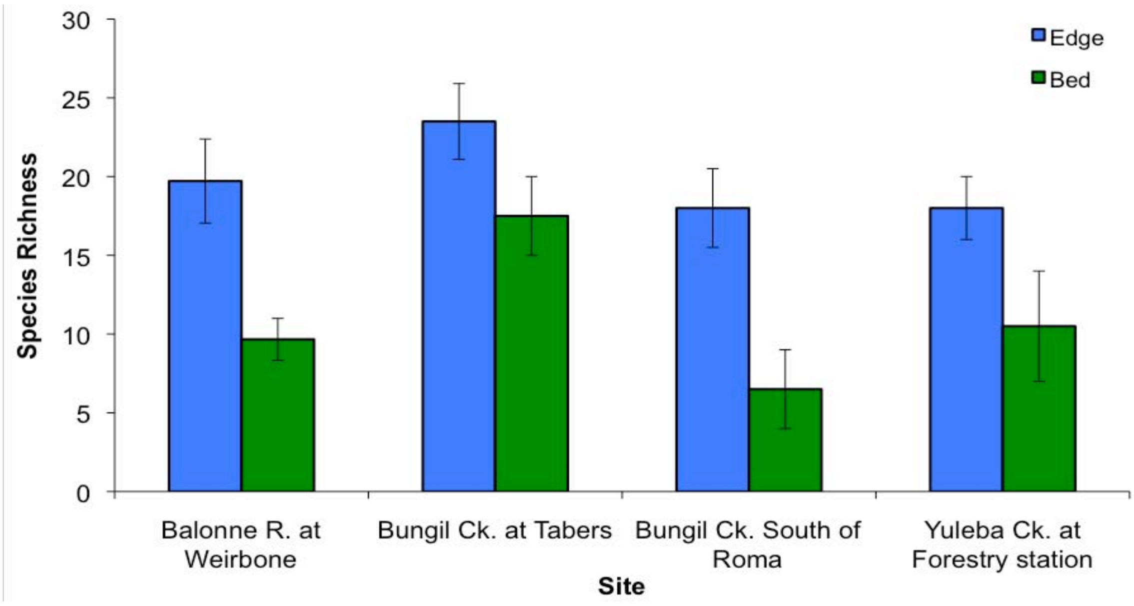


Figure 4.27 Taxonomic richness in edge and bed habitats in the Condamine – Upper Balonne Catchment from 1994 – 2004 (DNRW sites 422213A [1994 – 2004]; 422210A, [1997]; 4222061 [1998]; and 422219A [1997]).

[1] Based on or contains data provided by the State of Queensland (Department of Natural Resources and Water, 2008). In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

PET Richness

The PET richness reported from bed and edge habitats in the Balonne River, Bungil Creek and Yuleba Creek by the DNRW was generally indicative of moderate to healthy habitat and / or water quality (Figure 4.28). PET richness varied between locations and over time, but was generally higher than the PET richness recorded from the present study in watercourses that cross the CSG Fields in the Condamine – Upper Balonne Catchment.

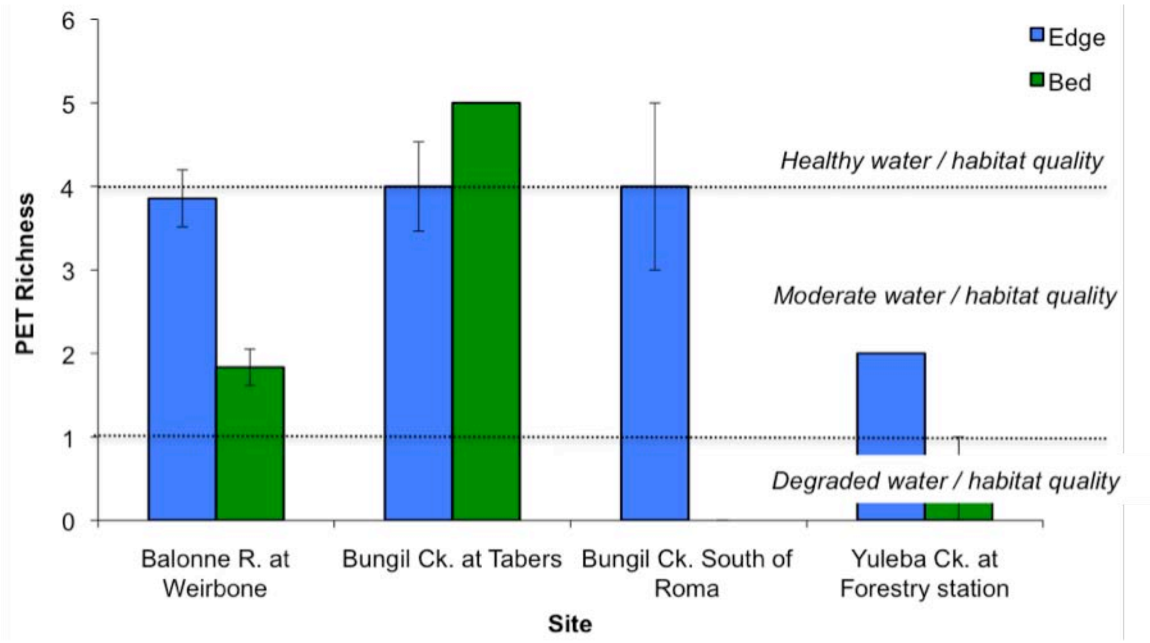


Figure 4.28 PET richness in edge and bed habitats in the Condamine – Upper Balonne Catchments from 1994 – 2003 (DNRW sites 422213A [1994 – 2004]; 422210A, [1997]; 4222061 [1998]; and 422219A [1997]).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots for communities sampled from the Balonne River, Bungil Creek and Yuleba Creek by the DNRW display a clustering of samples in Quadrants 4 and 2 of the bi-plot (Figure 4.29), indicating that these communities may be affected by high nutrient or salinity levels, urban or agricultural pollution, and / or harsh physical conditions (Appendix B). Communities surveyed in the Condamine – Upper Balonne Catchment in the present study were affected by these same factors.

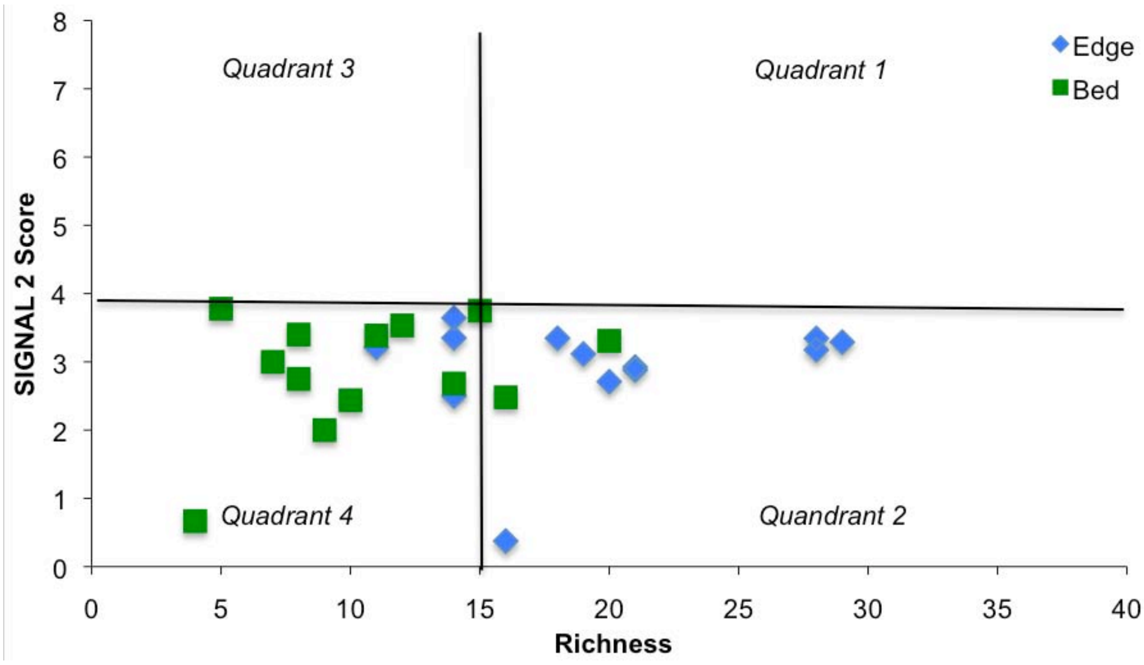


Figure 4.29 SIGNAL 2 / family bi-plot for edge and bed habitats in the Condamine – Upper Balonne Catchments from 1994 – 2003 (DNRW sites 422213A [1994 – 2004]; 422210A, [1997]; 4222061 [1998]; and 422219A [1997]).

Macrocrustacean Communities of the Condamine – Upper Balonne Catchment

No specific information regarding the macrocrustacean communities of the Condamine – Upper Balonne Catchment could be found. Crayfish, shrimp and prawns (identified to family level) were all collected in the DNRW macroinvertebrate samples collected from this catchment, and based on the results of the present survey, the species have similar environmental tolerances as those found in the Upper Dawson Catchment, see below.

Macroinvertebrate Communities of the Upper Dawson Catchments

Richness

DNRW sampled macroinvertebrates from the Upper Dawson Catchments in the vicinity of the CSG Fields, between 1994 and 2004. This sampling included the survey of bed and edge habitats from: the Dawson River at Baroondah Crossing (Site 1303211), from 1994 to 2001, the Dawson River at Beckers (Site 130332A) in from 1994 to 1996, the Dawson River at Taroom (Site 1303003) in 1998; edge habitats from Juandah Creek at Sandy Bridge (Site 1303086) in 1997 and Eurombah Creek at Peekadoo (Site 130302A) from 1994 to 2004; and riffle habitat on the Dawson River at Baroondah (Figure 4.30). During the DNRW surveys, the richness of macroinvertebrate communities varied over time and between locations, ranging from 17 to 33 in edge habitats and 12 to 24 in bed habitats; 19 families were recorded in the only riffle surveyed (Figure 4.30). The present study reported a lower richness of macroinvertebrates from watercourses that cross the CSG Fields in the Upper Dawson Catchments, with a mean of 10.5, 5.4 and 8.5 families reported from edge, bed and riffle habitats, respectively.

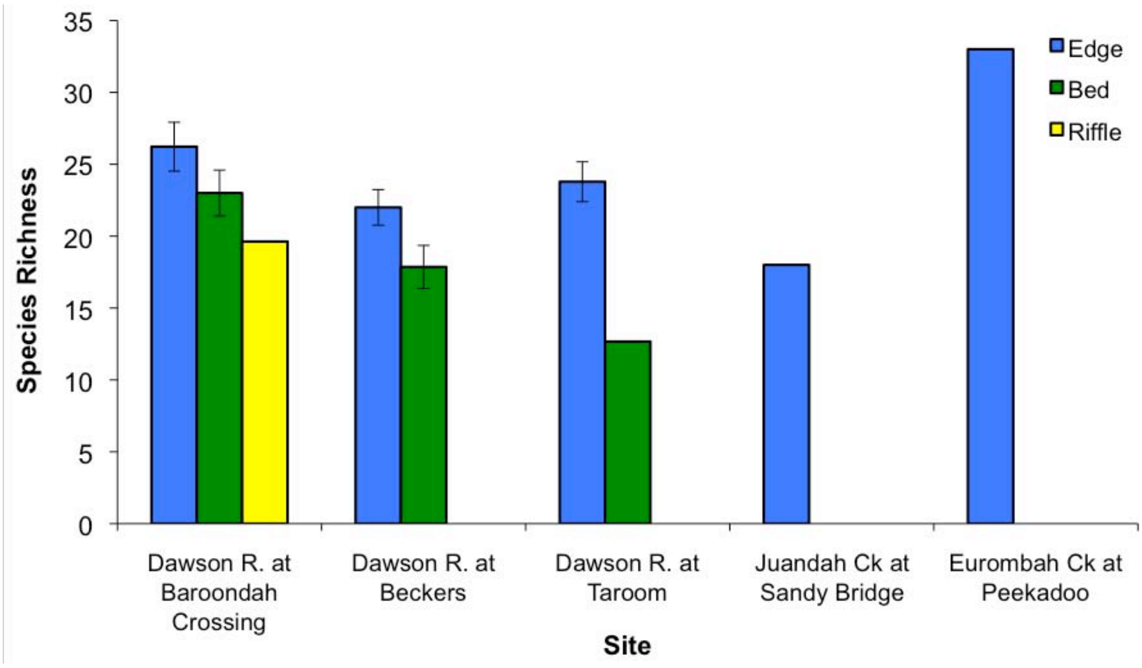


Figure 4.30 Taxonomic richness in edge and bed and riffle habitats in the Upper Dawson Catchments (DNRW sites 1303211 [1994 – 2001]; 130332A [1994 – 1996]; 1303003 [1998]; 1303086 [1997], and 130302A [1994 – 2004]).

PET Richness

The PET richness reported from bed and edge habitats in the Dawson River and Juandah Creek by the DNRW is indicative of moderate to healthy habitat and / or water quality (Figure 4.31). PET richness varied between locations and over time, but was generally higher than the PET richness recorded from watercourses that cross the CSG Fields in the Upper Dawson Catchment. Notably, the DNRM recorded no PET families in Eurombah Creek.

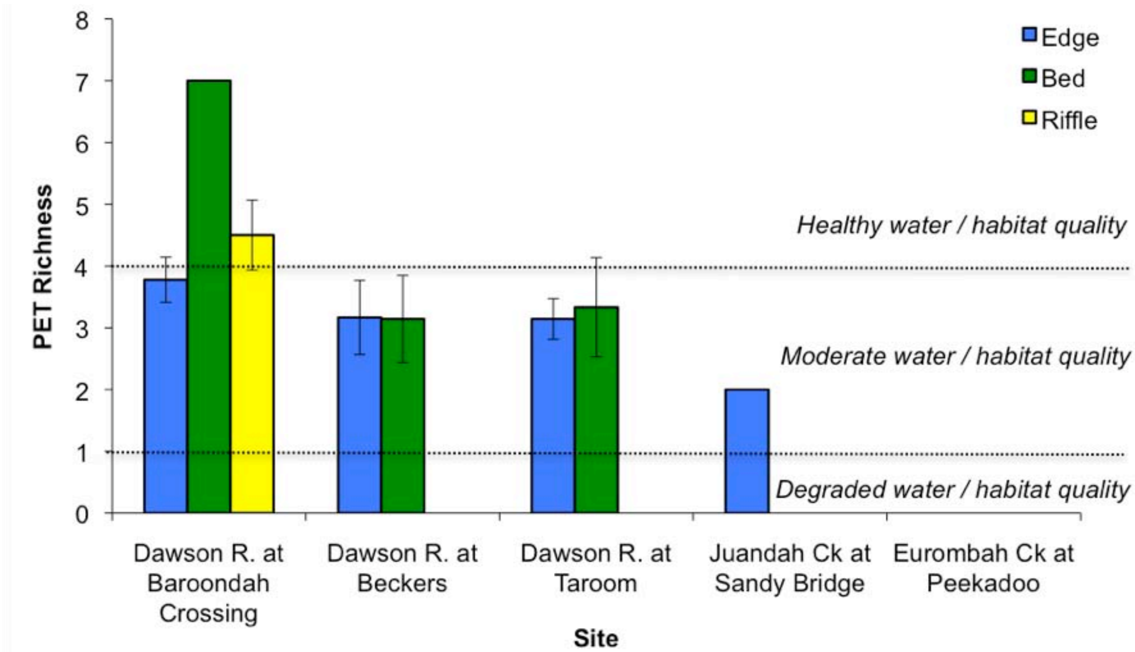


Figure 4.31 PET richness in edge and bed and riffle habitats in the Upper Dawson Catchment (DNRW sites 1303211 [1994 – 2001]; 130332A [1994 – 1996]; 1303003 [1998]; 1303086 [1997], and 130302A [1994 – 2004]).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots for communities sampled from Dawson River and Juandah and Eurombah Creeks by the DNRW display a clustering of edge samples in Quadrant 2; bed habitats are dispersed between the quadrants and riffle habitats are clustered in Quadrant 1 (Figure 4.32). This may be indicative of fair to good habitat and water quality across the catchment, however, it also suggests that communities are commonly affected by high nutrient or salinity levels, urban or agricultural pollution, and / or harsh physical conditions (Appendix B). Communities surveyed in the Upper Dawson Catchment in the present study were affected by these same factors.

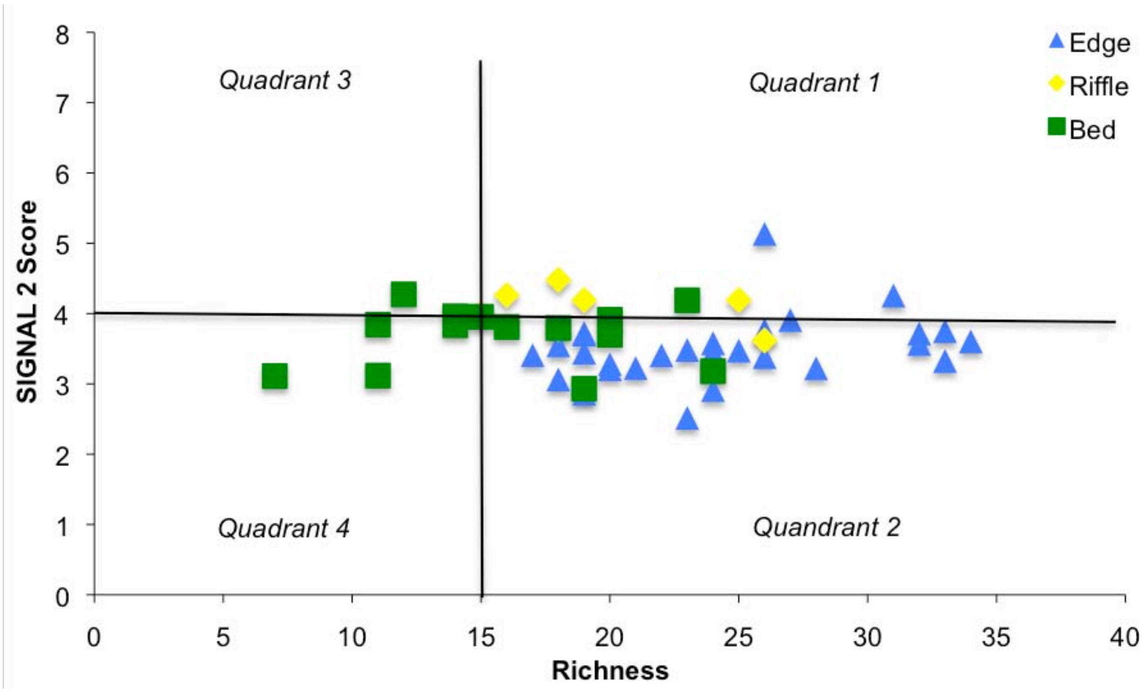


Figure 4.32 SIGNAL 2 / family bi-plot for edge and bed and riffle habitats in the Upper Dawson Catchment (DNRW sites 1303211 [1994 – 2001]; 130332A [1994 – 1996]; 1303003 [1998]; 1303086 [1997], and 130302A [1994 – 2004]).

Macrocrustacean Communities of the Upper Dawson Catchment

Macrocrustaceans were also abundant in a recent study in the upper Dawson River Catchment (frc environmental 2007), where a similar array of Australian river prawns, freshwater shrimps and yabbies were caught.

Macroinvertebrate Communities of the Comet Catchment

Richness

DNRW sampled macroinvertebrates from the Comet Catchment in the vicinity of the CSG Fields, between 1995 and 1998. This sampling included the survey of edge habitats on the Brown River (Sites 1305027, 1305003, 1305001) between 1998 and 1999, and surveys of edge and bed habitats on the Comet River (130504A, 1305002, 1305004 and 130506A) between 1995 and 1999 (Figure 4.33). During the DNRW surveys, the richness of macroinvertebrate communities varied over time and between locations, ranging from 21 to 29 in edge habitats and 15 to 26 in bed habitats (Figure 4.33). The present study reported a lower richness of macroinvertebrates from watercourses that cross the CSG

Fields in the Comet Catchment, with a mean of 15.7 and 9.7 families reported from edge and bed habitats, respectively.

PET Richness

The PET richness reported from bed and edge habitats in the Brown and Comet Rivers by the DNRW is indicative of moderate to healthy habitat and / or water quality (Figure 4.34). PET richness varied between locations and over time, but was generally higher than the PET richness recorded from watercourses that cross the CSG Fields in the Comet Catchment. Notably, the DNRM recorded no PET families from bed habitats on the Comet River at Springsure Road.

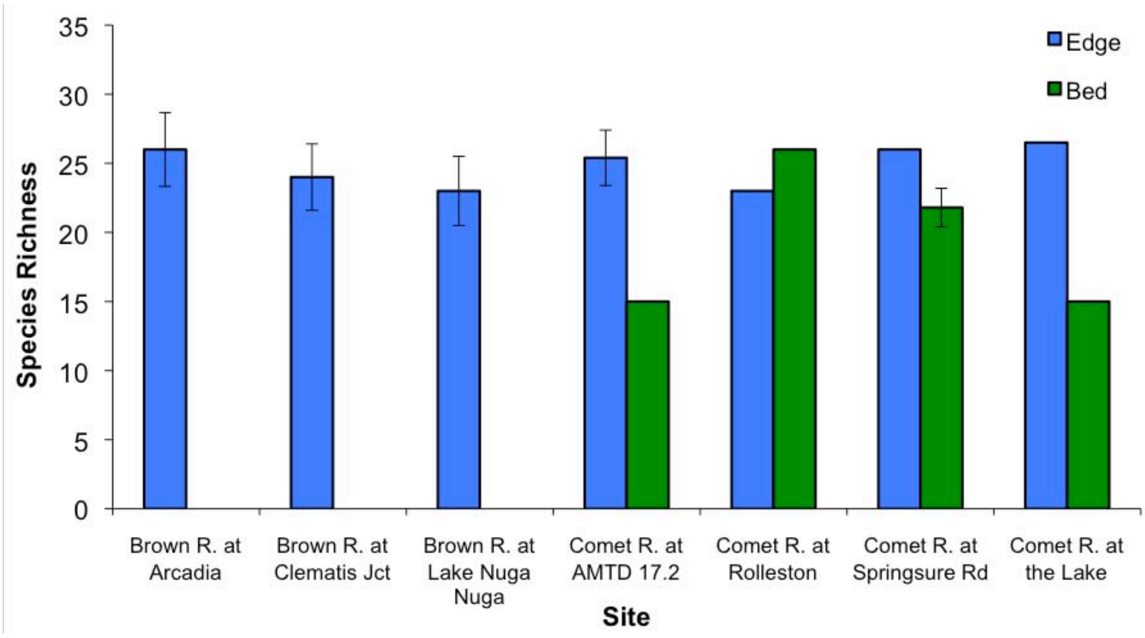


Figure 4.33 Taxonomic richness in edge and bed habitats in the Comet Catchment (DNRW sites 1305027 [1998 – 1999]; 1305003 [1999]; 1305001 [1998]; 130504A [1995 – 1998], 1305002 [1999]; 1305004 [1999], and 130506A [1995 – 1996]).

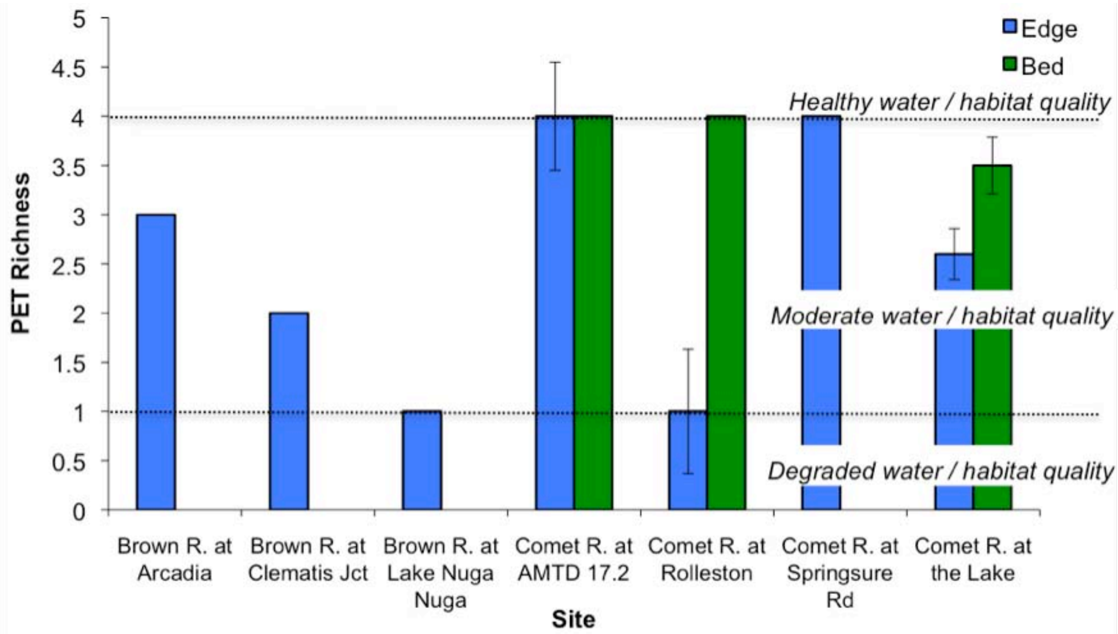


Figure 4.34 PET richness in edge and bed habitats in the Comet Catchment (DNRW sites 1305027 [1998 – 1999]; 1305003 [1999]; 1305001 [1998]; 130504A [1995 – 1998], 1305002 [1999]; 1305004 [1999], and 130506A [1995 – 1996]).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots for communities sampled from Brown and Comet Rivers by the DNRW display a clustering of samples in quadrant 2 (Figure 4.35). This is indicative of poor to fair water quality and suggests that communities are affected by high nutrients and / or salinity (Appendix B). Communities surveyed in the Comet Catchment by the present study were affected by these same factors.

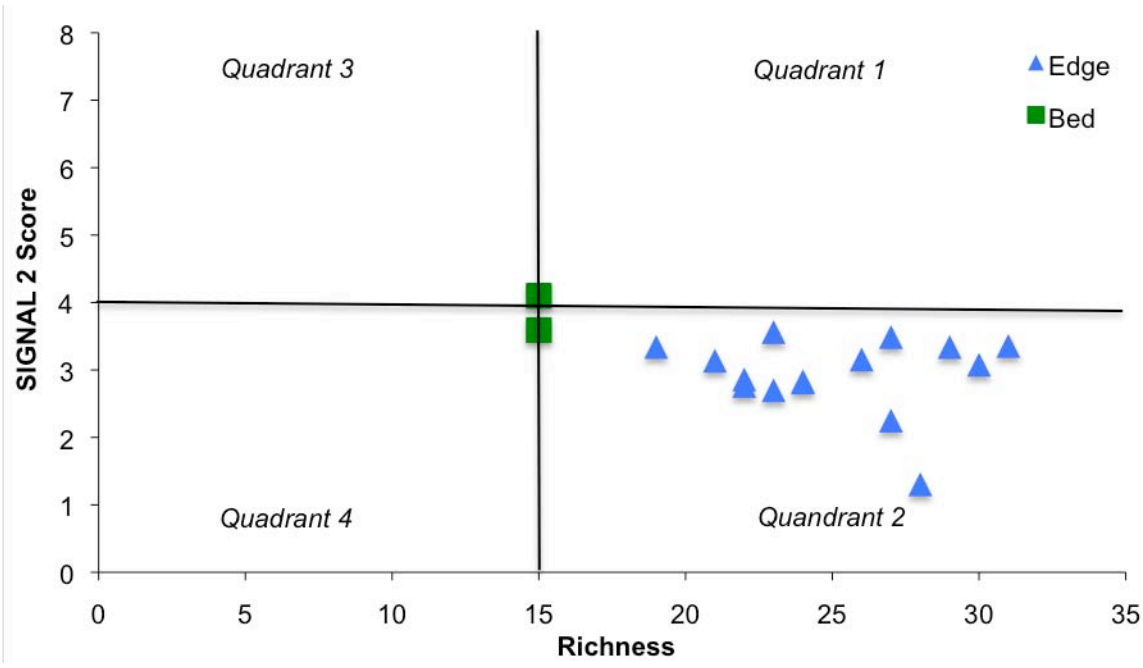


Figure 4.35 SIGNAL 2 / family bi-plot for edge and bed habitats in the Comet Catchment (DNRW sites 1305027 [1998 – 1999]; 1305003 [1999]; 1305001 [1998]; 130504A [1995 – 1998], 1305002 [1999]; 1305004 [1999], and 130506A [1995 – 1996]).

Macrocrustacean Communities of the Comet Catchment

No specific information regarding the macrocrustacean communities of the Comet Catchment could be found. Crayfish, shrimp and prawns (identified to family level) were all collected in the DNRW macroinvertebrate samples collected from this catchment, and based on the results of the present survey, the species within this catchment have similar environmental tolerances as those found in the Upper Dawson Catchment, see above.

4.4.4 Temporal Variance in Macroinvertebrate Communities

Macroinvertebrate communities within ephemeral waterways, such as those of western Queensland, are highly variable over time, with community composition, structure and abundance being strongly linked to flow conditions (Smith et al. 2004). Indeed, the life-history strategies of fauna native to a particular region have evolved primarily in response to its natural flow regime (Bunn & Arthington 2002). In ephemeral environments, significant rainfall, the timing of floods and the presence of pooled water are the main driving forces for aquatic ecology. Therefore, the specific composition and abundance of a given macroinvertebrate community may vary considerably between periods of high and low flow.

In general, environmental factors that affecting large spatial scales (such as seasonal rainfall events) would be expected to have a longer-term impact on macroinvertebrate communities (Morrisey et al. 1992). However, in addition to this inter-annual or seasonal temporal variability, macroinvertebrate communities can also vary significantly over shorter time periods (i.e. intra-seasonal variation). Such short-term variations usually result from factors acting at small spatial scales, such as localised environmental perturbations (e.g. runoff events) and differences in the timing of biological processes (e.g. egg deposition and recruitment) (Morrisey et al. 1992).

4.4.5 Ecology of Macrocrustaceans Captured

Parastacids (freshwater crayfish), the largest freshwater invertebrate family, are common in a variety of habitats such as lakes, streams, ponds and swamps. *Cherax* is a common genus of this family, and is also known as the yabby. Yabbies are omnivorous, and feed on decaying plant matter, aquatic invertebrates and fish. They are able to aestivate in their burrows (which may be up to 2 m deep) to survive droughts (Gooderham & Tsyrlin 2002). *Cherax* are moderately tolerant to poor water quality (Chessman 2003), including low dissolved oxygen levels, therefore allowing them to survive in ephemeral streams that are impacted by surrounding land-uses.

Freshwater prawns (*Macrobrachium* sp.), unlike yabbies, are not resistant to desiccation and therefore mostly inhabit permanent waterbodies (Williams 1980). Freshwater prawns tend to be more common in more permanent waterways, and feed on decaying organic matter (Gooderham & Tsyrlin 2002). Atyid shrimps are more tolerant of seasonal drying of creeks and rivers, breeding when creeks become a series of poorly connected pools (Gooderham & Tsyrlin 2002). However for the first months of their lives the shrimp have a planktonic stage (Gooderham & Tsyrlin 2002) and are therefore unable to survive complete drying of the pools at such time.

The freshwater crab (*Austrothelphusa* sp., formerly *Holthuisana* sp.) is widespread throughout Australia and is well adapted to living in ephemeral streams (Jones & Morgan 1994).

4.4.6 Summary

Aquatic macroinvertebrate communities within the study area were generally indicative of poor – moderate habitat and / or water quality, reflecting the results of water quality and aquatic habitat assessments at the sites (see Sections 4.1 & 4.2).

The larger waterways in the study area support more permanent water, and therefore offer more stable habitat for macroinvertebrates. As a result, these waterways would be expected to support a more abundant and diverse community of macroinvertebrates, and contain more taxa that are sensitive to pollution and disturbance. However, this was not consistently the case, with many of the smaller ephemeral creeks supporting macroinvertebrate communities that were comparable with the larger waterways. The specific differences in macroinvertebrate communities between sites appeared to be related to site-specific differences in the availability and diversity of habitat.

Freshwater crabs, crayfish and prawns / shrimp were common in the study area.

4.5 Fish Communities

4.5.1 Of the CSG Fields

In total, 387 fish from thirteen species were captured across the 32 sites surveyed. A total of 66 fish from seven species were recorded in the Condamine – Upper Balonne Catchment; 255 fish from seven species were recorded in the Upper Dawson Catchment; and 66 fish from eight species were recorded in the Comet Catchment (Figure 4.36 to Figure 4.37 and Table 4.6 to Table 4.8). The abundance of fish varied across the sites, from no fish caught at Yalebone Creek (Site 11), Injune Creek (Site 20) and the upper Comet River (Site 27) to 190 fish caught at Kinnoul Creek (Site 15) (Figure 4.36 to Figure 4.37 and Table 4.6 to Table 4.8). Sites in the Comet Catchment; Planet Creek (Site 28), Humboldt Creek (Site 29), Minerva Creek (Site 31) and Orion Creek (Site 32), were dry at the time of survey, and therefore supported no fish.

Species richness at each site ranged from no species at Yalebone Creek (Site 11), Injune Creek (Site 20) and the upper Comet River (Site 27) to seven species at Dulacca Creek (Site 7) in the Condamine – Upper Balonne Catchment (Figure 4.37). Species richness and abundance at each survey site was likely related to site-specific factors, such as the level of connectivity in the waterway, the size of the waterbody surveyed, water quality and the presence and abundance of physical habitat, such as large woody debris, in the waterway.

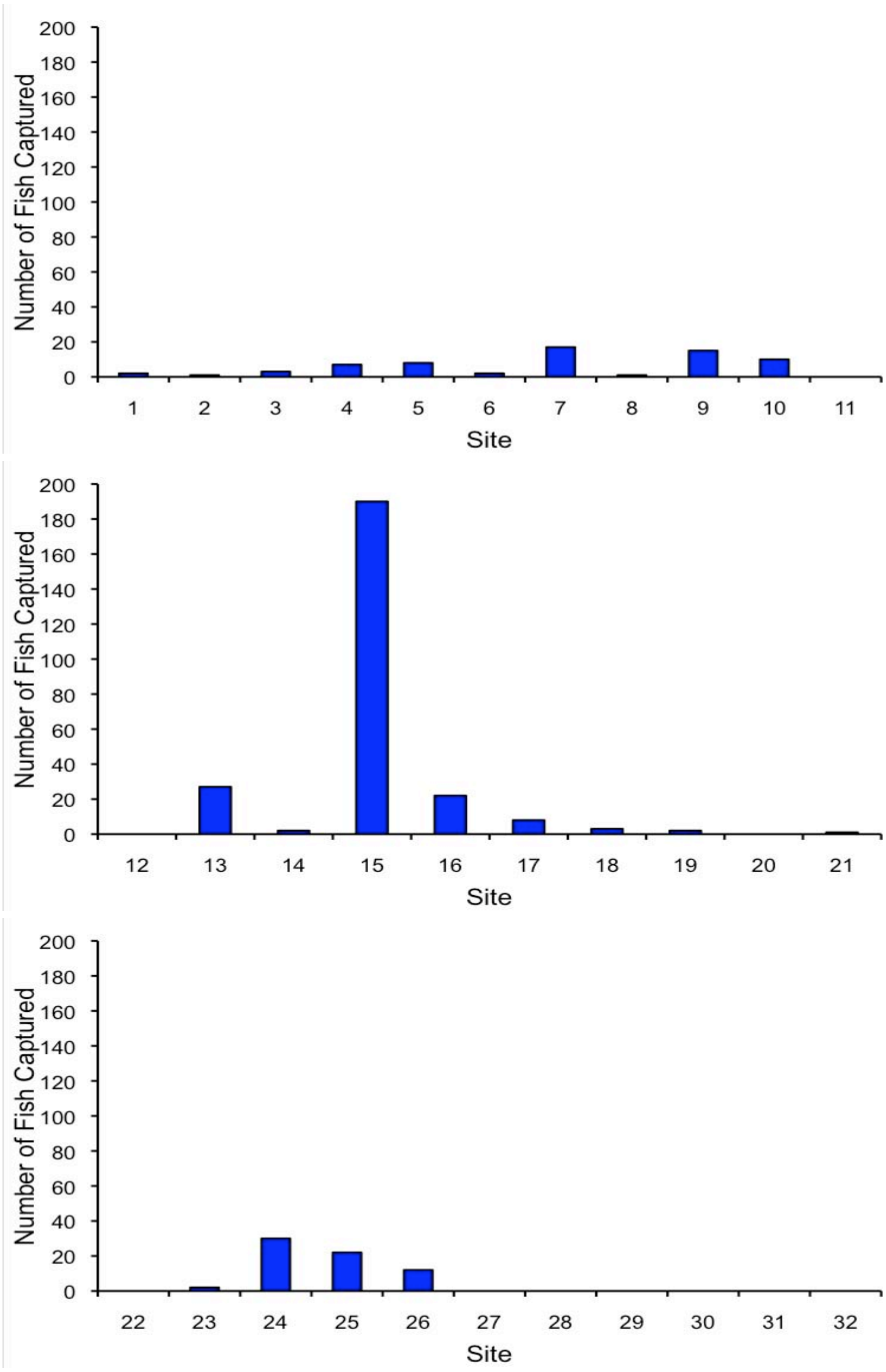


Figure 4.36 Fish abundance at sites in the Condamine – Upper Balonne (sites 1-11), Upper Dawson (sites 12-21) and Comet Catchments (sites 22-32) (all survey methods combined).

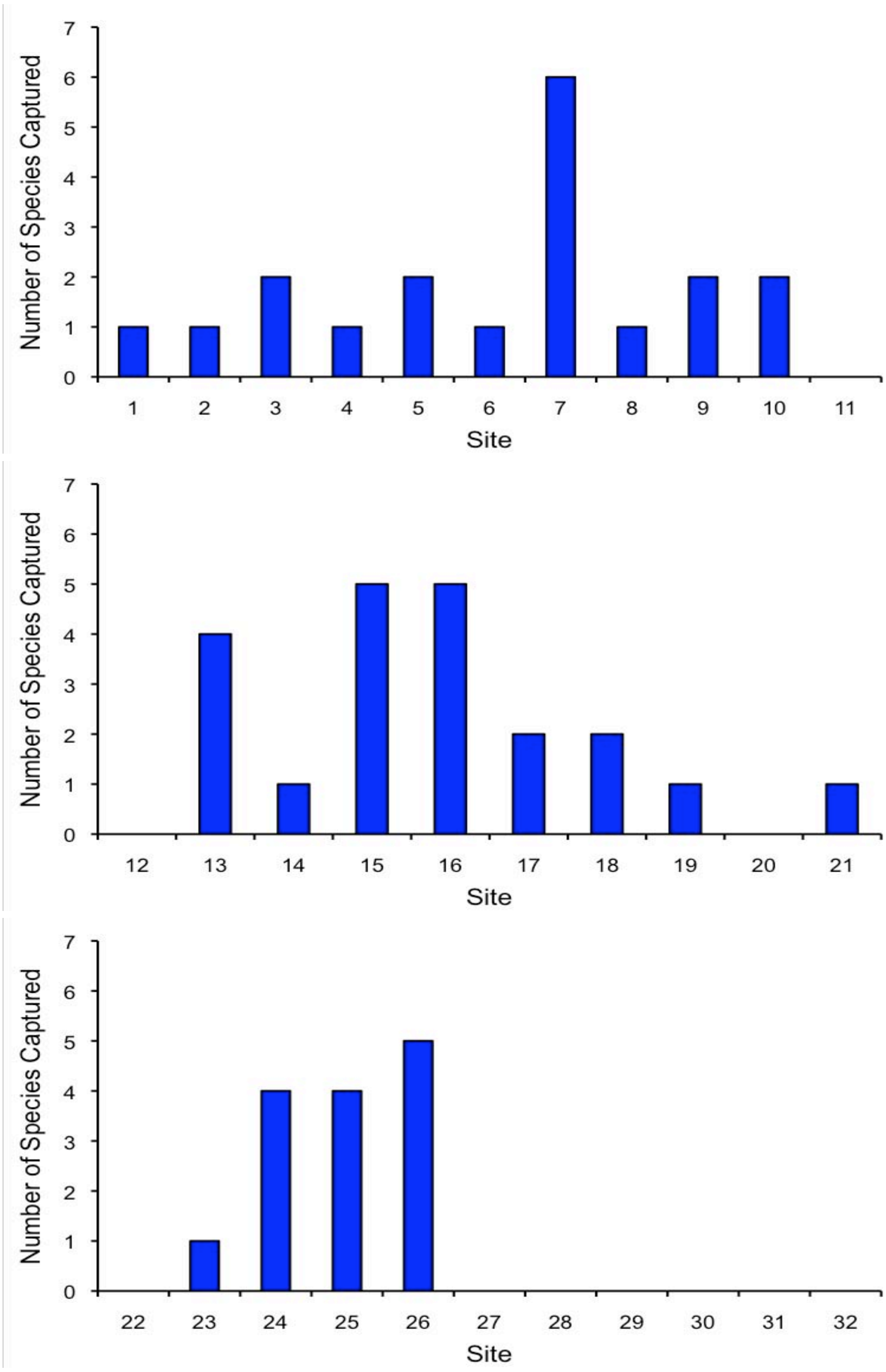


Figure 4.37 Species richness of fish at sites in the Condamine – Upper Balonne (sites 1-11), Upper Dawson (sites 12-21) and Comet Catchments (sites 22-32) (all survey methods combined).

Table 4.6 Abundance of fish species at each site in the Condamine – Upper Balonne Catchment.

Family	Latin Name	Common Name	1	2	3	4	5	6	7	8	9	10	11
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	2										
Clupeidae	*Nematalosa erebi*	bony bream			1				1				
Cyprinids	*Carassius auratus*	goldfish					1				3		
Cyprinids	*Cyprinus carpio*	carp							1				
Eleotridae	*Hypseleotris* spp.	carp gudgeon				7	7	2	11	1		1	
Percichtyidae	*Macquaria ambigua*	golden perch							1				
Poeciliidae	*Gambusia holbrooki*	mosquitofish							3		12	9	
Terapontidae	*Leiopotherapon unicolor*	spangled perch		1	2				1				

Table 4.7 Abundance of fish species at each site in the Upper Dawson Catchment.

Family	Latin Name	Common Name	12	13	14	15	16	17	18	19	20	21
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish		1		9						
Cyprinidae	*Carassius auratus*	goldfish				3						
Eleotridae	*Hypseleotris* spp.	carp gudgeon		15	2	152	7			2		
Melanotaeniidae	*Melanotaenia splendida*	rainbowfish		6		20	3	7	1			
Percichtyidae	*Macquaria ambigua*	golden perch					2					
Pseudomugilidae	*Pseudomugil signifer*	Pacific blue eye					7					
Terapontidae	*Leiopotherapon unicolor*	spangled perch		5		6	3	1	2			1

Table 4.8 Abundance of fish species at each site in the Comet Catchment.

Family	Latin Name	Common Name	22	23	24	25	26	27	28	29	30	31	32
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish			4								
Atherinidae	*Craterocephalus stercusmuscarus*	fly-speckled hardyhead			4								
Eleotridae	*Hypseleotris spp.*	carp gudgeon		2		18							
Eleotridae	*Mogurnda adspersa*	purple spotted gudgeon			1	1	2						
Melanotaeniidae	*Melanotaenia splendida*	eastern rainbowfish			21	2	1						
Percichtyidae	*Macquaria ambigua*	golden perch					5						
Plotosidae	*Tandanus tandanus*	eel-tailed catfish					1						
Terapontidae	*Leiopotherapon unicolor*	spangled perch				1	3						

Figure 4.38

An adult spangled perch at Clemantis Creek (site 25) in the Comet Catchment.

Figure 4.39

An intermediate golden perch at the Dawson River (site 12) in the Upper Dawson Catchment.

Figure 4.40

An adult common carp at Dulacca Creek (Site 7) in the Condamine – Upper Balonne Catchment.

At the time of our survey, Tchanning Creek (Site 6), the lower Dawson River (Site 12), Lake Nuga Nuga (Site 22) and the lower Comet River (Site 27) supported a very large volume of water. This prevented an accurate survey of fish at these sites (See Section 3.10); therefore the potential fish communities of these locations are discussed in the regional context of those in each of the greater catchments.

Carp gudgeon (*Hypseleotris* sp.) was the most widely distributed and abundant species, and was captured from thirteen of the sites surveyed. Spangled perch (*Leiopotherapon unicolor*) was also relatively widely distributed and abundant. Both species were present in each of the three Catchments. Eastern rainbowfish (*Melanotaenia splendida*) was common at a number of sites in the Upper Dawson and Comet Catchments. Less common species included: Agassiz's glassfish (*Ambassis agassizii*), bony bream (*Nematalosa erebi*), goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), golden perch (*Macquaria ambigua*), mosquitofish (*Gambusia holbrooki*) and purple spotted gudgeon (*Morgurnda adspersa*). Pacific blue-eye (*Pseudomugil signifer*), fly-speckled hardyhead (*Craterocephalus stercusmuscarus*) and freshwater catfish (*Tandanus tandanus*) were each only recorded at a single site.

Life History Stages

All life history stages (juvenile, intermediate and adult) were captured for each of the thirteen species caught. Juveniles were most abundant life stage in the study area.

Indicators of Stream Health

Three introduced species were captured during the survey: goldfish, common carp and mosquitofish. In total, 31 introduced fish were captured at the six of the 32 sites surveyed. These were: Bungeworgorai Creek (Site 1), Yuleba Creek (Site 5), Dulacca Creek (site 7), Bony Creek (Site 9) and Yalebone Creek (Site 10) in the Condamine – Upper Balonne Catchment, and the Dawson River (Site 15) in the Upper Dawson Catchment. The abundance of exotic fish accounted for between 1.6% and 100% of the fish captured at these locations (Figure 4.41). No introduced fish were captured in the Comet Catchment. Carp and mosquitofish were only recorded in the Condamine – Upper Balonne Catchments.

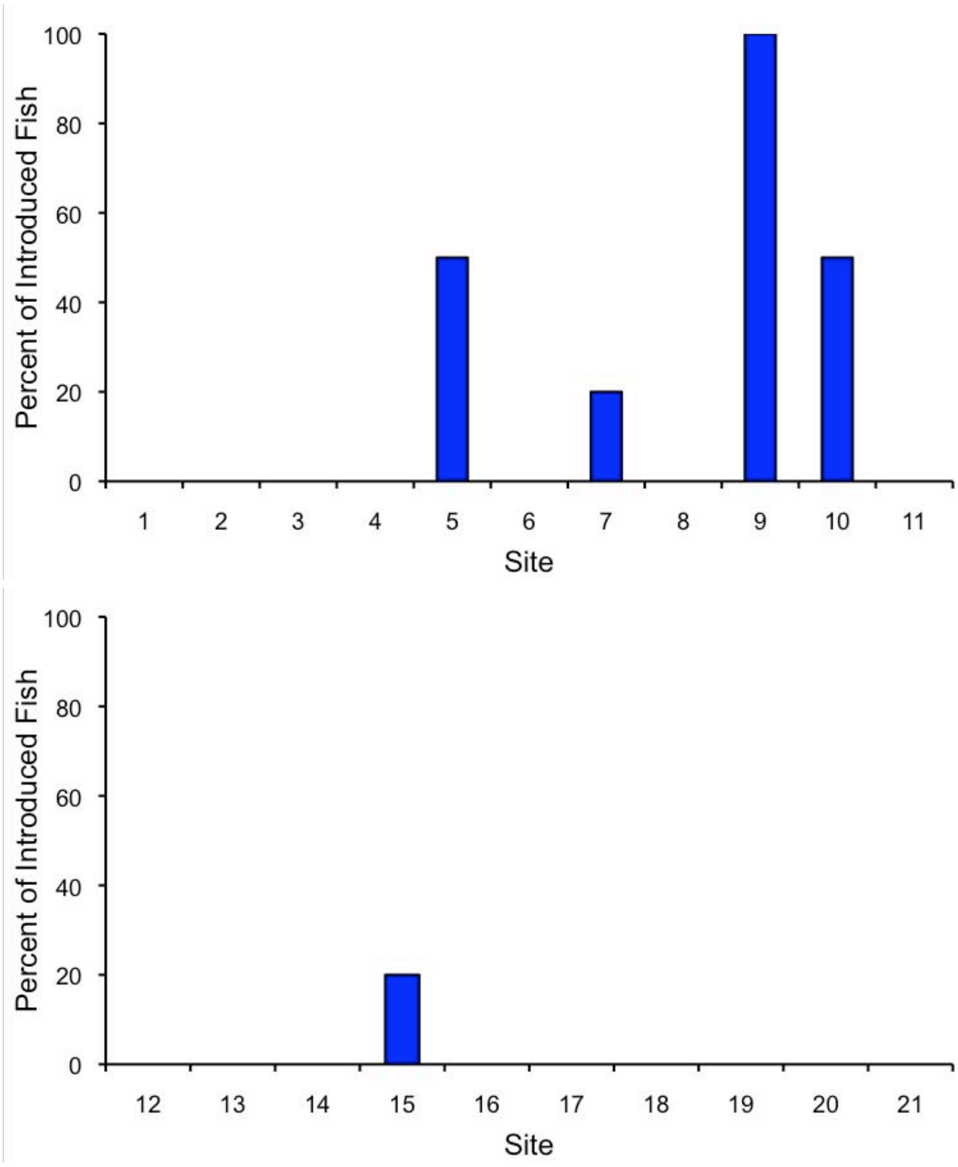


Figure 4.41 Percentage of introduced fish captured at sites in the Condamine – Upper Balonne (sites 1-11) and Upper Dawson (sites 12-21) Catchments (all survey methods combined).

No listed threatened species were captured during the survey. All fishes appeared healthy.

4.5.2 A Regional and Ecological Perspective

Condamine – Upper Balonne Catchment

The Department of Primary Industries & Fisheries (DPI&F) sampled seven sites along the Condamine River between 2000 and 2001, and caught twelve species (DPI 2002). The EPA reports that the Condamine River catchment contains 24 species of fish from 14 families, based on Wildnet records (EPA 2007). Four introduced species have been recorded: goldfish, carp, mosquitofish and guppy (*Poecilia reticulata*). Mosquitofish and carp are declared noxious species in Queensland, under the *Fisheries Regulation 2008*. Goldfish and guppies are listed as a non-indigenous fish under the *Fisheries Regulation 2008*.

Table 4.9 Presence of fish species caught in the Condamine-Upper Balonne Catchment during previous studies.

Family *Species*	**Common Name**	**Study**		
		EPA (2007)	**DPI (2002)**	**frc environmental (2008)**
Ambassidae				
Ambassis agassizii	Agassiz's glassfish	✓		✓
Atherinidae				
Craterocephalus stercusmuscarum	fly-specked hardyhead	✓	✓	✓
Clupeidae				
Nematalosa erebi	bony bream	✓	✓	✓
Cyprinidae				
Cyprinus carpio	common carp	✓	✓	✓
Carassius auratus	goldfish	✓	✓	✓
Eleotridae				
Hypseleotris sp.	carp gudgeon		✓	✓
Hypseleotris sp. A	Midgley's gudgeon	✓		
Hypseleotris klunzingeri	western carp gudgeon	✓		
Mogurnda adspersa	purple spotted gudgeon	✓		
Hypseleotris galii	firetail gudgeon	✓		
Hypseleotris species 2	Lake's carp gudgeon	✓		
Philypnodon grandiceps	flathead gudgeon	✓		

Family *Species*	Common Name	Study		
		EPA (2007)	DPI (2002)	frc environmental (2008)
Melanotaeniidae				
Melanotaenia fluviatilis	Murray River rainbowfish	✓	✓	✓
Melanotaenia duboulayi	Crimson spotted rainbowfish	✓	✓	
Galaxiidae				
Galaxias olidus	mountain galaxias	✓		
Gadopsidae				
Gadopsis marmoratus	river blackfish	✓		
Percichthyidae				
Maccullochella peelii peelii	Murray River cod	✓	✓	
Macquaria ambigua oriens	golden perch	✓	✓	✓
Plotosidae				
Neosilurus hyrtlii	Hyrtl's tandan	✓		
Tandanus tandanus	eel-tailed catfish	✓	✓	✓
Poecillidae				
Poecilia reticulata	guppy	✓		
Gambusia holbrooki	mosquitofish	✓	✓	✓
Retropinnidae				
Retropinna semoni	Australian smelt	✓	✓	
Terapontidae				
Leiopotherapon unicolor	spangled perch	✓	✓	✓
Bidyanus bidyanus	silver perch	✓		

Upper Dawson Catchment

The DPI&F sampled two sites along the upper Dawson River during surveys of the Fitzroy Basin undertaken between 1994 and 1996, and caught 775 fish comprising ten species (Berghuis & Long 1999). More recently, a dry season survey of four sites in the Upper Dawson Catchment captured 267 fishes, comprising eight species (frc environmental 2007), and a wet season survey of eight sites captured a total of 481 fish from 20 species. The number and species of fish caught during these studies are listed in Table 4.10.

The most abundant fish species captured in the Upper Dawson Catchment during these studies were bony bream and eastern rainbowfish (Berghuis & Long 1999). Conversely, carp gudgeon and spangled perch were the most abundant species captured in the present study.

Berghuis & Long (1999) did not report any exotic species in the Upper Dawson Catchment, although exotics have been recorded in the greater Fitzroy Basin. Guppy's were caught from an urban creek near Rockhampton. Goldfish was also seen (but not caught) near Rockhampton (Berghuis & Long 1999). Since then, goldfish have been caught in Juandah Creek and the Dawson River (frc environmental 2007, Ecowise 2008), and mosquitofish have been captured in the Dawson River in November 2007 and June 2008 (frc environmental 2007, Ecowise 2008).

Table 4.10 Number and species of fish caught in the Upper Dawson Catchment during previous studies.

Family		**Study**			
Species	**Common Name**	frc environmental **(2007a)**	**Berghuis & Long (1999)**	frc environmental **(2007b)**	**Ecowise 2008**
Ambassidae					
Ambassis agassizii	Agassiz's glassfish	65	52	0	3
Atherinidae					
Craterocephalus stercusmuscarum	fly-specked hardyhead	0	88	0	2
Clupeidae					
Nematalosa erebi	bony bream	15	214	196	211
Cyprinidae					

Family *Species*	Common Name	Study frc environmental (2007a)	Berghuis & Long (1999)	frc environmental (2007b)	Ecowise 2008
Carassius auratus	goldfish	10	0	0	5
Eleotridae					
Hypseleotris sp.	carp gudgeon	72	–	–	–
Hypseleotris sp. A	Midgley's gudgeon	–	89	8	2
Hypseleotris klunzingeri	western carp gudgeon	–	23	0	20
Mogurnda adspersa	purple spotted gudgeon	0	0	0	8
Oxyeleotris lineolata	sleepy cod	1	0	4	8
Philypnodon grandiceps	flathead gudgeon	0	0	0	3
Melanotaeniidae					
Melanotaenia s. splendida	eastern rainbowfish	17	224	3	26
Osteoglossidae					
Scleropages leichardti	Southern saratoga	0	0	0	4
Percichthyidae					
Macquaria ambigua oriens	golden perch	10	16	0	20
Plotosidae					
Neosilurus hyrtlii	Hyrtl's tandan	26	0	8	22
Porochilus rendahli	Rendahl's catfish	0	0	0	1
Tandanus tandanus	eel-tailed catfish	0	6	1	9
Poecillidae					
Gambusia	mosquitofish	0	0	16	32

Family *Species*	Common Name	Study frc environmental (2007a)	Berghuis & Long (1999)	frc environmental (2007b)	Ecowise 2008
holbrooki					
Pseudomugilidae					
Pseudomugil signifer	pacific blue eye	0	56	0	0
Terapontidae					
Leiopotherapon unicolor	spangled perch	100	7	31	76
Scortum hillii	leathery grunter	0	0	0	13

Comet Catchment

The DPI&F surveyed one site in the Comet River and caught 207 fish from eight species, all of which were native (Berghuis & Long 1999). The eastern rainbowfish and the spangled perch were the most abundant species caught during their study (Berghuis & Long 1999). A more recent survey of eight sites in the Rolleston region by frc environmental (2004) reported spangled perch in Bootes and Meteor Creeks, both tributaries of the Comet River. Neither of these studies, nor the current study, recorded any exotic species in the Comet River.

Table 4.11 Presence of fish species caught in the Comet Catchment during previous studies and the present survey.

Family Species	**Common Name**	**Study** **Berghuis (1999)**	 **frc environmental (2004)**	 **Present Survey**
Ambassidae				
Ambassis agassizii	Agassiz's glassfish	✓		✓
Atherinidae				
Craterocephalus stercusmuscarum	fly-specked hardyhead			✓
Clupeidae				
Nematalosa erebi	Bony bream	✓		
Eleotridae				
Hypseleotris compressa	empire gudgeon	✓		
Hypseleotris sp.	carp gudgeon	✓	✓	✓
Mogurnda adspersa	purple spotted gudgeon			✓
Oxyeleotris lineolatus	Sleepy cod	✓		
Melanotaeniidae				
Melanotaenia sp.	rainbowfish			✓
Melanotaenia s. splendida	Eastern rainbowfish	✓	✓	
Plotosidae				
Tandanus tandanus	eel-tailed catfish	✓		✓
Neosilurus hyrtlii	Hyrtl's tandan		✓	
Terapontidae				
Leiopotherapon unicolor	spangled perch		✓	✓
Scortum hilli	leathery grunter	✓		

Comparison of Catchments

Twenty-five fish species have been recorded in the Condamine – Upper Balonne Catchment; 20 species have been recorded in the Upper Dawson Catchment; and thirteen species have been reported from the Comet Catchment. Eleven of the species that have been reported from the Condamine – Upper Balonne Catchment have not been recorded in the Upper Dawson or Comet Catchment. These are: Australian smelt (*Retropinna semoni*), common carp, crimson spotted rainbowfish (*Melanotaenia duboulayi*), firetail gudgeon (*Hypseleotris galii*), guppy, Lake's carp gudgeon (*Hypseleotris* species 2), mountain galaxias (*Galaxias olidus*), Murray cod (*Maccullochella peelii peelii*), Murray River rainbowfish (*Melanotaenia fluviatilis*), river blackfish (*Gadopsis marmoratus*), and silver perch (*Bidyanus bidyanus*). Five of the species reported from the Upper Dawson Catchment have not been recorded in the Condamine – Upper Balonne or Comet Catchments. These are: sleepy cod (*Oxyeleotris lineolata*), southern saratoga (*Scleropages leichardti*), Rendahl's catfish (*Porochilus rendahli*), pacific blue eye (*Pseudomugil signifer*) and leathery grunter (*Scortum hillii*).

Rare and Threatened Fish

Murray River cod (*Maccullochella peeli peeli*) are listed as vulnerable under the EPBC Act, and occur throughout the Murray Basin. They have been recorded by previous surveys of the Condamine – Upper Balonne Catchment, but not of the Upper Dawson or Comet Catchments. No Murray cod were recorded in the Condamine – Upper Balonne Catchment during the present study. This species prefers deeper-water habitats around instream habitat structures such as boulders, logs, undercut banks and overhanging vegetation (Allen et al. 2002), and therefore it is unlikely to occur in the relatively isolated pools present at many of the creeks in the project area. However, Murray River cod may occur in the deeper, larger and more well connected pools that are present in Tchanning Creek, Bungil Creek and Wallumbilla Creek.

4.5.3 Temporal Variance in Fish Communities

The relative composition and abundance of fish communities within the study area is largely controlled by the life history requirements of the species involved. Many of the fish native to ephemeral systems of central and western Queensland migrate up and downstream and between different habitats at particular stages of their lifecycle. Stimuli for movement include small and large discharge events and changes in temperature. Australian rivers are notoriously unstable, and fish may need to move up and downstream to avoid undesirable water quality and the drying out of pools (Kennard 1997, Freshwater Fisheries Advisory Committee 1996).

Of the fish likely to be found in the study areas, most undertake freshwater migrations (Cotterell 1998, Marsden & Power 2007, Table 4.12). Adult golden and spangled perch move upstream to spawn, and juveniles move downstream for dispersal. This movement typically occurs in spring and summer, and is triggered by large flow events (Cotterell 1998). Glassfish, rainbowfish and gudgeons move within freshwaters to disperse to new habitats. This movement also typically occurs following flow events; and in the case of the study area could only occur when the creeks are flowing (i.e. when the isolated pools are connected). The weirs that are present downstream in the Fitzroy and Murray-Darling Basins create substantial barriers to movement of many of these fish.

Table 4.12 Timing of critical movements of fish known to inhabit the region (shaded cells indicate large numbers of fish are known to migrate) (Marsden and Power 2007, Cotterell 1998).

Family *Species*	**Common Name**	**Season**[1]			
		Summer	**Autumn**	**Winter**	**Spring**
Ambassidae					
Ambassis agassizii	Agassiz's glassfish	s	L	L	L
Antheridia					
Craterocephalus stercusmuscarum	fly-specked hardyhead	s	-	s	L
Clupeidae					
Nematalosa erebi	bony bream	L	L	L	L
Cyprinidae					
Cyprinus carpio	common carp	?	?	?	?
Carassius auratus	goldfish	?	?	?	?
Eleotridae					
Hypseleotris sp.	carp gudgeon	?	?	?	?
Hypseleotris sp. A	Midgley's gudgeon	?	?	?	?
Hypseleotris klunzingeri	western carp gudgeon	?	?	?	?
Mogurnda adspersa	purple spotted gudgeon	?	?	?	?
Oxyeleotris lineolata	sleepy cod	?	?	?	?
Hypseleotris galii	firetail gudgeon	L	?	?	?
Hypseleotris species 2	Lake's carp gudgeon	?	?	?	?
Philypnodon grandiceps	flathead gudgeon				
		?	?	?	?

Family *Species*	Common Name	Season[1]			
		Summer	Autumn	Winter	Spring
Melanotaeniidae					
Melanotaenia s. splendida	eastern rainbowfish	s	s	s	L
Melanotaenia fluviatilis	Murray River rainbowfish	?	?	?	?
Melanotaenia duboulayi	crimson spotted rainbowfish	?	?	?	?
Osteoglossidae					
Scleropages leichardti	southern saratoga	s	?	?	s
Galaxiidae					
Galaxias olidus	mountain galaxias	?	?	?	?
Gadopsidae					
Gadopsis marmoratus	river blackfish	?	?	?	?
Percichthyidae					
Maccullochella peelii peelii	Murray River cod	L	s	s	L
Macquaria ambigua oriens	golden perch	L	s	s	L
Plotosidae					
Neosilurus hyrtlii	Hyrtl's tandan	L	?	?	L
Porochilus rendahli	Rendahl's catfish	L	?	?	L
Tandanus tandanus	eel-tailed catfish	?	?	?	?
Poecillidae					
Poecilia reticulata	guppy	?	?	?	?
Gambusia holbrooki	mosquitofish	?	?	?	?

Family *Species*	**Common Name**	**Season[1]**			
		Summer	**Autumn**	**Winter**	**Spring**
Retropinnidae					
Retropinna semoni	Australian smelt	?	?	?	?
Pseudomugilidae					
Pseudomugil signifer	pacific blue eye	?	?	?	?
Terapontidae					
Leiopotherapon unicolor	spangled perch	L	s	s	L
Bidyanus bidyanus	silver perch	L	s	s	L
Scortum hillii	leathery grunter	s	s	s	s

[1]L= large number of fish migrate, s = small numbers of fish migrate, ? = limited information.

4.5.4 Ecology of Fish in the Study Area

The habitat preferences, diet and migrations of each of the fish species captured in the study area (including the timing of critical movements of these fishes) are described below. Each of the native fish species found in study area require some physical instream habitat to provide shelter or for reproduction. A variety of physical aquatic habitat such as woody debris and substrate diversity also support diverse macroinvertebrate communities, which are prey to many of the fish found in the study area.

Agassiz's Glassfish (Ambassis agassizii)

Agassiz's glassfish is commonly found in rivers, creeks, ponds, reservoirs, drainage ditches and swamps from Cairns in Queensland to Lake Hiawatha in New South Wales, and in the Murray-Darling system (McDowall 1996, Allen et al 2002). This species can be found in a variety of still or slow-flowing habitats in lowland larger rivers, upland rivers and streams and small coastal streams, and occasionally in lakes, and river impoundments, particularly in areas with submerged macrophyte and bank side vegetation (Pusey et al 2004). This species has a temperature range of 18 – 27 °C (Merrick & Schmida 1984), although they are not tolerant of low dissolved oxygen levels (Tait & Perna 2002), and are generally found in areas of low turbidity (Pusey et al 2004). The diet of this species consists largely of small crustaceans and adult and larval insects, including mosquitoes (McDowall 1996). This species spawns and completes its lifecycle in freshwater, and during spawning deposits and fertilises demersal eggs on aquatic vegetation (Merrick & Schmida 1984). Information on the migration habits of Agassiz's glassfish is limited, however it appears that this species may undertake upstream migrations triggered by increased flow (Pusey et al 2004). The Agassiz's glassfish was caught in the present survey.

Bony Bream (Nematalosa erebi)

Bony bream are abundant detritivores / algivores that form the basis of the food chain for a number of higher order consumers including larger fishes and birds, such as cormorants and pelicans (Pusey et al. 2004). Bony bream commonly occur in the shallows of still or slow-flowing streams, particularly in turbid waters, such as those of the region (Allen et al. 2002). Within the Fitzroy River system, bony bream have been recorded from water temperatures between 24 and 29 °C (Pusey et al. 2004). They have a wide pH (4.8 – 8.6) tolerance and have been recorded from waters with salinity levels approaching those of the seawater (Ruello 1976). High salinity tolerance is undoubtedly one of the factors influencing the widespread distribution of bony bream throughout Australia's freshwater habitats. However, they cannot tolerate low dissolved oxygen levels (Allen et al. 2002) and are the first species to perish when ephemeral habitats start to dry up (Allen et al. 2002). Bony bream were only caught in the Condamine-Balonne Catchment in the present study.

Common Carp (Cyprinus carpio)

Common Carp are an exotic species, and are listed as noxious in Queensland, under the *Fisheries Regulation 2008*. Their diet includes: molluscs, crustaceans, insect larvae and seeds but when food is scarce, aquatic plants and detritus is sucked from the substrate causing high turbidity (Allen et al. 2002). They prefer still or slow flowing water with abundant aquatic vegetation, but can also be found in brackish lower reaches of rivers and coastal lakes (Allen et al. 2002). Eggs are deposited on any fibrous plant matter and hatch after only a few days, with juveniles growing rapidly in warm water (McDowall 1996). Common Carp were only caught at Dulacca Creek in the Condamine – Upper Balonne Catchment in the present study.

Goldfish (Carassius auratus)

Goldfish are an exotic species, introduced into Australia in the 1960's as an ornamental fish (Allen et al. 2002). They have are now established in the Murray-Darling and Fitzroy basins (Allen et al. 2002). Inhabiting slow or still water, they are able to tolerate high temperatures and low oxygen concentrations (Allen et al. 2002). Goldfish feed on plant materials, organic detritus and a variety of small insects (McDowall 1996). Eggs are laid among aquatic plants and hatch after a few days, at which point the young attach themselves to aquatic plants for a few days while they absorb the remainder of their egg yolk (McDowall 1996). Goldfish were caught in the Upper Dawson and Condamine – Upper Balonne Catchment in the present study.

Carp Gudgeons (Hypseleotris spp.)

There is considerable taxonomic uncertainty surrounding the systematics of this genus (especially in juveniles), with some species capable of hybridising, however ecologically, the species are probably very similar (Pusey et al 2004). Carp gudgeons (*Hypseleotris* spp.) are common in coastal drainage basins of eastern Australia, from the northern section of the Murray-Darling Basin and parts of coastal NSW to north Queensland. Some species such as *Hypseleotris compressa* have broader distributions extending across northern Australia (Pusey et al 2004). Gudgeons are often shelter around aquatic vegetation and under logs and tree roots, commonly in slow moving water in streams, ponds, swamps and drains (Allen et al 2002; Marsden & Power 2007). Adult carp and firetail gudgeons are known to feed on invertebrates, such as mosquito larvae (Diptera: Culicidae), and small crustacea such as cladocerans and ostracods (Merrick & Schmida 1984, Allen et al 2002). These species are quite tolerant to changes in water quality, and under ideal conditions can rapidly increase in numbers (Merrick & Schmida 1984). Most *Hypseleotris* species undertake upstream spawning migrations in low to high water flow, however the timing of migration and spawning can vary among the different species (Marsden & Power 2007). These species were recorded in relatively high abundance in each of the three catchments surveyed in the present study.

Purple-spotted Gudgeons (Morgurnda adspersa)

Purple spotted gudgeons (*Mogurnda adspersa*) occur along the east coast of Australia from Cape York to the Murray-Darling River. This species is generally found in slow-flowing waters over a range of substrate types. It prefers areas of cover, and it can be found amongst macrophytes or emergent vegetation, although it requires solid substrates on which to deposit eggs (Pusey *et al.* 2004). They feed mostly on aquatic insects, terrestrial invertebrates and molluscs (Pusey *et al.* 2004). Purple spotted gudgeons were only recorded in the Comet Catchment in the present study.

Eastern Rainbowfish (Melanotaenia s. splendida)

The eastern rainbowfish is the common to many parts of north-eastern and central Australia, and is usually abundant wherever it occurs (Allen et al 2002). Where found, this species usually prefers areas of sluggish water flow, and can be found a variety of habitats including streams, wetlands, floodplains and lowland rivers (Pusey et al 2004). This tropical species is tolerant of a wide range of environmental conditions, however is not often found in highly degraded streams (Marsden & Power 2007). This species spawns all year round, although spawning peaks immediately before and during flood periods (Merrick & Schmida 1984). Adults migrate upstream to spawn during the wet season from (November to April) when water flows are high and juveniles disperse from the spawning grounds (Merrick & Schmida 1984). During the present study, eastern rainbowfish were captured at many sites in both the Upper Dawson and Comet Catchments. Creeks of the study area may provide breeding habitat for this species; spawning tends to occur in slow-flowing, weedy areas (Merrick & Schmida 1984).

Murray River Rainbowfish (Melanotaenia fluviatilis)

Murray River rainbowfish are the most southward ranging rainbowfish, adapted to low winter temperatures (Allen et al. 2002). They extend within the Murray-Darling Basin system from Roma in Queensland to the Murray River and its Tributaries in New South Wales, Victoria and South Australia (Allen et al. 2002). They often congregate along grassy banks or around submerged logs and branches (Allen et al. 2002). Murray River rainbowfish were not recorded in the present study.

Golden Perch (Macquaria ambigua oriens)

Golden perch are large piscivorous predatory fish that are sought after by anglers. Golden perch inhabit numerous water bodies east of the Great Dividing Range, due to transplanting and stocking, however the Fitzroy River Basin is the only drainage (east of the Great Dividing Range) where they naturally occur as the subspecies *Macquaria ambigua oriens.* Golden perch can tolerate extremes in temperature (4 – 35 °C) (Allen et al 2002) although in the Fitzroy River they have been recorded in waters ranging from 24 – 31 °C (Midgeley 1942, cited in Pusey et al 2004). Golden perch are very tolerant of high turbidity (Gehrke et al 1993), and may move long distances upstream during floods (Allen et al 2002). This species was only recorded in Dulacca Creek in the Condamine – Upper Balonne Catchment and the Dawson River in the Upper Dawson Catchment in the present study. They are unlikely to be common in the smaller, isolated pools that characterise many of the creeks in the study area.

Mosquitofish (Gambusia holbrooki)

The mosquitofish is an introduced species in Australia. The mosquitofish is declared noxious under the Fisheries Regulation 2008. They were initially brought into the country for aquariums and subsequently introduced into waterways to help control the mosquito populations (McDowall 1980, Allen et al. 2002). They are widespread and abundant throughout Victoria, New South Wales, South Australia, coastal drainages of Queensland and parts of Western Australia. They prefer warm gently flowing or still waters and are typically associated with aquatic vegetation. They are livebearers and spawning occurs in spring. They feed on terrestrial and aquatic insects, including mosquitoes, and have the capacity to displace native fish populations. Mosquitofish were caught at Dulacca, Bony and Wallumbilla Creeks in the present study, all within the Condamine – Upper Balonne Catchment.

Australian Smelt (Retropinna semoni)

Australian smelt are common from the Fitzroy River in Queensland to the Murray River mouth in South Australia, and are also found in Cooper Creek (Allen et al. 2002). Australian Smelt are usually found in slow flowing streams and still water, and they shoal near the surface or around aquatic plants and woody debris (Allen et al. 2002). Their diet included insects, microcrustaceans and algae (Allen et al. 2002). Spawning tends to occur at temperatures over 15 ^{o}C, usually in late winter and spring (Pusey et al. 2004). Eggs are laid among aquatic vegetation and hatch in about 10 days (Allen et al. 2002). Australian Smelt were not observed in the present study.

Spangled Perch (Leiopotherapon unicolor)

Spangled perch are Australia's most widespread native fish, being abundant within most aquatic habitats extending across coastal northern Australia and inland waters (Allen et al. 2002; Pusey et al 2004). Of particular relevance to their abundance in western and central Queensland creeks is their ability to aestivate in wet mud or under moist leaf litter in ephemeral water holes during droughts (Allen et al. 2002), therefore spangled perch are likely to persist in the creeks within the study area throughout the year. As an adaptation to living in quick-drying waterholes, spangled perch eggs hatch in 2 days and the larvae develop in 24 days (Allen et al. 2002). This species can generally tolerate a wide range of environmental conditions including water temperatures (5 – 44 °C), salinity (0 –34 ppt) and pH (4 – 10.2) (Pusey et al 2004).

Like other terapontids, the spangled perch is also capable of rapid and extensive movements and migrating past barriers that impede other fish species (Pusey et al 2004; Marsden & Power 2007). Adults migrate upstream during high flow events to spawn and adults and juveniles undertake dispersive (lateral) migrations from refuge habitats to floodplain habitats during the wet season (Marsden & Power 2007).

Spangled perch were caught at roughly 30 percent of the sites surveyed during the present study; they were found in each of the three Catchments and are likely to persist in the creeks within the study area throughout the year.

Eel-tailed catfish (Tandanus tandanus)

Eel-tailed catfish have been stocked throughout eastern Australia for recreational angling. They are found in a range of habitats, from small-order streams to rivers, and they are generally more abundant when the riparian zone is intact and there is abundant terrestrial debris in the channel to provide habitat (Pusey et al. 2004). In general, they are tolerant of low oxygen concentrations and a range of temperatures (8.4 – 33.6 °C), although they can be sensitive to sudden decreases in temperature (Pusey et al. 2004). They mainly feed on aquatic insects as juveniles and switch to a more varied diet as adults. Adults exhibit some parental care by building circular nests in gravel beds. Eel-tailed catfish were only recorded in the Comet Catchment in the present study.

Hyrtl's Tandan (Neosilurus hyrtlii)

This species is very common and widespread in coastal drainages of northern Australia, as far south as Mary River on the east coast and the Pilbara on the west coast (Allen et al 2002). It also occurs widely throughout central Australia (Allen et al 2002) and is known to occur in the Fitzroy River (Merrick & Schmida 1984). Hyrtl's tandan is a shoaling species that occupies a diverse range of habitats including still or flowing waters, pools and billabongs (Allen et al 2002). This species feeds on insects, molluscs, small crustaceans and worms (Allen et al 2002). The spawning behaviours of interior populations are unknown; however, northern populations breed at the beginning of the wet season in shallow, sandy areas in the upper reaches of streams (Allen et al 2002). Further research is required as this species may actually represent more than one species (Allen et al 2002). Hyrtl's tandan was not recorded in the present study and are not likely to be common in any of the Catchments.

Sleepy Cod (Oxyeleotris lineolata)

Sleepy cod are common and widespread in northern Australia between the Ord River on the west coast and Noosa on the east coast (Allen et al 2002). They are a hardy species inhabit rivers, creeks and billabongs, usually in quiet or slow-flowing water among vegetation, around woody debris or beneath undercut banks (Merrick & Schmida 1984, Allen et al 2002). This species is a sluggish bottom dwelling carnivore that feeds on insects, small fishes and crustaceans (Merrick & Schmida 1984, Allen et al 2002). Sleepy cod appear to have a lower thermal limit of 15 °C and Northern Territory populations can withstand temperatures to 32 °C (Merrick & Schmida 1984). Sleepy cod generally do not undertake substantial migrations, with spawning usually occurring between October and February (Allen et al 2002), when water temperatures reach 24 °C. The nest is located on a solid surface (usually rock, tree roots or submerged log) and the male guards the nest for the incubation period of 5 – 7 days (Merrick & Schmida 1984, Allen et al 2002). Sleepy cod were not recorded in the present study, though they are likely to be present in the larger water bodies in each of the catchments.

Pacific Blue Eye (Pseudomugil signifer)

This species is found along the eastern Australia, along the coast from Cape York Peninsula, south to Narooma (NSW) (Pusey et al 2004 and references cited within). This species is common and widespread in a variety of fast flowing coastal habitats including rivers, lagoons, streams and estuaries in central Queensland (Pusey et al 2004 and references cited within). This loosely schooling species is most commonly found in the mid to upper water column, in association with some form of submerged cover. This species is tolerant of a wide variety of temperatures and salinity levels, given the distribution, and generally prefers well-oxygenated, low turbidity waters (Pusey et al 2004). This species can complete reproduction naturally in fresh or marine waters and may undertake dispersal migrations, although these are not common (Pusey et al 2004). This species is a microphagous carnivore. In freshwater habitats more than 62% of its diet consists of aquatic insects, with a greater proportion of flying aquatic insects in estuarine situations (Pusey et al 2004). Pacific blue-eye were only recorded in the Dawson River (Site 16) during the present study.

Fly-speckled Hardyhead (Craterocephalus stercusmuscarum)

The fly-speckled hardyhead is a very widespread species found in coastal and inland drainages of eastern and northern Australia, south to the Queensland border (Pusey et al 2004). This species is common and widely distributed in central Queensland, and is known to occur in the Fitzroy River Basin (Burghuis & Long 1999; Pusey et al 2004). The species can be found in a variety of habitat types including rivers, streams, lakes, water impoundments and in brackish river estuaries, with moderate to fast water flows (Pusey et al 2004). This species is likely to migrate year round, migrating upstream to spawn (Marsden & Power 2007), although only low numbers have been found in barrage fishways in the Fitzroy River Basin (Pusey et al 2004).

This tropical species is moderately tolerant of a wide range of temperatures, dissolved oxygen, pH and conductivity levels, however appears to be intolerant to high turbidity levels (>100 NTU) (Pusey et al 2004 and references within). This species is a microphagic carnivore consuming aquatic insects and microcrustaceans and to a lesser extent aquatic algae and macrophytes (Pusey et al 2004 and references cited within). Fly-speckled hardyhead were only recorded in Carnarvon Creek (Site 24) during the present study.

4.5.5 Summary

Most of the species that were captured from the study area can tolerate a large range of water quality conditions (Table 4.13). Spangled perch, glassfish, carp gudgeons, eastern rainbowfish and eel-tailed catfish are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table 4.13). Although exact water quality tolerances could not be sourced for the exotic carp, goldfish and mosquitofish, these species are also reported to have wide environmental tolerances. Golden perch, bony bream, fly-speckled hardyheads, purple-spotted gudgeons and Pacific blue-eye have narrower water quality tolerances than the other species collected.

The relative composition and abundance of fish communities within the study area is largely controlled by the life history requirements of the species involved. Many of the fish in the study area undertake freshwater migrations for reproduction, dispersal or foraging. This movement typically occurs in spring and summer, and is triggered by large flow events. Therefore, the specific composition of fish communities at any given site is likely to vary between seasons, with a greater abundance and diversity of fish likely to be present at many locations during periods of flow.

Table 4.13 Reported water quality tolerances of fish species captured in, or that are considered likely to occur in, the study area (data sourced from Pusey at al. 2004).

Family	Latin Name	Common name	Water Temperature (º C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	11 – 33	0.3 – 19.5	6.3 – 9.9	19.5 – 15 102	0.2 – 144
Atherinidae	*Craterocephalus stercusmuscarum*	fly-specked hardyhead	12 – 33.6	2.9 – 19.5	6.1 – 9.1	19.1 – 5380	0.2 – 62.3
Clupeidae	*Nematalosa erebi*	bony bream	24 – 29	4.8 – 11	6.9 – 8.8	70 – 770	4 – 160
Cyprinidae	*Cyprinus carpio*	common carp	NA	NA	NA	NA	NA
	Carassius auratus	goldfish	NA	NA	NA	NA	NA
Eleotridae	*Hypseleotris* spp.[A]	carp gudgeons	8.4 – 31.2	0.3 – 19.5	4.4 – 8.9	51 – 4 123	0.1 – 331.4
	Morgurnda adspersa[A]	Purple-spotted gudgeon	11.9 – 31.7	0.6 – 12.8	5.6 – 8.8	72.0 - 2495	0.2 - 200
Melanotaeniidae	*Melanotaenia splendida*[C]	eastern rainbowfish	15 – 32.5	1.1 – 10.8	6.8 – 8.5	49 – 790	0.6-16, but up to 600
	Melanotaenia fluviatilis	Murray River rainbowfish	NA	NA	NA	NA	NA
Percichthyidae	*Macquaria ambigua*[B]	golden perch	24 – 31	3.6 – 10.0	7.2 – 8.8	NA	4 – 40 cm secchi depth
Plotosidae	*Tandanus tandanus*[A]	eel-tailed catfish	8.4 – 33.6	0.3 – 17.1	4.8 – 9.1	19.5 – 3 580	0.2 – 250
Poecillidae	*Gambusia holbrooki*	mosquitofish	NA	NA	NA	NA	NA
Pseudomugilidae	*Pseudomugil signifer*	Pacific blue-eye	8.4 – 31.7	3.6 – 12.3	6.0 – 9.1	72 – 1897.5	0.3 – 144
Retropinnidae	*Retropinna semoni*[A]	Australian smelt	8.4 – 31.7	0.6 – 16.2	6 – 9.1	51 – 1 624.2	0.4 – 144
Terapontidae	*Leiopotherapon unicolor*	spangled perch	5 – 41	≥ 0.4	4 – 8.6	0.2 – 35.5 ppt salinity	1.5 – 260

A environmental data from captures during surveys in south-east Queensland
B environmental data from captures during surveys in the Fitzroy River system
C environmental data from captures during surveys in the Burdekin River system
NA not available

4.6 Turtle Communities

4.6.1 Of the CSG Fields

Two turtle species were recorded during our surveys. Krefft's river turtle (*Emydura krefftii*) was captured from the Dawson River (Site 12) in the Upper Dawson Catchment, and from Lake Nuga Nuga (Site 22) and the Comet River (Site 30) in the Comet Catchment (Table 4.14 & Table 4.15). The white-throated snapping turtle (*Elseya albagula*) was recorded from the Dawson River (Site 15) in the Upper Dawson Catchment (Table 4.14). In addition, three white-throated snapping turtles were captured by hand in a tributary of the Dawson River, immediately upstream of Site 15. A single white-throated snapping turtle was also captured by hand from Carnarvon Creek in the Comet Catchment, immediately upstream of the study area.

No turtles were recorded in the Condamine – Upper Balonne Catchment.

Table 4.14 Abundance of turtles at each site in the Upper Dawson Catchment.

Latin Name	Common Name	12	13	14	15	16	17	18	19	20	21
Emydura krefftii	Krefft's river turtle	25									
Elseya albagula	white-throated snapping turtle				1						

Table 4.15 Abundance of turtles at each site in the Comet Catchment.

Latin Name	Common Name	22	23	24	25	26	27	28	29	30	31	32
Emydura krefftii	Krefft's river turtle	7								4		
Elseya albagula	white-throated snapping turtle			1								

Nine of the Krefft's river turtles that were caught from the Dawson River at Taroom (Site 12) were juveniles; all other captured turtles were adults.

Figure 4.42

An adult female Krefft's river turtle at Lake Nuga Nuga (Site 22) in the Comet Catchment.

Figure 4.43

A juvenile Krefft's river turtle at the Dawson River (site 12) in the Upper Dawson Catchment.

Figure 4.44

An adult female white-throated snapping turtle at Carnarvon Creek in the Comet Catchment.

4.6.2 A Regional and Ecological Perspective

Condamine – Upper Balonne Catchment

Turtle species occurring in the Condamine – Upper Balonne Catchment include: the broad-shelled river turtle (*Chelodina expansa*), the eastern snake-necked turtle (*Chelodina longicollis*), and the Macquarie turtle (*Emydura macquarii*) (Wilson & Swan 2008). None of these species are listed as rare or threatened under the Queensland NCWR or the Commonwealth EPBC Act.

Broad-shelled river turtle (Chelodina expansa)

The broad-shelled river turtle occurs throughout the Murray-Darling Catchment, in South Australia, Victoria, New South Wales and western Queensland, and in the coastal rivers and streams of Queensland from the Albert to the Fitzroy River Catchments (Cogger 1996, EPA 2007). It typically inhabits floodplain billabongs, wetlands, and the larger, slower flowing reaches of coastal rivers (Cogger 1996, EPA 2007), and is therefore unlikely to be abundant in the ephemeral creeks of this catchment.

Eastern snake-necked turtle (Chelodina longicollis)

The eastern snake-necked turtle occurs throughout the Murray-Darling Catchment, in South Australia, Victoria, New South Wales and western Queensland, and in coastal drainages from New South Wales to Central Queensland (Cogger 1996, EPA 2007). This species is most abundant in shallow ephemeral waterways and in farm dams that are remote from natural permanent water (Cogger 1996, EPA 2007). This species survives extended dry periods by either burrowing into the substrate of drying waterholes or aestivating, and has the capacity to make large overland movements to take up residence in previously dried out habitats (EPA 2007). This species is likely to be present in the ephemeral creeks of this catchment, particularly in the larger, deeper pools that are present in Tchanning, Bungil and Wallumbilla Creeks.

Macquarie River turtle (Emydura macquarii)

Macquarie river turtles occur the Murray-Darling River system and associated drainages west of the Great Diving Range (Cogger 1996). They occur in rivers, creeks and lagoons, but are most abundant in larger rivers and floodplain waterholes (Cogger 1996). This species may be present in the larger, deeper pools that are present in Tchanning, Bungil and Wallumbilla Creeks.

Upper Dawson and Comet Catchments

Six species of turtle have been recorded in the greater Fitzroy River Catchment, these include: the Krefft's river turtle[2] (*Emydura macquarii krefftii*), the broad-shelled river turtle (*Chelodina expansa*), the eastern snake-necked turtle (*Chelodina longicollis*), the saw-shelled turtle[3] (*Wollumbinia latisternum*), the white-throated snapping turtle (*Elseya albagula*) and the Fitzroy River turtle (*Rheodytes leukops*). The Fitzroy River turtle is listed as 'vulnerable' under the NCWR, EPBC Act and the IUCN Red List.

Krefft's river turtle (Emydura macquarii krefftii)

Krefft's river turtles occur in all coastal drainages of Queensland, from the Mary River north to Princess Charlotte Bay (Cann 1998, EPA 2007, Wilson & Swan 2008). They inhabit rivers, creeks and lagoons, and is the most widespread and abundant turtle in the greater Fitzroy Catchment, occurring from the uppermost spring fed pools down to the billabongs and estuarine waters of the coastal plains (EPA 2007). Krefft's river turtles have been recorded in both the Upper Dawson and Comet Catchments previously (EPA 2007, frc environmental 2007), and are likely to be relatively common in the larger permanent waterways of both catchments.

Broad-shelled river turtle (Chelodina expansa)

The broad-shelled river turtle has only been recorded from floodplain billabongs, wetlands, and the larger, slower flowing coastal reaches of the Fitzroy River (EPA 2007). It is not likely to be present in either the Upper Dawson or Comet Catchments.

Eastern snake-necked turtle (Chelodina longicollis)

In the greater Fitzroy Catchment, the eastern snake-necked turtle has only been recorded from the Dawson River drainage and the lower Fitzroy River (EPA 2007). This species is most abundant in shallow ephemeral waterways and in farm dams that are remote from natural permanent water (Cogger 1996, EPA 2007). It may be present, though not abundant, in the ephemeral creeks of the Upper Dawson Catchments.

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[2] Formerly known as *Emydura krefftii*. This species has recently been re-classified and included in the *Emydura macquarii* complex, a group of closely related sub-species (Wilson & Swan 2008).
[3] Formerly known as *Elseya latisternum*. This species has recently been re-classified as a new genus, and is now *Wollumbinia latisternum* (Wells 2007).

Saw-shelled turtle (Wollumbinia latisternum)

The saw-shelled turtle occurs in coastal rivers from Arnhem Land, down through coastal Queensland to the Richmond River in northern New South Wales (Cann 1998, EPA 2007, Wilson & Swan 2008). It is widespread at a relatively low density throughout the greater Fitzroy Catchment, but is more common in the flowing streams of the upper catchment than in the slower flowing lower reaches (EPA 2007). Saw-shelled turtles have been recorded in both the Upper Dawson and Comet Catchments (EPA 2007), and may be relatively common in the faster flowing upper tributaries of the main rivers.

White-throated snapping turtle (Elseya albagula)

The white-throated snapping turtle (*E. albagula*) was only described in 2006 (Thomson et al. 2006); previously it had been regarded as part of the more common and widely distributed northern snapping turtle (*Elseya dentata*). It is found in the Fitzroy, Raglan, Burnett and Mary river drainages in central and southern Queensland. This species is listed as 'least concern' under the NCWR, but has been identified as a high priority for conservation in the EPA's species prioritisation framework. Within the greater Fitzroy Catchment, this species occurs from the barrage on the lower Fitzroy River to the uppermost spring fed pools in the Upper Dawson, Mackenzie and Comet Catchments (EPA 2007, pers. obs.). White-throated snapping turtles are most common in flowing water habitats with suitable shelters and refuges (Hamann et al. 2004, EPA 2007), and are therefore likely to be present in flowing water habitats across both the Upper Dawson and Comet Catchments.

Fitzroy River turtle (Rheodytes leukops)

The Fitzroy River turtle only occurs in the greater Fitzroy River Catchment; where it has been recorded from the Fitzroy Barrage to the Theodore Weir on the Dawson River, and the Duck Ponds on the Lower Nogoa River, upstream of the Comet-Mackenzie Junction (EPA 2007). It has not been recorded in the Upper Dawson or Comet Catchments, however extensive field surveys have only been conducted in the Dawson River at Korcha Station, Hutton Creek at Warndoo Station and at Carnarvon Creek (EPA 2007). The Environmental Protection Agency's Turtle Group expect that with further survey, the Fitzroy River turtle will be identified in the Dawson River upstream of Theodore, and at additional sites within the middle to upper Comet River (EPA 2007).

No Fitzroy River turtles were not captured during our limited field survey, however this species is particularly difficult to catch in nets, and rarely enters traps (M. Gordos, Conservation Manager, NSW DPI, pers. comm. July 2007). The most successful, and therefore most commonly used, method to survey Fitzroy River turtles is hand capture on snorkel (M. Gordos, Conservation Manager, NSW DPI, pers. comm. July 2007). Snorkel surveys were not possible during the present surveys, as most sites were very shallow, and had very high turbidity (and hence extremely low visibility).

Fitzroy River turtles are often found in shallow, fast-flowing riffle zone habitats characterised by well-oxygenated water (Cann 1998, Tucker et al. 2001), however they have also been recorded in weir impoundments and deeper riverine systems, distant from such habitat (EPA 2007, frc environmental 2007). Female Fitzroy River turtles nest on sandy banks with a deep layer of sand and a low vegetative cover. Biological data on the movement patterns of *R. leukops* is largely limited to tracking studies conducted in the Fitzroy River at Glenroy Crossing (above the Eden Bann Weir) (Tucker et al. 2001). Home ranges typically vary widely among individuals, however, on average, turtles were observed to have a local mean range span of 562 m (Tucker et al. 2001), suggesting that viable populations are likely to be limited to waters in relative proximity to potential nesting habitat. During our surveys, potential nesting banks and riffle habitats were observed along the Dawson River, from Yebna Crossing to Dawson's Bend. Therefore, the potential presence of Fitzroy River turtles in this catchment cannot be discounted.

4.6.3 Temporal Variance in Turtle Communities

Very little is known of the movement patterns of turtles in the study area, or in western Queensland generally. However, it is unlikely that the relative composition of turtle communities within the study area will not vary significantly between seasons, with distribution and abundance largely being controlled by the presence of water and the level of connectivity at each watercourse. The Fitzroy River turtle and white-throated snapping turtle are known to have small home ranges and undertake limited spatial and temporal movements (Tucker et al. 2001, Hamann et al. 2007). Therefore, the distribution of these species is unlikely to change markedly over time. In contrast, the eastern snake-necked turtle has the capacity to make large overland movements to take up residence in previously dried out habitats (EPA 2007). Therefore, the presence and abundance of his species may vary following fluctuations in environmental conditions. No information could be located on the specific movement patterns of the Macquarie River turtle, Krefft's river turtle or the saw-shelled turtle.

The abundance and distribution of individual animals may be expected to vary during the breeding season, with an increase in the abundance of female turtles adjacent to suitable nesting sites, followed by an increase in the abundance of juveniles post hatching. The white-throated snapping turtle nests in autumn and winter; the Fitzroy River turtle nests in spring; the Macquarie River turtle, Krefft's river turtle and saw-shelled turtle nest in spring and summer and the eastern snapping turtle nest in summer (Judge 2001, EPA 2007).

4.6.4 Summary

Krefft's river turtles are likely to be relatively common in the larger permanent waterways of both the Upper Dawson and Comet Catchments. White-throated snapping turtles are also likely to be present in flowing water habitats across both the Upper Dawson and Comet Catchments. Saw shelled turtles may be present in the faster flowing waterways in the Upper Dawson and Comet Catchments, such as the upper Dawson River. Fitzroy River turtles may also be present in the flowing waters of the Dawson and Comet Rivers. Eastern snake-necked turtles may be present in the ephemeral creeks of the Upper Dawson and Condamine – Upper Balonne Catchments, though there absence during our surveys suggests they are not likely to be common. The Macquarie River turtle may occur in the deeper pools of the larger (more well connected waterways) in the Condamine – Upper Balonne Catchment, such as Tchanning, Bungil and Wallumbilla Creeks. However, their absence from our surveys indicates that they are not likely to be abundant, a likely reflection of the highly ephemeral nature of these waterways and the lack of instream habitat.

It is unlikely that the relative composition of turtle communities within the study area will vary significantly between seasons, with distribution and abundance largely being controlled by the presence of water and the level of connectivity at each watercourse. The abundance and distribution of individual animals may be expected to vary during the breeding season, with an increase in the abundance of female turtles adjacent to suitable nesting sites, followed by an increase in the abundance of juveniles post hatching.

4.7 Artesian Spring Communities

4.7.1 Of the Upper Dawson Catchment

Aquatic Habitat

The condition of artesian springs in the Upper Dawson Catchment varied considerably between the springs surveyed (See Appendix D), with the state of each spring largely dependent on: the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds.

The availability and condition of aquatic habitat ranged from poor to good. The smaller, shallower springs (including: 13, 15, A, B, E, F, I, K, L and M) provided little habitat for aquatic organisms before trickling into the Dawson River (Figure 4.45 & Figure 4.46 and Appendix D); but usually supported some macrophytes (see below). In contrast, the larger more complex springs (including: 5, 8, 8a, 14, C and G) provided higher value aquatic habitat. These springs often supported a moderate abundance of instream habitat, including: boulders, undercut banks and woody debris (Figure 4.47). Macrophytes were particularly abundant at springs 5, 8a and 14 (see below and Figure 4.48).

Springs 1, 2, 3, 4, D, N, O and P were dry at the time of survey, and would be unlikely to provide significant habitat for aquatic organisms when inundated. Spring 4 originated in the bed of the Dawson River and provided habitat typical of the river (refer Section 4.1).

Channel diversity was relatively low, with the majority of springs providing only shallow run habitat between the point of origin and the discharge to the Dawson River. Bends and changes in water depth provided some channel diversity to the larger springs, including 5, 8, 14 and G. Streambeds were sandy at the majority of sites surveyed (See Appendix D).

Figure 4.45

Spring 15 was a short soak from the right bank of the Dawson River that provided little habitat for aquatic organisms.

Figure 4.46

Spring E had a relatively steep drop from its origin to the Dawson River, was largely filled with leaf litter, and provided poor habitat for aquatic organisms.

Figure 4.47

Spring 8 had a long and complex drainage from its origin to its discharge to the Dawson River, and supported macrophytes, fish and turtles.

Figure 4.48

Spring 5 supported a moderate abundance of macrophytes and aquatic snails.

Grazing was the dominant adjoining land use, and cattle were able to gain access to the majority of springs surveyed. Cattle damage was evident at many springs (including 1, 2, 3, 9, 10, A, G, H, J, K, L, M and O), and access had significantly degraded springs 1, 2, 9, 10, K and M (Figure 4.49). The wallowing activity of feral pigs had degraded the condition of springs 4 and B.

Figure 4.49

Extensive cattle damage at Spring 9.

Dirt farm tracks had been constructed across the upper waters of two springs (14 and P), and have the potential to degrade the value of 'downstream' aquatic habitats at these two locations (Figure 4.50).

Figure 4.50

Dirt road crossing over the upstream waters of Spring 14.

Grasses and sedges dominated the riparian zone of many artesian springs, although shrubs and trees also grew at most locations. Callistemons, eucalypts, cypress pines and casuarinas were common components of the riparian zone at many of the springs visited. Terrestrial weeds were common at many of the springs surveyed. Common riparian weeds included: prickly poppy (*Argemone ochroleuca*), red-head cottonbush (*Asclepias curassavica*), cobbler's pegs (*Bidens pilosa*), thistles (*Cirsium vulgare*), fireweed (*Senecio lautus*), wild tobacco (*Solanum mauritianum*), noogoora burr (*Xanthium pungens*), Mayne's pest (*Verbena tenuisecta*). The exotic macrophyte, curled dock (*Rumex crispis*), was also common at a number of the springs (see below).

Hydraulic Activity

The level of hydraulic activity, and indeed the presence of water, varied considerably between springs in the Upper Dawson Catchment (Figure 4.51). The rate of discharge was relatively low (<1 L / second) at springs 8a, C, E, F, H, I, J, K, L and M; and relatively high (approx. 5 L / second) at springs 11 and G.

Springs 1, 2, 3, D, N, O and P were dry at the time of survey. Spring 4 originated in the bed of the Dawson River; consequently its rate of discharge was unable to be measured.

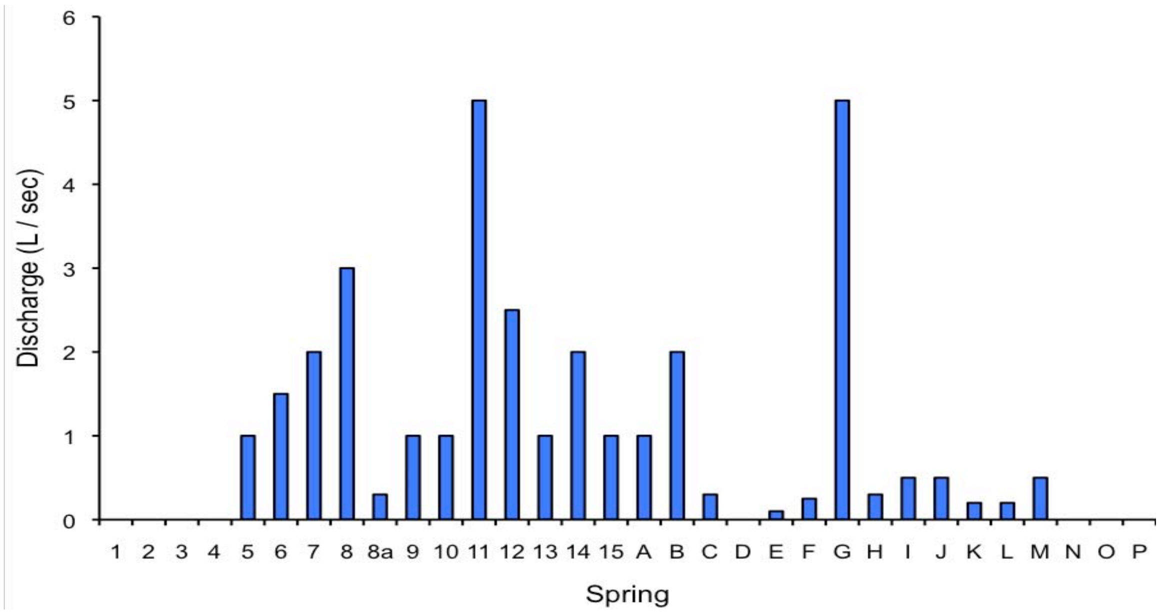


Figure 4.51 Rate of water discharge (L / Sec.) at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

Water Quality

The temperature of spring water was typically warm and consistent between springs; temperature varied between 22 °C, at spring 8a, and 30 °C, at spring 8 (Figure 4.52). The temperature of springs was not influenced by the time of day and the ambient weather conditions. Spring water was typically warmer at the point of origin and cooler further downstream, reflecting a cooling of waters in contact with the atmosphere. There are no guidelines available for water temperatures in artesian springs.

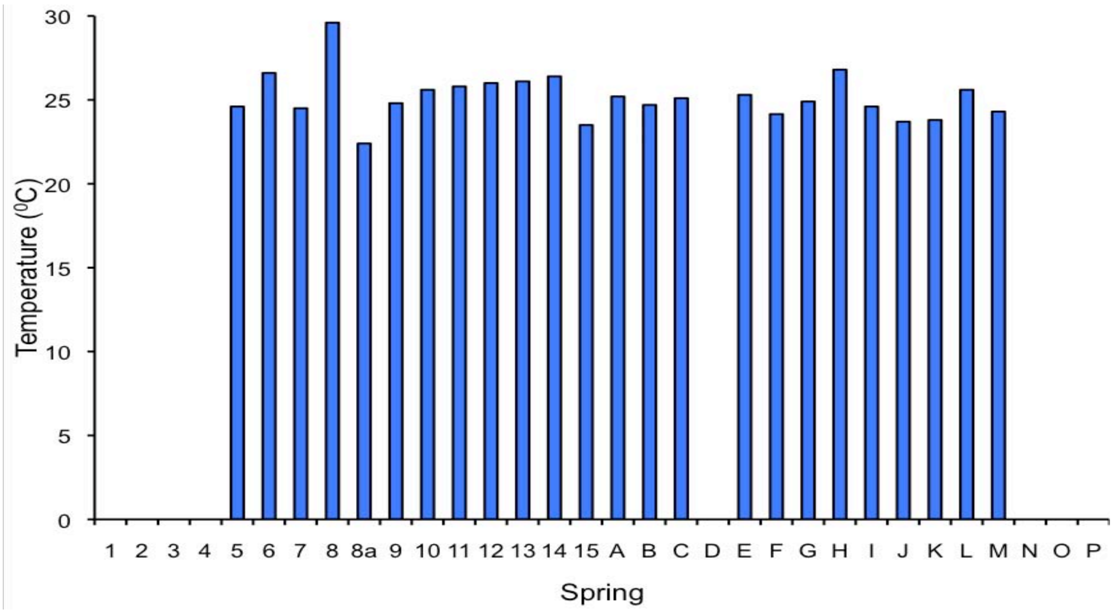


Figure 4.52 Water temperature at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

The level of Dissolved Oxygen (DO) varied considerably between springs, with the lowest level of DO (3.2% Saturation (Sat.)) recorded at Spring G, and the highest (105% Sat.) recorded at Spring F (Figure 4.53). DO levels were typically quite low (generally below 70%, and often below 20%), reflecting a lack of oxygenation in underground waters. Higher DO levels were recorded in longer springs, further from the point of origin. There are no guidelines available for DO levels in artesian springs; DO levels were typically below the range (90 – 110% Sat.) specified in the QWQG for upland streams in central Queensland (EPA 2007a).

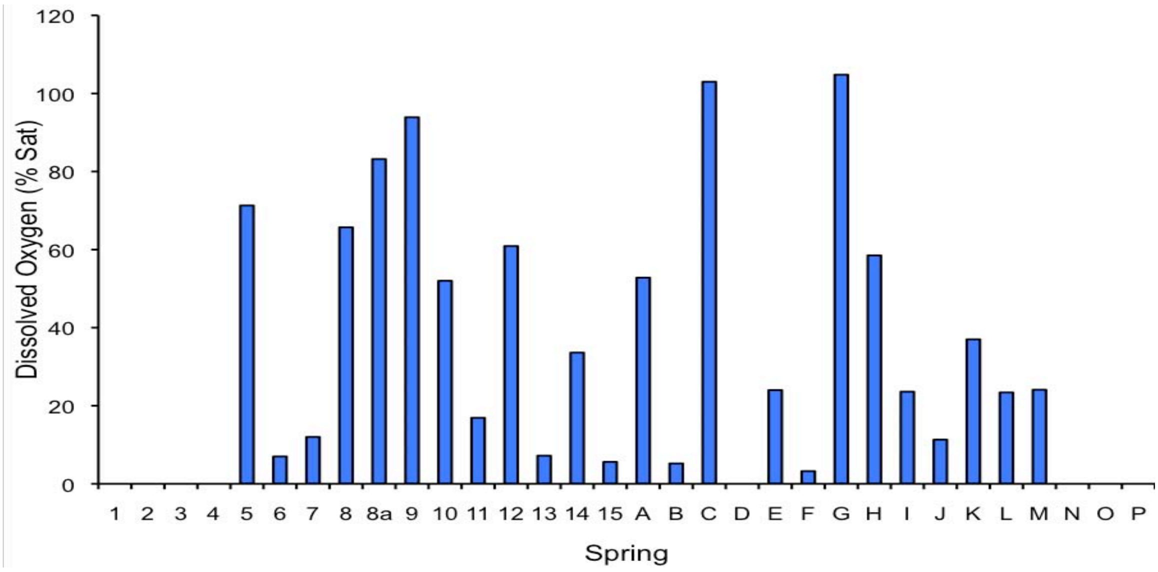


Figure 4.53 Dissolved Oxygen (DO) (Percent Saturation) at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

pH tended to be slightly acidic (< 7) and relatively consistent (5.7 to 7.1) across springs in the Upper Dawson Catchment (Figure 4.54). This is likely to be reflective of the acidity of the underlying groundwater. pH was typically higher at springs that supported algae and instream macrophytes. There are no guidelines available for pH levels in artesian springs; pH was often below the range (6.5 – 7.5) specified in the QWQG for upland streams in central Queensland (EPA 2007a).

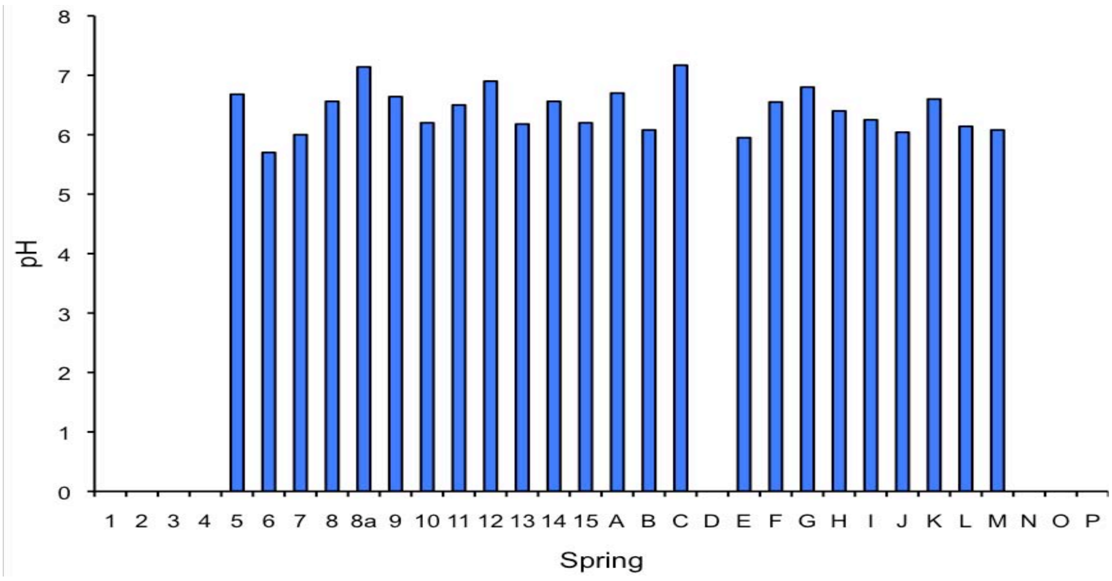


Figure 4.54 pH at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

Electrical conductivity ranged from 94 µS/cm at Spring 9 to 360 µS/cm at Spring 8 (Figure 4.55), but was typically below 200 µS/cm. There are no guidelines available for electrical conductivity levels in artesian springs; electrical conductivity was typically below the upper limit (340 µS/cm) specified in the QWQG for the Fitzroy Basin salinity zone (EPA 2007a).

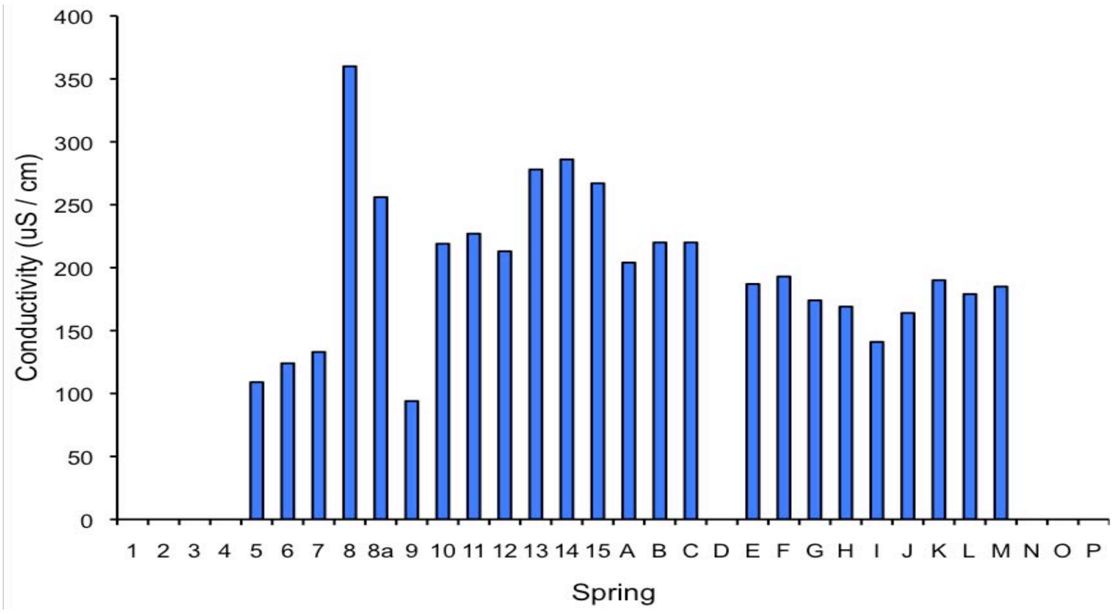


Figure 4.55 Electrical Conductivity at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

Turbidity was typically low across springs in the Upper Dawson Catchment (Figure 4.56), reflecting the clarity of the underlying groundwater. Higher levels of turbidity (35 – 50 NTU) were recorded at Springs 7, 8 and E; however these levels were considerably lower than the turbidity of surface waters in the catchment (refer Section 4.2). There are no guidelines available for turbidity levels in artesian springs; turbidity was typically below the upper limit (30 NTU) specified in the QWQG for upland streams in central Queensland (EPA 2007a).

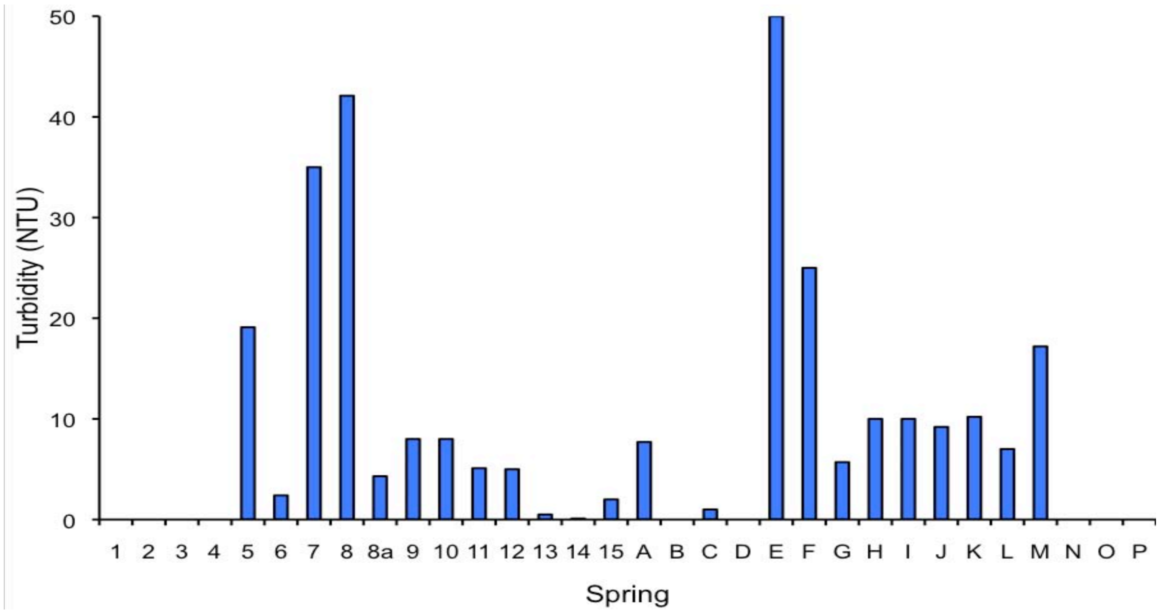


Figure 4.56 Turbidity at spring sites in the Upper Dawson Catchment. Springs 1, 2, 3, 4, D, N, O & P were dry.

Aquatic Flora

The cover of macrophytes varied considerably between springs in the Upper Dawson Catchment. Springs 5, 7, 8a and 14 supported extensive well-established macrophyte communities, whilst many of the other springs were poorly vegetated (springs 1 and 9 in particular) (Table 4.16 and Table 4.17). The most common macrophytes were mat rushes (*Lomandra longifolia*), willow ludwigia *(Ludwigia octovalvis*), lesser joyweed (*Alternanthera denticulata*) (Figure 4.57) and the sedges (*Cyperus gracilis* and *C. difformis*).

Spring G supported the greatest number of macrophyte species (13) and spring 2 supported the fewest (2). Ferns were found at springs 5, 7, 8, and G, which emanated from beneath bedrock in deep, well shaded gullies (Figure 4.58).

No rare or threatened macrophyte species were recorded from the springs in the Upper Dawson Catchment. Curled dock (*Rumex crispus*) and slender celery (*Cyclospermum leptophyllum*) were the only exotic macrophytes encountered (Table 4.16 and Table 4.17).

Figure 4.57

Lesser joyweed (*Alternanthera denticulata*) grew at many of the springs in the Upper Dawson Catchment.

Figure 4.58

Ferns and moss growing from seeps in the bedrock at Spring 8.

Emergent species dominated the macrophyte communities at all sites (Table 4.16 and Table 4.17). Only one submerged (*Blyxa* sp.) and three floating (*Azolla* sp., *Ottelia ovalifolia* and *Spirodela* sp.) macrophytes were recorded (Figure 4.59). The paucity of submerged and floating macrophytes in the springs in the Upper Dawson Catchment may be reflective of temporal inconsistencies in flow and the availability of water at many locations.

Figure 4.59

Swamp lilies (*Otellia ovalifolia*) were one of the few large floating macrophytes recorded from the artesian springs in the Upper Dawson Catchment (shown here at Spring J).

Table 4.16 Aquatic macrophytes at springs 1 – 15 in Upper Dawson Catchment, listed by growth form.

GROWTH FORM / Family *I Latin name*	**Common name**	**Native/ exotic**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**8a**	**9**	**10**	**11**	**12**	**13**	**14**	**14i**	**15**
EMERGENT																			
Amaranthaceae																			
Alternanthera denticulata	lesser joy-weed	N						x				x			x	x			
Apiacea																			
Centella asiatica	indian pennywort	N		x			x								x				x
Cyclospermum leptophyllum	slender celery	E	x							x							x		
Hydrocotyle laxiflora	stinking pennywort	N			x							x							
Blechnaceae																			
Blechnum sp.	water fern	N								x									
Commelinaceae																			
Commelina sp.		N						x									x		
Cyperaceae																			
Carex appressa	tall sedge	N					x	x			x			x					
Carex inversa	sedge	N						x											
Carex lophocarpa	sedge	N						x											
Cyperus difformis	dirty dora	N	x		x					x						x	x		x
Cyperus exaltus	giant sedge	N									x						x		
Cyperus flavidus	yellow flat	N								x									

GROWTH FORM / Family / *Latin name*	Common name	Native/ exotic	1	2	3	4	5	6	7	8	8a	9	10	11	12	13	14	14i	15
	sedge																		
Cyperus haspan	sedge	N																x	
Cyperus gracilis	delicate sedge	N			x						x			x	x	x	x	x	
Cyperus polystachyus	bunchy sedge	N																	
Cyperus trinervis	sedge	N			x	x	x	x											
Eleocharis cylindrostachys	spike rush	N								x						x		x	x
Schoenoplectus mucronatus		N					x	x	x					x			x	x	
Schoenoplectus validus	river club rush	N																	
Graminae																			
Echinochloa colona	awnless barnyard grass	N				x						x	x	x	x				x
Glycera maxima	reed sweet grass	N										x	x	x	x				
Leptochloa digitata	umbrella canegrass	N				x	x							x	x				
Phragmites australis	common reed	N					x												
Juncaceae																			
Juncus prismatocarpus	rush	N					x		x			x			x	x		x	
Juncus usitatus	rush	N	x		x				x		x	x			x		x	x	

GROWTH FORM / Family / *Latin name*	Common name	Native/ exotic	1	2	3	4	5	6	7	8	8a	9	10	11	12	13	14	14i	15
Lomandraceae																			
Lomandra longifolia	mat rush	N				x	x	x		x	x	x	x	x	x	x			x
Marsileaceae																			
Marsilea drummondi	nardoo	N		x			x		x	x									
Onagraceae																			
Ludwigia octovalvis	willow ludwigia	N	x					x	x		x	x					x	x	
Ludwigia peploides	water primrose	N						x		x			x	x	x				
Poaceae																			
Cynodon dactylon	couch grass	N	x					x	x	x		x		x					x
Oplismenus sp.	grass	N					x	x											
Polygonacea																			
Persicaria attenuata	knotweed	N																	
Persicaria decipiens	slender knotweed	N			x	x			x	x						x			
Persicaria hydropiper	water pepper	N									x								
Persicaria strigosa	knotweed	N							x										
Rumex crispus	curled dock	E				x			x	x		x							
Rumex sp.	dock	N							x						x		x		
Pteridaceae																			
Pteris vittata	ladder brake	N																x	
Thelypteridaceae																			
Christella sp.		N							x	x									

GROWTH FORM / Family */ Latin name*	Common name	Native/ exotic	1	2	3	4	5	6	7	8	8a	9	10	11	12	13	14	14i	15
SUBMERGED																			
Hydrocharitaceae																			
Blyxa sp.		N				x													
FLOATING																			
Azollaceae																			
Azolla sp.		N																	
Hydrocharitaceae																			
Ottelia ovalifolia	swamp lily	N								x									
Lemnaceae																			
Spirodela sp.		N												x		x			

Table 4.17 Aquatic macrophytes at springs A – P in Upper Dawson Catchment, listed by growth form.

GROWTH FORM / Family / *Latin name*	**Common name**	**Native/ Exotic**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
EMERGENT																		
Amaranthaceae																		
Alternanthera denticulata	lesser joy-weed	N	x					x	x	x	x	x	x		x	x		
Apiacea																		
Centella asiatica	indian pennywort	N			x				x								x	
Cyclospermum leptophyllum	slender celery	E			x													
Hydrocotyle laxiflora	stinking pennywort	N						x				x						x
Blechnaceae																		
Blechnum sp.	water fern	N							x									
Commelinaceae																		
Commelina sp.		N						x		x		x						
Cyperaceae																		
Carex appressa	tall sedge	N		x			x	x	x		x	x			x		x	
Carex inversa	sedge	N																
Carex lophocarpa	sedge	N																
Cyperus difformis	dirty dora	N			x			x	x	x	x	x		x			x	
Cyperus exaltus	giant sedge	N																
Cyperus flavidus	yellow flat sedge	N																
Cyperus haspan	sedge	N			x			x	x						x			

GROWTH FORM / Family / Latin name	Common name	Native/ Exotic	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Cyperus gracilis	delicate sedge	N	x					x	x		x	x			x	x		x
Cyperus polystachyus	bunchy sedge	N						x										
Cyperus trinervis	sedge	N			x													
Eleocharis cylindrostachys	spike rush	N																
Schoenoplectus mucronatus		N		x						x	x	x						
Schoenoplectus validus	river club rush	N								x								
Graminae																		
Echinochloa colona	awnless barnyard grass	N					x		x		x		x					
Glycera maxima	reed sweet grass	N		x						x	x		x					
Leptochloa digitata	umbrella canegrass	N							x									
Phragmites australis	common reed	N																
Juncaceae																		
Juncus prismatocarpus	rush	N						x	x			x				x		
Juncus usitatus	rush	N			x				x	x	x		x				x	
Lomandraceae																		
Lomandra longifolia	mat rush	N	x		x	x		x					x		x			x
Marsileaceae																		

GROWTH FORM / Family / Latin name	Common name	Native/ Exotic	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Marsilea drummondi	nardoo	N														x		
Onagraceae																		
Ludwigia octovalvis	willow ludwigia	N		x				x	x	x	x	x					x	
Ludwigia peploides	water primrose	N																
Poaceae																		
Cynodon dactylon	couch grass	N				x	x						x					
Oplismenus sp.	grass	N																
Polygonacea																		
Persicaria attenuata	knotweed	N			x			x					x	x		x		
Persicaria decipiens	slender knotweed	N		x		x				x		x						
Persicaria hydropiper	water pepper	N									x							
Persicaria strigosa	knotweed	N																
Rumex crispus	curled dock	E	x	x	x			x	x		x							
Rumex sp.	dock	N			x					x	x	x		x	x			x
Pteridaceae																		
Pteris vittata	ladder brake	N																
Thelypteridaceae																		
Christella sp.		N							x									
SUBMERGED																		
Hydrocharitaceae				x	x											x	x	
Blyxa sp.		N																

GROWTH FORM / Family / Latin name	Common name	Native/ Exotic	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
FLOATING																		
Azollaceae																		
Azolla sp.		N																
Hydrocharitaceae																		
Ottelia ovalifolia	swamp lily	N																
Lemnaceae												x		x				
Spirodela sp.		N																

Aquatic Fauna

This study did not intend to provide a comprehensive description of the aquatic fauna present at the artesian springs in the Upper Dawson catchment. As such, no targeted fauna surveys were undertaken; however, all aquatic fauna that was encountered was identified and enumerated. Aquatic snails, fish and turtles were recorded from the artesian springs in the Upper Dawson Catchment.

Aquatic snails (*Glyptophysa cf gibbosa*) were recorded in abundance at Springs 5, 8a, 9, 12, C and H (Figure 4.60). *G. gibbosa* is relatively common snail species that is found outside of artesian spring communities, however the collected snails were considerably smaller than the smallest non-spring specimens on record, and therefore may actually be a subspecies (Stanisic, J. [Queensland Museum] pers. comm. 2008, 9 December). No other aquatic snails were recorded; no boggomoss snails (*Adclarkia dawsonensis*) were recoded from searches through damp leaf litter at each spring.

Figure 4.60

Aquatic snails (*Glyptophysa cf gibbosa*) collected from Spring 8a in the Upper Dawson Catchment.

Spangled perch (*Leipotherapon unicolor*) and eastern rainbowfish (*Melanotaenia splendida*) were sighted at Springs 8, 14 and G; the noxious mosquito fish (*Gambusia holbrooki*) was also sighted in Spring 8 (Figure 4.61 & Figure 4.62). No other fish were recorded, suggesting that the springs surveyed may provide relatively poor habitat for fish. However, fish of the Dawson River would be expected to utilise the lower waters of springs, near the confluence with the river. Refer to Section 4.5 for a detailed discussion of the distribution and ecology of fish in the study area.

Three white-throated snapping turtles (*Elseya albagula*) were captured from Spring 8 (Figure 4.63). Turtles of the Dawson River would be expected to utilise the lower waters of springs, near the confluence with the river. Refer to Section 4.6 for a detailed discussion of the distribution and ecology of turtles in the study area.

Figure 4.61

Spangled perch (*Leipotherapon unicolor*) from spring 14.

Figure 4.62

Eastern rainbowfish (*Melanotaenia splendida*) from spring 8.

Figure 4.63

Three white-throated snapping turtles (*Elseya albagula*) were captured from Spring 8.

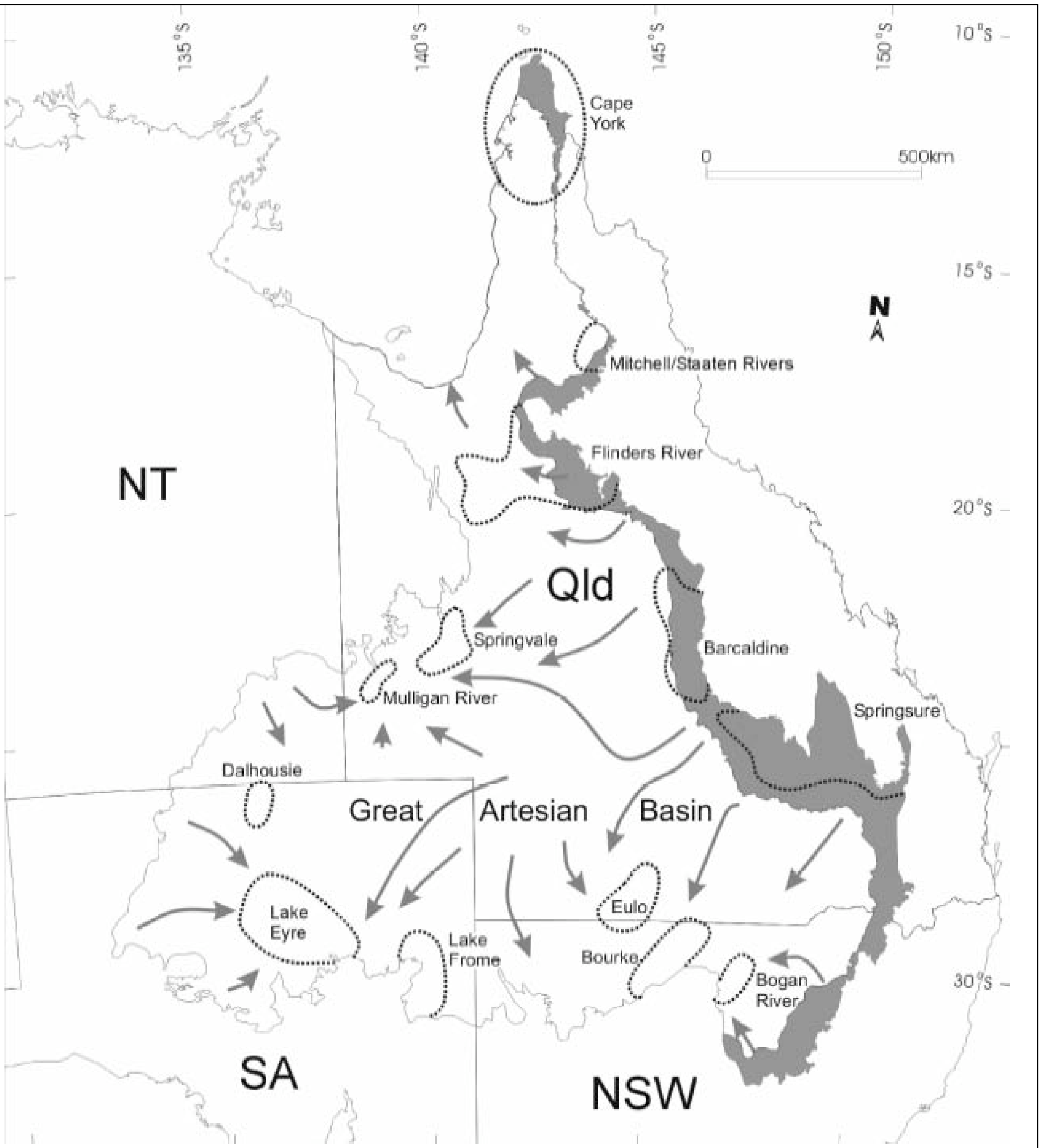
4.7.2 A Regional and Ecological Perspective

The Great Artesian Basin (GAB) is an extensive underground aquifer that covers much of Queensland, and parts of New South Wales, South Australia, and the Northern Territory (Figure 4.64). Although its hydrology is not entirely understood, it appears that it is composed of several basins of largely impermeable rock that permit vertical movement of water at the margins of these basins. Water flows into the GAB through recharge zones, largely along the eastern and northern edges of the GAB, with water slowly moving to the western discharge area over 1-2 million years (Habermehl 2001, cited in Fenshan & Fairfax, 2003). Recharge areas also exist along the western margin of the GAB, but intake is temporally variable. Spring water emanating from the recharge areas is substantially younger than the water at the discharge area, but both spring types support endemic plant, snail and fish communities

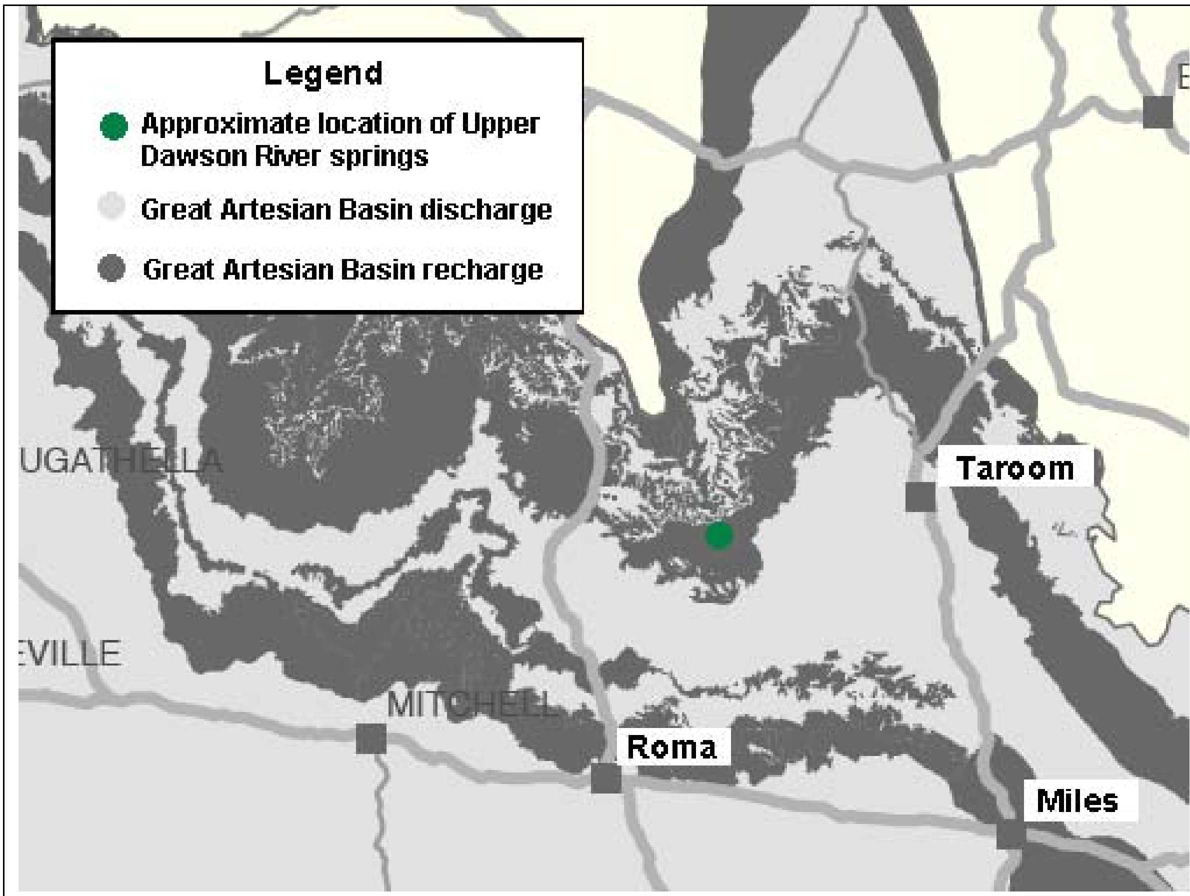
Artesian springs are present throughout much of Queensland and have been located in nine of the 13 biogeographic regions (Fensham et al. 2003). They are known from the Gulf Plains, Einasleigh Uplands, Northwest Highlands, Mitchell Grass Downs, Channel Country, Mulga Lands, Desert Uplands and the Brigalow Belt (the Cape York Peninsula has not been surveyed). The CSG Fields lie within the Brigalow Belt bioregion (Figure 2.1); springs in the vicinity of the CSG Fields are located on recharge areas of the GAB. The position of the Upper Dawson River springs (surveyed in this study) in relation to the recharge areas of the GAB is shown in Figure 4.65.

Of all the Queensland biogeographic regions, the Brigalow belt has the highest number of land-zone settings; springs are found in recent alluvium, ancient clay sheets, alkaline igneous soils, fine-grained sediments, coarse-grained sediments and metamorphics.

Fensham et al. (2003) examined similarities and differences in the floral communities occupying springs in the Brigalow Belt and throughout Queensland using non-metric multidimensional scaling. This study investigated 269 springs or spring complexes (springs within 6 km of each other) containing at least four native macrophytes. Floral communities in non-GAB springs were found to be similar to GAB recharge sites; both communities were significantly different from GAB discharge communities. This was considered to result from the pH of the spring water, because water pH, soil pH and soil texture were found to be a major influence of macrophyte communities. The pH of discharge springs was consistently higher than that of recharge springs.



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 4.64 The Great Artesian Basin. Shaded areas represent recharge areas, arrows indicate flow, and dashed lines show groups of springs. The western recharge areas are not shown.	
	Adapted from Habermehl & Lau 1997	December 2008



frc environmental deep thinking. science.	Santos Coal Seam Gas Fields: Aquatic Ecology Impact Assessment	
	Figure 4.65 Location of Upper Dawson River springs in relation to the Great Artesian Basin.	
	Adapted from Herczeg & Lau 2007	December 2008

Within the Brigalow Belt, spring communities differed according to soil characteristics. Communities growing on coarse-grained sediments (quartose sandstones) were distinct from communities growing on recent alluvium, the latter being most similar to fine-grained sediments (Fensham et al. 2003). The relevance of these findings to this study are that most of the springs in the Upper Dawson Catchment are within close proximity to one another and are likely to contain similar floristic communities, considering the similarities in landform and water pH among sites.

Mound spring communities in the CSG Fields are dependent on the natural discharge of water from the Great Artesian Basin and are listed as threatened ecological communities under the EPBC Act. These communities may also support a number of species that are listed as threatened under the EPBC Act, the NCWR 2006 and the IUCN Red List (See Section 2.3.1).

The CSG Fields fall within the Springsure “Supergroup” of spring communities; springs occur in each of the Comet, Upper Dawson and Condamine – Upper Balonne Catchments (refer Figure 2.1). The floristic condition of many of these springs or spring groups has been ranked according to the presence of native and endemic plant species (Fensham et al. 2004, Fensham & Price 2004). In contrast, the aquatic fauna of these spring communities has been poorly studied, though it is widely recognised that Queensland’s artesian springs are home to many indigenous fish and invertebrates (Ponder 2002). The following section provides a summary of what has been reported from the artesian springs in each of the three catchments that encompass the CSG Fields.

Condamine – Upper Balonne Catchment

There are approximately 19 active artesian springs in the Condamine – Upper Balonne Catchment (EPA 2008b, refer Figure 2.1), as surveyed by Fensham et al. (2003). Three of these springs are located in the CSG Fields; all border Bungil Creek (refer Figure 2.1).

No rare or threatened aquatic flora or fauna have been recorded from artesian springs in the Condamine – Upper Balonne Catchment (Fensham & Price 2004, DEHWA 2008a, EPA 2008). However, this absence of significant species may be because these springs have been poorly studied to date. The Crystalbrook and Mahlong Plains spring groups in the northwest of the catchment (distant from the CSG Fields) are listed as priorities for conservation (Fensham & Price 2004), however, neither of these groups supported endemic plant species at the time of survey. The floristic condition of springs in the CSG Fields did not rank highly in the assessments conducted by Fensham et al. (2004) and Fensham & Price (2004), suggesting a lack of endemic plant species in these communities.

Upper Dawson Catchment

There are approximately 52 active artesian springs in the Upper Dawson Catchment (Fensham et al. 2003, EPA 2008b, this study – refer Figure 2.1). All but three of these springs are located in the CSG Fields (refer Figure 2.1).

The endangered macrophyte salt pipewart (*Eriocaulon carsonii*) has been recorded at the Hutton spring group on Hutton Creek in the Upper Dawson Catchment (Fensham & Price 2004, DEHWA 2008a, EPA 2008). No rare or threatened species of aquatic fauna have been recorded from artesian springs in the Upper Dawson Catchment (DEHWA 2008a, EPA 2008). However, this absence of significant species may be reflective of the unsurveyed status of many of these communities. The Pony Hills and Dawson Two spring groups both lie within the CSG Fields (along the Upper Dawson River) and ranked relatively highly in the assessments conducted by Fensham et al. (2004) and Fensham & Price (2004), but did not support any endemic plant species. The floristic condition of other springs in the CSG Fields did not rank highly in their assessments, suggesting a similar lack of endemic plant species in these communities. This conclusion is supported by the findings of our recent field assessments.

Comet Catchment

There are approximately 30 active artesian springs in the Comet Catchment (EPA 2008b, refer Figure 2.1), as surveyed by Fensham et al. (2003). Four of these springs are located in the CSG Fields (refer Figure 2.1). These springs lie to the west of the upper waters of Planet Creek, and adjacent to the upper waters of Moonlayember and Spring Creeks.

No rare or threatened aquatic flora or fauna have been recorded from artesian springs in the Comet Catchment (Fensham & Price 2004, DEHWA 2008a, EPA 2008). However, this absence of significant species may be reflective of the unsurveyed status of many of these communities. The Carnarvon Gorge spring group in the southwest of the catchment (in the Carnarvon Gorge National Park, distant from the CSG Fields) is listed as a priority for conservation and was ranked as the most significant spring group across the three catchments that encompass the CSG Fields (Fensham & Price 2004). It supports 21 known springs, but is not known to contain any endemic species. The Carnarvon Station and the Bogarella springs groups (both distant to the CSG Fields) also ranked highly (Fensham & Price 2004), but did not support any endemic plant species. The floristic condition of other springs in the CSG Fields did not rank highly in their assessments, suggesting a similar lack of endemic plant species in these communities.

Significant Artesian Spring Groups in Adjacent Catchments

Changes to the hydrology of the GAB are felt across the entire basin, not just at a point of water extraction (Fenshaw & Fairfax 2003), and therefore have the potential to affect spring groups in neighbouring catchments. Catchments that are immediately adjacent to the CSG Fields support three major spring groups of conservation significance; these are the: Major Mitchell, Cockatoo Creek and Boggomoss (or Dawson One) spring groups (Fensham et al. 2004, Fensham & Price 2004). Major Mitchell springs, which are located in the Salvator Rosa Section of the Carnarvon Gorge National Park (in the Nogoa River Catchment), support an endemic species of grass (*Diemeria sp.*) (Fensham et al. 2004). The Cockatoo Creek springs, which are located on the Dawson River downstream of

Taroom (in the Dawson River Catchment), contain two endangered plant species, salt pipewort (*E. carsonii*) and artesian milfoil (*Myriophyllum artesium*) (Fensham et al. 2004). The Boggomoss springs, which are also located on the Dawson River downstream of Taroom (in the Dawson River Catchment), support the critically endangered boggomoss snail (*Adclarkia dawsonensis*) (Stanisic 1996).

4.7.3 Temporal Variance in Artesian Spring Communities

The stability of aquatic organisms in artesian spring communities is entirely dependent on the supply of water from the underlying GAB, and the subsequent variability in the discharge of this water at the spring itself. Historically, the supply of water to GAB springs was relatively consistent, and flow at the springs was fairly constant across years, but varied across seasons (EPA 2005). Logically, spring flow would be expected to be greatest following sustained heavy rainfall (i.e. after infiltration had recharged the GAB, increased artesian pressure and subsequently enhanced spring discharge) and lowest after prolonged dry periods. The condition of aquatic communities would likely follow this pattern of hydraulic activity. In addition, artesian springs are known to exhibit natural temporal dynamism in both presence and condition (Ponder 2002, Fenshaw & Fairfax 2003). That is, artesian springs (and the aquatic communities that they support) may come and go naturally over longer ecological time scales. Indeed, recently emerged mound springs have been recorded in the GAB, and there are examples of mound springs that probably 'dried out' prior to European settlement (Fenshaw & Fairfax 2003).

Since the GAB was discovered as a water resource in 1878, the pressure of the GAB has been reduced through the continued extraction of water, an effect known as "draw-down" (Ponder 2002, Fenshaw & Fairfax 2003, EPA 2005). Roughly 80% of natural discharge springs, and 8% of recharge springs, have become completely or partially inactive during this time (Fenshaw & Fairfax 2003, Fenshaw & Price 2004). The impact of this draw-down is felt across the entire basin, not just at the point of water extraction, and has reduced the volume and rate of discharge at certain springs, resulting in a localised loss of flora and fauna species, especially those species that require permanent water (Fenshaw & Fairfax 2003). The higher rates of inactivity for discharge springs compared with recharge springs may reflect the higher density of bores in the relatively arid discharge areas (Fenshaw & Fairfax 2003). The limited effect of draw down on recharge springs may also be reflective of their occurrence in areas with relatively high rainfall (Fenshaw & Fairfax 2003).

4.7.4 Summary

The condition of artesian springs in the Upper Dawson Catchment varied considerably between the springs surveyed, with the state of each spring largely dependent on: the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds. The smaller, shallower springs provided little habitat for aquatic organisms, but usually supported some macrophytes. In contrast, the larger more complex springs often supported relatively abundant instream habitat and macrophytes. Cattle damage and weeds were common and had degraded the condition of many springs. Farm tracks had been constructed across the upper waters of two springs.

Water quality in the springs was characterised by relatively high temperatures, a slight acidity, and low levels of DO and turbidity. This is likely to be reflective of the condition of the underlying groundwater in the GAB, rather than indicative of any external pressures acting on the water quality of the springs.

The springs typically supported many aquatic macrophytes, but little aquatic fauna, suggesting that these communities may offer relatively poor habitat and connectivity for aquatic organisms. However, the larger more mobile fish and turtles of the Dawson River would be expected to utilise the lower waters of springs, near the confluence with the river. Given the temporal variability in spring flows, it is likely that the springs with smaller flow volumes are less reliable sources of moisture. This may explain why some springs were not intensely vegetated, and why the larger springs typically supported a greater abundance of fauna.

No rare or threatened species were recorded from the artesian springs in the Upper Dawson Catchment, however, given the preliminary nature of the field surveys conducted in this study, the potential presence of rare and threatened aquatic flora and fauna cannot be discounted. Indeed, the endangered macrophyte salt pipewart has been recorded at springs on Hutton Creek in the Upper Dawson Catchment.

Artesian springs elsewhere in the CSG Fields may support similar communities to the springs in the Upper Dawson Catchment, where similar geomorphic and hydraulic conditions are present. However, no rare or threatened aquatic floral or fauna have been recorded from artesian springs in the Condamine – Upper Balonne and Comet Catchments, though this may be because these springs have been poorly surveyed to date.

4.8 Other Aquatic Vertebrates

Our survey did not specifically target other vertebrates, however, the presence of any semi-aquatic vertebrates encountered was recorded.

Six frog species were observed in the present study. Broad-palmed frogs (*Litoria latopalmata*) were recorded at Yalebone Creek (Site 11), the Dawson River (Sites 12 & 16), Kinnoul Creek (Site 16), Baffle Creek (Site 18), Commissioner Creek (Site 21) and the Comet River (Site 30). Desert tree frogs (*Litoria rubella*) were recorded at the Dawson River (Sites 12 & 16), Kinnoul Creek (Site 15) and Injune Creek (Site 20). Emerald-spotted tree frogs (*Litoria peronii*) were recorded at the Dawson River (Site 12) and Injune Creek (Site 20). Rocket frogs (*Litoria nasuta*) were recorded at Bony Creek (Site 9) and Injune Creek (Site 20). An ornate burrowing frog (*Lymnodynastes ornatus*) was recorded at Yalebone Creek (Site 11), and a green tree frog (*Litoria caerulea*) was recorded at Bony Creek (Site 9).

Figure 4.66

A desert tree frog (*Litoria rubella*) at the Dawson River (Site 16) in the Upper Dawson Catchment.

Figure 4.67

A broad-palmed frog (*Litoria latopalmata*) at Yalebone Creek (Site 11) in the Condamine-Upper Balonne Catchment.

A goanna (*Varanus varius*) was observed at Tchanning Creek (Site 6) and Yalebone Creek (Site 11). A keelback snake (*Tropidonophis mairii*) was observed at the Comet River (Site 27). Two black ducks (*Anas superciliosa*) were observed at the Dawson River (Site 15); three black ducks were observed at Dulacca Creek (Site 7). An echidna (*Tachyglossus aculeatus*) was observed on top of the bank at Hutton Creek (Site 17).

No aquatic amphibians, reptiles (other than turtles) or mammals of significant conservation status have been recorded from, or are likely to occur in, the study area (DEW 2007a; EPA 2007b). Platypus (*Ornithorhynchus anatinus*) have not been recorded from waterways in the study area (EPA 2007b). However, local residents of Taroom have reported platypus in the Upper Dawson River. No evidence of platypus was observed at the sites visited during the field surveys. It is unlikely that they would inhabit ephemeral streams in the CSG Fields; however, they may be present in more permanent waterbodies in the region (EPA 2006), such as the Dawson and Comet Rivers.

4.9 Summary of Aquatic Environmental Values

4.9.1 Watercourses of the CSG Fields

The Environmental Values of watercourses within the study area are relatively low and consistent with those of the wider catchments. Environmental values are dictated primarily by the ephemeral nature of many of the region's waterways, although agricultural development (particularly grazing) within the region has significantly influenced water quality and the physical characteristics of aquatic habitat. Degraded creeks in the catchment are characterised by riparian vegetation loss, erosion, low habitat diversity, invasion of weed species, poor water quality and sedimentation. Several road crossings of creeks in the study area are likely to cause alterations of flow and restrict aquatic fauna passage under particular flow regimes.

Water quality is generally poor and is characterised by high turbidity and low or variable dissolved oxygen levels. Watercourses within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants from surrounding land uses, and are subject to a range of severe natural stresses. As such, the water quality of the creeks within the CSG Fields is currently affected by elevated turbidity, salinity, and is likely to be impacted by nutrient enrichment.

Biodiversity is relatively low, with only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions inhabiting the study area. Introduced species, including the declared noxious mosquitofish and carp, and the introduced goldfish were found in the waterways of the CSG Fields. Nevertheless, these creeks do offer some habitat to the native fish species that were recorded in the study area, and may be provide habitat for breeding and dispersal during periods of high flow. The larger waterways in the study area, such as the Dawson and Comet Rivers and Lake Nuga Nuga support more permanent water, and therefore offer more stable habitat for aquatic organisms. As a result, these waterways would be expected to support more abundant and diverse communities, and contain more taxa that are sensitive to pollution and disturbance. However, this was not consistently the case, with many of the smaller ephemeral creeks supporting communities that were comparable with the larger waterways. The specific differences in communities between sites appeared to be related to site-specific differences in the availability and diversity of habitat. Though the presence of permanent water and the level of connectivity in each watercourse was clearly an important factor in structuring the communities of larger aquatic vertebrates, such as fish and turtles.

No rare or threatened species of aquatic fauna have been recorded from the watercourses of the study area. However, the upper Dawson River (in the CSG Fields) does support potential nesting habitat for the Fitzroy River turtle, between Yebna Crossing and Dawson's Bend. Therefore, the potential presence of this endangered species in this catchment cannot be discounted.

4.9.2 Spring of the CSG Fields

The condition of artesian springs in the Upper Dawson Catchment varied considerably between the springs surveyed, with the state of each spring largely dependent on: the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds. Cattle damage and weeds were common and had degraded the condition of many springs. Farm tracks had been constructed across the upper waters of two springs.

Springs in the Upper Dawson Catchment typically supported many aquatic macrophytes, but little aquatic fauna, suggesting that these communities may offer relatively poor habitat and connectivity for aquatic organisms. However, these springs do provide habitat for macrophytes, aquatic invertebrates, fish and turtles, and are unique and important habitats with intrinsic environmental values.

The endangered macrophyte salt pipewart has been recorded at springs on Hutton Creek in the Upper Dawson Catchment. No other rare or threatened aquatic flora or fauna have been recorded from artesian springs in the CSG Fields, though this may be because these springs have been poorly surveyed to date.

5 Potential Impacts

5.1 Key Components of the Development of the CSG Fields

The proposed development of the Coal Seam Gas (CSG) Fields will involve the drilling of development wells to supply approximately 5300 petajoules (PJ) (140 billion m^3) CSG to a natural gas liquefaction and export facility (the LNG Facility) on Curtis Island, near Gladstone. This will likely equate to approximately 600 development wells prior to 2015 and possibly 1400 or more wells after 2015 (excluding exploration wells). In addition to the drilling of wells, development of the CSG Fields will include the construction of supporting associated infrastructure. Details of the specific number and location of well sites, access roads and facilities are yet to be determined.

The development and operation of the CSG Fields has the potential to impact on aquatic ecology through:

- discharge or injection of associated water
- stormwater and associated water entering creeks or springs as runoff
- vegetation clearing and earth moving within or adjacent to creeks and springs
- extraction of associated water for CSG production
- operation of vehicles and equipment
- creation of pipeline creek crossings
- construction of vehicle creek crossings
- obstruction of flow and aquatic fauna passage, and
- creation of breeding habitat for biting insects.

The assessment of potential impacts relates to the development and expansion of the CSG Fields. Given that furture development will be subject to an incremental planning process, this assessment has been conducted across the CSG Fields generally, and therefore does not consider the specific locations of potential impacting processes. Rather, it provides an overall assessment of the range of potential impacts at the catchment level, and outlines recommended controls to avoid, minimise or mitigate the potential for impacts on aquatic ecology. Therefore, this assessment of potential impacting processes will need to be refined once the specific details of the development have been determined.

5.2 Potential Impacts and Mitigation Controls

A summary of the potential impacts of the development, operation and decommissioning of the CSG Fields is provided in Table 5.1. The table outlines recommended controls to avoid, minimise or mitigate the potential for impacts on aquatic ecology. A more detailed discussion of potential impacting processes, and an appraisal of opportunities to avoid, minimize and mitigate impacts is provided in Appendix E and F, respectively. Following is a brief summary of likely residual impacts on aquatic ecology.

5.2.1 Construction

Roads and pipelines in the CSG Fields should be planned to avoid artesian springs. These communities are listed as threatened ecological communities under the EPBC Act. Where possible, a minimum ecological buffer of 100 m should be retained. Where the construction of roads and pipelines is required in proximity to artesian springs, further detailed assessments of the potential for impact may be required. Where roads and pipelines are located to minimise disturbance to the riparian vegetation and instream habitats of watercourse in the CSG Fields, and the recommended mitigation controls (Table 5.1) are followed, it is unlikely that construction would have an ecologically significant impact on the watercourses of the CSG Fields. Where the construction of road and pipeline crossings follows the recommended mitigation controls (Table 5.1) and instream habitats are appropriately rehabilitated following the completion of work, there will be no permanent impact on the watercourses of the CSG Fields. However, there may be a temporary impact to the passage of fish and turtles (in waterways that support these species) during construction activities.

Drilling leases should also be planned to avoid artesian springs. A groundwater impact study to assess the potential impacts of drawdown on artesian springs should be conducted prior to the commencement of any drilling works. This study would need to inform the design of a monitoring program aimed at detecting changes in rates of spring discharges over the period of water extraction. Where drilling operations are located to minimize disturbance to the riparian vegetation of watercourses in the CSG Fields, and the recommended mitigation controls (Table 5.1) are followed, it is unlikely that drilling works would have an ecologically significant impact on the watercourses of the CSG Fields.

Where fuel storage and handling activities are undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols), the risk to the aquatic ecology posed by fuel spilt during construction is considered to be very low.

Appendix A Description of the Sites Surveyed

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	18
Flow Regime:	Ephemeral	pH:	6.59
Channel Width (m):	60	Conductivity (uS/cm):	105.1
Wetted Width (m):	4	DO (% Sat):	35.3
Water Level:	Low	Turbidity (NTU):	204.5
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	2
Rapid:	-	Pebble:	25
Cascade:	-	Gravel:	20
Fall:	-	Sand:	53
Overall Complexity:	Low	Silt/Clay:	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 40
Dominant Type:	Eucalypt, Acacia	

Fauna

Agassiz's glassfish (*Ambassis agassizii*)
River prawn (*Macrobrachium sp.*)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Small woody debris and cobble

Comments: Erosion downstream of road crossing. Box culverts at crossing, reinforced with concrete downstream. Riparian clearing to bank in places.

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08.07.02 GLNG CSG Fields

Survey Date: 26-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Bungeworgorai Creek, Condamine-Balonne Catchment

Cond. M

frc site number 1

UTM Zone 55J 681825 E 7043137 N GDA 94


View upstream through the site


View of right bank


View of left bank


View downstream through the site


Spangled perch captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	30
Wetted Width (m):	5
Water Level:	Low
Bank Shape:	Vertical and sloping

Water Quality

Temperature (C):	16.4
pH:	6.67
Conductivity (uS/cm):	160.2
DO (% Sat):	22.6
Turbidity (NTU):	241

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	5
Sand:	90
Silt/Clay:	5

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 15
Dominant Type:	Eucalypt, Casuarina	

Fauna

Spangled perch (*Leipotherapon unicolor*)
River prawn (*Macrobrachium sp.*)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Small and large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	35-65%	Deep pools and detritus

Comments: Steep eroded banks to creek bed. Bridge crossing immediately downstream.

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08.07.02 GLNG CSG Fields

Survey Date: 27-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Bungil Creek, Condamine-Balonne Catchment

frc site number 2
UTM Zone 55J 678722 E 7075125 N GDA 94

Cond. M

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Mat Rush on the right bank

Channel Habitat

Morphology		Water Quality	
Pattern:	Meanders	Temperature (C):	23.4
Flow Regime:	Ephemeral	pH:	6.76
Channel Width (m):	50	Conductivity (uS/cm):	105.8
Wetted Width (m):	8	DO (% Sat):	47.6
Water Level:	Low	Turbidity (NTU):	266
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	-
Rapid:	-	Pebble:	-
Cascade:	-	Gravel:	2
Fall:	-	Sand:	80
Overall Complexity:	Low	Silt/Clay:	12

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 20
Dominant Type:	Eucalypt	

Fauna

Spangled perch (*Leipotherapon unicolor*)
Bony bream (*Nematolosa erebi*)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep polls and banks
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Man made

Comments: Steep eroded banks; debris and reosion from recent high flows. Bridge crossing immediately downstream; small instream stone weir (1 m high) approximately 20m downstream of the bridge.

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08.07.02 GLNG CSG Fields

Survey Date: 24-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Blyth Creek, Condamine-Balonne Catchment

frc site number 3

UTM Zone 55J 695658 E 7058537 N GDA 94

Cond. P

View upstream through the site

View of right bank

View of left bank

View downstream through the site

Channel Habitat

Morphology		Water Quality	
Pattern:	Meanders	Temperature (C):	18.4
Flow Regime:	Ephemeral	pH:	6.69
Channel Width (m):	30	Conductivity (uS/cm):	121
Wetted Width (m):	4	DO (% Sat):	31.8
Water Level:	Low	Turbidity (NTU):	364
Bank Shape:	Vertical and sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	2
Rapid:	-	Pebble:	8
Cascade:	-	Gravel:	10
Fall:	-	Sand:	65
Overall Complexity:	Low	Silt/Clay:	15

Flora and Fauna

Vegetation

Riparian Width (m): Left: 8 Right: 10

Dominant Type: Eucalypt, pasture grass

Fauna

Carp gudgeon (*Hypseleotris* spp.)

Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep pools
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Small and large woody debris, man made and instream vegetation

Comments: E rosion downstream of road crossing. Four box culverts at crossing, reinforced with concrete downstream. Riparian clearing to bank in places. Litter present in waterway.

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08.07.02 GLNG CSG Fields

Survey Date: 24-09-08

Written By: MK Approved By: AO

Date Issued: Oct 2008

Wallumbilla Creek, Condamine-Balonne Catchment

Cond. M

frc site number 4

UTM Zone 55J 717611 E 7057057 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Goldfish captured at the site.

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	18
Wetted Width (m):	12
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	18
pH:	6.68
Conductivity (uS/cm):	269.1
DO (% Sat):	18.8
Turbidity (NTU):	880

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	5
Cobble:	5
Pebble:	5
Gravel:	10
Sand:	15
Silt/Clay:	60

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 5	Right: 8
Dominant Type:	Eucalypt, Melaleuca	

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Goldfish (*Carassius auratus*)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep pools
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	65-90%	Large woody debris and overhanging vegetation

Comments: Bridge crossing immediately downstream; old dirt crossing immediately adjacent to bridge (fill remains and partially obstructs waterway).

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08.07.02 GLNG CSG Fields

Survey Date:	25-09-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Yuleba Creek, Condamine-Balonne Catchment

Cond.
M

frc site number 5

UTM Zone 55J 742986 E 7023475 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Carp gudgeon captured

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	8
Wetted Width (m):	7
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	21.9
pH:	5.94
Conductivity (uS/cm):	111
DO (% Sat):	33.5
Turbidity (NTU):	569

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	50
Silt/Clay:	50

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 20
Dominant Type:	Eucalypt, Callistemon	

Fauna

Carp gudgeon (*Hypseleotris* spp.)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	10-35%	Overhanging vegetation

Comments: Old dirt road crossing downstream. Steep eroded banks. Some stock damage.

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08.07.02 GLNG CSG Fields

Survey Date: 23-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Tchanning Creek, Condamine-Balonne Catchment

frc site number 6

UTM Zone 55J 756616 E 7040013 N GDA 94

Cond.

P

View upstream through the site

View of right bank

View of left bank

View downstream through the site

Carp captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	8
Wetted Width (m):	3
Water Level:	Low
Bank Shape:	Vertical

Water Quality

Temperature (C):	19.9
pH:	6.85
Conductivity (uS/cm):	300
DO (% Sat):	61.9
Turbidity (NTU):	144.9

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	40
Silt/Clay:	60

Flora and Fauna

Vegetation

Riparian Width (m): Left: 20 Right: 10

Dominant Type:

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Mosquitofish (*Gambusia holbrooki*)
Carp (*Cyprinus carpio*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Small woody debris
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	10-35%	Large woody debris and detritus

Comments: Some stock damage. Road crossing with culvert approximately 50 m downstream.

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08.07.02 GLNG CSG Fields

Survey Date: 23-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Dulacca Creek, Condamine-Balonne Catchment

Cond. P

frc site number 7

UTM Zone 55J 777507 E 7036044 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Road bridge upstream of the site

Channel Habitat

Morphology		Water Quality	
Pattern:	Meanders	Temperature (C):	18.6
Flow Regime:	Ephemeral	pH:	6.87
Channel Width (m):	40	Conductivity (uS/cm):	121.6
Wetted Width (m):	4	DO (% Sat):	44.7
Water Level:	Low/mod.	Turbidity (NTU):	158.6
Bank Shape:	Vertical and sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	5
Rapid:	-	Pebble:	2
Cascade:	-	Gravel:	18
Fall:	-	Sand:	75
Overall Complexity:	Low/mod.	Silt/Clay:	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 5	Right: 10
Dominant Type:	Eucalypt, grasses	

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Instream vegetation
Filamentous algae:	<10%	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Small and large woody debris and Man made

Comments: Road crossing with perched culvert perched immediately upstream. Substantially concrete armourment downstream of culvert. Significant flood erosion on left bank.

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08.07.02 GLNG CSG Fields

Survey Date: 24-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Yuleba Creek, Condamine-Balonne Catchment

Cond. P

frc site number 8

UTM Zone 55J 731009 E 7088261 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Nardoo on the banks

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	ephemeral
Channel Width (m):	100
Wetted Width (m):	8
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	19
pH:	6.56
Conductivity (uS/cm):	106.2
DO (% Sat):	24.1
Turbidity (NTU):	361

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	4
Sand:	6
Silt/Clay:	80

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 15
Dominant Type:	Eucalypt, Callistemon	

Fauna

Mosquitofish (*Gambusia hollbrooki*)
Goldfish (*Carassius auratus*)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Overhanging vegetation
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Small and large woody debris and Deep pools

Comments: Road bridge immediately upstream.

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08.07.02 GLNG CSG Fields

Survey Date:	26-09-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Bony Creek, Condamine-Balonne Catchment

Cond. M

frc site number 9

UTM Zone 55J 693744 E 7030609 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Couch grass on the right bank

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	21.1
Flow Regime:	Ephemeral	pH:	6.24
Channel Width (m):	15	Conductivity (uS/cm):	130
Wetted Width (m):	4	DO (% Sat):	52
Water Level:	Moderate	Turbidity (NTU):	322
Bank Shape:	Vertical and sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	1
Pool:	100	Cobble:	9
Rapid:	-	Pebble:	20
Cascade:	-	Gravel:	20
Fall:	-	Sand:	20
Overall Complexity:	Moderate	Silt/Clay:	30

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 15
Dominant Type:	Eucalypt, Melaleuca	

Fauna

Mosquitofish (*Gambusia hollbrooki*)
Carp gudgeon (*Hypseleotris* spp.)
Yabby (*Cherax destructor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Trailing bank vegetation
Filamentous algae:	None	
Macrophytes:	35-65%	Sub Dominate Cover Type:
Detritus:	10-35%	Deep pools and overhanging vegetation

Comments: Road bridge immediately upstream.

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08.07.02 GLNG CSG Fields

Survey Date: 25-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Wallumbilla Creek, Condamine-Balonne Catchment

frc site number 10
UTM Zone 55J 720992 E 7020391 N GDA 94

Cond.
M

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Crayfish captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	15
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Vertical and sloping

Water Quality

Temperature (C):	23.2
pH:	6.3
Conductivity (uS/cm):	207
DO (% Sat):	78
Turbidity (NTU):	340

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	70
Silt/Clay:	30

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 20
Dominant Type:	Eucalypt	

Fauna

Yabby (*Cherax destructor*)
River prawn (*Macrobrachium* sp.)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	<10%	Small woody debris and overhanging vegetation

Comments: Disused old road bridge through site; dirt road crossing approximately 200 m upstream,

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08.07.02 GLNG CSG Fields

Survey Date:	25-09-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Yalebone Creek, Condamine-Balonne Catchment

Cond. P

frc site number 11

UTM Zone 55J 684194 E 7021915 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Perennial
Channel Width (m):	50
Wetted Width (m):	15
Water Level:	Low/mod.
Bank Shape:	Sloping

Water Quality

Temperature (C):	22.6
pH:	7.47
Conductivity (uS/cm):	368
DO (% Sat):	50.1
Turbidity (NTU):	77

Habitat (%)

Riffle:	-
Run:	100
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	5
Silt/Clay:	95

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 20
Dominant Type:	Eucalypt, Melaleuca	

Fauna

Krefft's river turtle (*Emydura krefftii*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep polls
Filamentous algae:	<10%	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Overhanging vegetation

Comments: Old road bridge through site; new road bridge approximately 100 m upstream.

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08.07.02 GLNG CSG Fields

Survey Date: 30-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Dawson River, Upper Dawson Catchment

Cond. **G**

frc site number 12

UTM Zone 55J 780167 E 7160879 N GDA 94

View upstream through the site

View of right bank

View of left bank

View downstream through the site

Crayfish captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	7
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	21.8
pH:	7.45
Conductivity (uS/cm):	304
DO (% Sat):	48.9
Turbidity (NTU):	1537

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	2
Cobble:	3
Pebble:	5
Gravel:	8
Sand:	72
Silt/Clay:	10

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 5	Right: 3
Dominant Type:	Eucalypt	

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Eastern rainbowfish (*Melanotaenia splendida*)
Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Small woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Boulder, cobble and deep pools

Comments: Bitumen road crossing through site; no culvert.

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08.07.02 GLNG CSG Fields

Survey Date: 01-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Bungaban Creek, Upper Dawson Catchment

Cond. M

frc site number 13

UTM Zone 55J 792663 E 7140201 N GDA 94


View upstream through the site


View of right bank


View of left bank


View downstream through the site


Carp gudgeon captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	4
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Vertical

Water Quality

Temperature (C):	20.5
pH:	6.74
Conductivity (uS/cm):	136.5
DO (% Sat):	39.4
Turbidity (NTU):	535

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	High

Substrate (%)

Bedrock:	-
Boulder:	10
Cobble:	10
Pebble:	-
Gravel:	-
Sand:	20
Silt/Clay:	60

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 6	Right: 5
Dominant Type:	Eucalypt	

Fauna

Carp gudgeon (*Hypseleotris* spp.)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Overhanging vegetation
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	<10%	Large woody debris and instream vegetation

Comments: Two road bridges through site; one now disused.

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08.07.02 GLNG CSG Fields

Survey Date: 01-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Roche Creek, Upper Dawson Catchment

Cond. M

frc site number 14

UTM Zone 55J 790708 E 7128177 N GDA 94

View upstream through the site

View of right bank

View of left bank

View downstream through the site

Rainbowfishs captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	12
Wetted Width (m):	3
Water Level:	Moderate
Bank Shape:	Vertical and sloping

Water Quality

Temperature (C):	27.6
pH:	7.10
Conductivity (uS/cm):	162.4
DO (% Sat):	64.9
Turbidity (NTU):	137.5

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	2
Cobble:	5
Pebble:	5
Gravel:	5
Sand:	5
Silt/Clay:	78

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 5	Right: 4
Dominant Type:	Eucalypt, Callistemon	

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Eastern rainbowfish (*Melanotaenia splendida*)
Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Boulder and deep pools

Comments: Bitumen road crossing with perched culvert through site. Extensive reparian clearing.

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08.07.02 GLNG CSG Fields

Survey Date: 30-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Kinnoul Creek, Upper Dawson Catchment

Cond. M

frc site number 15

UTM Zone 55J 764272 E 7157514 N GDA 94


View upstream through the site


View of right bank


View of left bank


View downstream through the site


Turtle trap on the right bank

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	50
Wetted Width (m):	8
Water Level:	High/mod.
Bank Shape:	Sloping and vertical

Water Quality

Temperature (C):	22.8
pH:	7.9
Conductivity (uS/cm):	575
DO (% Sat):	86.1
Turbidity (NTU):	82.5

Habitat (%)

Riffle:	10
Run:	90
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	High

Substrate (%)

Bedrock:	2
Boulder:	2
Cobble:	2
Pebble:	4
Gravel:	8
Sand:	20
Silt/Clay:	62

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 30	Right: 30
Dominant Type:	Eucalypt, Casuarina	

Fauna

Pcific blue eyes (*Pseudomugil signifer*)
Eastern rainbowfish (*Melanotaenia splendida*)
Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	<10%

Dominate Cover Type:
Large woody debris and overhanging vegetation
Sub Dominate Cover Type:
Undercut bank, man made and banks

Comments: Bitumen road crossing with three box culverts through site. Weeds abundant in the riparian zone.

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08.07.02 GLNG CSG Fields

Survey Date:	29-09-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Dawson River, Upper Dawson Catchment

Cond. **G**

frc site number 16

UTM Zone 55J 722222 E 7156673 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	24.1
Flow Regime:	Ephemeral	pH:	7.44
Channel Width (m):	8	Conductivity (uS/cm):	221
Wetted Width (m):	3	DO (% Sat):	71.4
Water Level:	Low	Turbidity (NTU):	46.5
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	-
Rapid:	-	Pebble:	2
Cascade:	-	Gravel:	5
Fall:	-	Sand:	18
Overall Complexity:	Moderate	Silt/Clay:	75

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 3	Right: 10
Dominant Type:	Eucalypt, Casuarina	

Fauna

Eastern rainbowfish (*Melanotaenia splendida*)
Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	10-35%	
Macrophytes:	10-35%	Sub Dominate Cover Type:
Detritus:	10-35%	Overhanging and trailing bank vegetation

Comments: Road bridge immediately upstream of site. Riparian clearing and evidence of a recent fire in the riparian zone.

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08.07.02 GLNG CSG Fields

Survey Date: 27-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Hutton Creek, Upper Dawson Catchment

Cond. M

frc site number 17

UTM Zone 55J 666311 E 7151767 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Spangled perch captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	5
Wetted Width (m):	5
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	19.7
pH:	6.81
Conductivity (uS/cm):	125
DO (% Sat):	75.4
Turbidity (NTU):	397

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	60
Boulder:	10
Cobble:	10
Pebble:	-
Gravel:	-
Sand:	10
Silt/Clay:	10

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 3	Right: 5
Dominant Type:	Eucalypt, Pine	

Fauna

Eastern rainbowfish (*Melanotaenia splendida*)
Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Overhanging vegetation
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Deep pools, trailing bank and instream vegetation

Comments: Dirt road crossing through site.

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08.07.02 GLNG CSG Fields

Survey Date: 28-09-08
Written By: MK   Approved By: AO
Date Issued: Oct 2008

Baffle Creek, Upper Dawson Catchment

frc site number 18

UTM Zone 55J 681774 E 7167960 N GDA 94

Cond. G





View upstream through the site	View of right bank	View of left bank	View downstream through the site	Road upstream of the site

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	21.5
Flow Regime:	Ephemeral	pH:	7.54
Channel Width (m):	1.5	Conductivity (uS/cm):	196.5
Wetted Width (m):	1	DO (% Sat):	88.9
Water Level:	Low	Turbidity (NTU):	860
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	15
Rapid:	-	Pebble:	15
Cascade:	-	Gravel:	20
Fall:	-	Sand:	30
Overall Complexity:	Moderate	Silt/Clay:	20

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 4	Right: 7
Dominant Type:	Eucalypt, Casuarina	

Fauna

Carp gudgeon (*Hypseleotris* spp.)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Boulder

Comments: Bitumen road csossing with two pipe-culverts through site. Weedscommon in the riparian zone.

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08.07.02 GLNG CSG Fields

Survey Date: 28-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Dawson River, Upper Dawson Catchment

Cond. M

frc site number 19

UTM Zone 55J 684000 E 7179902 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	*Carex* sp. on the banks

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Intermitent
Channel Width (m):	1
Wetted Width (m):	1
Water Level:	-
Bank Shape:	Vertical and sloping

Water Quality

Temperature (C):	22.4
pH:	6.8
Conductivity (uS/cm):	88.9
DO (% Sat):	57.1
Turbidity (NTU):	231

Habitat (%)

Riffle:	30
Run:	-
Pool:	70
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	5
Cobble:	60
Pebble:	10
Gravel:	5
Sand:	10
Silt/Clay:	10

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 4	Right: 4
Dominant Type:	Eucalypt	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Cobble

Comments: Road bridge through site. Evidence of recent flood erosion and debris.

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08.07.02 GLNG CSG Fields

Survey Date: 28-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Injune Creek, Upper Dawson Catchment

Cond. M

frc site number 20

UTM Zone 55J 657291 E 7140346 N GDA 94

View upstream through the site

View of right bank and dirt crossing

View of left bank

View downstream through the site

Spangled perch captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	20
Wetted Width (m):	3
Water Level:	Low
Bank Shape:	-

Water Quality

Temperature (C):	20.7
pH:	6.46
Conductivity (uS/cm):	120
DO (% Sat):	24.9
Turbidity (NTU):	1420

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	1
Gravel:	4
Sand:	5
Silt/Clay:	90

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 8	Right: 10
Dominant Type:	Eucalypt, Cyperus	

Fauna

Spangled perch (*Leipotherapon unicolor*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep pools and instream vegetation
Filamentous algae:	None	
Macrophytes:	10-35%	Sub Dominate Cover Type:
Detritus:	<10%	Overhanging vegetation and detritus

Comments: Dirt road crossing through site. Weeds common in the riparian zone. Some riparian vegetation clearing.

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08.07.02 GLNG CSG Fields

Survey Date: 29-09-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Commissioner Creek, Upper Dawson Catchment

Cond. M

frc site number 21

UTM Zone 55J 714247 E 7149046 N GDA 94

				
View along the bank	View along the bank	View though the reservoir	View though the reservoir	

Channel Habitat

Morphology

Pattern:	Lake
Flow Regime:	Perrenial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Moderate
Bank Shape:	Open

Water Quality

Temperature (C):	24.6
pH:	7.6
Conductivity (uS/cm):	336
DO (% Sat):	68.1
Turbidity (NTU):	31.5

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 5
Dominant Type:	Eucalypt	

Fauna

Krefft's river turtle *(Emydura kreffti)*

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	30
Silt/Clay:	70

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep pools and instream vegetation
Filamentous algae:	None	
Macrophytes:	10-35%	Sub Dominate Cover Type:
Detritus:	<10%	Overhanging vegetation and detritus

Comments: The site is a lake. Many long dead trees in the lake. Vegetation along lakeshore is indicative of a variable water level.

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08.07.02 GLNG CSG Fields

Survey Date: 2-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Lake Nuga Nuga, Comet Catchment

Cond. M

frc site number 22

UTM Zone 55J 670631 E 7234538 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Carp gudgeon captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	15
Wetted Width (m):	7
Water Level:	Low
Bank Shape:	Vertical

Water Quality

Temperature (C):	26.5
pH:	7.27
Conductivity (uS/cm):	259
DO (% Sat):	54.1
Turbidity (NTU):	439

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	1
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	4
Silt/Clay:	95

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 8	Right: 15
Dominant Type:	Eucalypt	

Fauna

Carp gudgeon (*Hypseleotris* spp.)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Detritus
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	65-90%	Large woody debris

Comments: Road bridge through site.

frc environmental deep thinking. science.	08.07.02 GLNG CSG Fields	Brown River, Comet Catchment	Cond.
	Survey Date: 2-10-08	frc site number 23	P
	Written By: MK Approved By: AO	UTM Zone 55J 678567 E 7210854 N GDA 94	
	Date Issued: Oct 2008		

View upstream through the site

View of right bank

View of left bank

View downstream through the site

Hardyhead flyspecked captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	10
Wetted Width (m):	1
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	30.8
pH:	8.84
Conductivity (uS/cm):	238
DO (% Sat):	139.1
Turbidity (NTU):	34.3

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	95
Silt/Clay:	5

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 2	Right: 2
Dominant Type:	Eucalypt, Casuarina	

Fauna

Eastern rainbowfish (*Melanotaenia splendida*)
Hardyhead flyspecked (*Craterocephalus stercusmuscarum*)
Purple spotted gudgeon (*Mogurnda adspersa*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	10-35%	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	<10%	Small woody debris

Comments: Road bridge upstream of site. Abundant flood debris. Water restricted to scenesing pools.

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08.07.02 GLNG CSG Fields

Survey Date:	6-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Carnavon Creek, Comet Catchment

Cond. **P**

frc site number 24

UTM Zone 55J 653931 E 7237744 N GDA 94


View upstream through the site


View of right bank


View of left bank


View downstream through the site


Purple spotted gudgeon captured

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	20
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Vertical and sloping

Water Quality

Temperature (C):	26
pH:	7.5
Conductivity (uS/cm):	236
DO (% Sat):	66.7
Turbidity (NTU):	50

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	2
Silt/Clay:	98

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 15
Dominant Type:	Eucalypt, Callistemon	

Fauna

Carp gudgeon (*Hypseleotris* spp.)
Eastern rainbowfish (*Melanotaenia splendida*)
Purple spotted gudgeon (*Mogurnda adspersa*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Instream vegetation and detritus
Filamentous algae:	35-65%	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	10-35%	Small and large woody debris and undercut banks

Comments: Bitumen road crossing with pipe culverts immediately upstream. Exotic curled dock (*Rumex cripens*) is abundant in the creek.

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08.07.02 GLNG CSG Fields

Survey Date:	7-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Clemantis Creek, Comet Catchment

Cond.

P

frc site number 25

UTM Zone 55J 679099 E 7255012 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	Eel-tailed catfish captured

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	22.9
Flow Regime:	Ephemeral	pH:	7.18
Channel Width (m):	15	Conductivity (uS/cm):	610
Wetted Width (m):	3	DO (% Sat):	15.9
Water Level:	Low	Turbidity (NTU):	9.6
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	-
Rapid:	-	Pebble:	-
Cascade:	-	Gravel:	-
Fall:	-	Sand:	90
Overall Complexity:	Moderate	Silt/Clay:	10

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 4	Right: 4
Dominant Type:	Eucalypt, Callistemon	

Fauna

Spangled perch (*Leipotherapon unicolor*)
Purple spotted gudgeon (*Mogurnda adspersa*)
Eel-tailed catfish (*Tandanus tandanus*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	<10%	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	35-65%	Small woody debris and detritus

Comments: Road bridge upstream of site. Abundant flood debris and bank erosion.

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08.07.02 GLNG CSG Fields

Survey Date:	8-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Consuelo Creek, Comet Catchment

Cond. **M**

frc site number 26

UTM Zone 55J 662656 E 7294017 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	25.7
Flow Regime:	Ephemeral	pH:	7.81
Channel Width (m):	60	Conductivity (uS/cm):	326
Wetted Width (m):	5	DO (% Sat):	85.5
Water Level:	Low	Turbidity (NTU):	50.3
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	2
Rapid:	-	Pebble:	-
Cascade:	-	Gravel:	3
Fall:	-	Sand:	5
Overall Complexity:	Low	Silt/Clay:	90

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 30	Right: 20
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	-
Filamentous algae:	None	
Macrophytes:	35-65%	Sub Dominate Cover Type:
Detritus:	<10%	Large woody debris, detritus and man made

Comments: Road bridge through site. Some riparian clearing.

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08.07.02 GLNG CSG Fields

Survey Date: 8-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Comet River, Comet Catchment

Cond. M

frc site number 27

UTM Zone 55J 664174 E 7293206 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	45
Wetted Width (m):	-
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (% Sat):	-
Turbidity (NTU):	-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	2
Pebble:	-
Gravel:	-
Sand:	83
Silt/Clay:	5

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 25	Right: 20
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Man made and banks
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	<10%	Cobble, Overhanging vegetation
		And detritus

Comments: Road bridge through site. Weeds common in the riparian zone.

frc environmental
deep thinking. science.

08.07.02 GLNG CSG Fields

Survey Date: 8-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Planet Creek, Comet Catchment

frc site number 28
UTM Zone 55J 672048 E 7303144 N GDA 94

Cond. P

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	20	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	5
Rapid:	-	Pebble:	-
Cascade:	-	Gravel:	-
Fall:	-	Sand:	90
Overall Complexity:	Low	Silt/Clay:	5

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 10
Dominant Type:	Eucalypt	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Instream vegetation
Filamentous algae:	None	
Macrophytes:	10-35%	Sub Dominate Cover Type:
Detritus:	<10%	Detritus

Comments: Road crossing with box culverts across waterway.

frc environmental
deep thinking. science.

08.07.02 GLNG CSG Fields

Survey Date: 9-10-08
Written By: MK Approved By: AO
Date Issued: Oct 2008

Humboldt Creek, Comet Catchment

Cond. M

frc site number 29

UTM Zone 55J 680433 E 7317681 N GDA 94

View upstream through the site

View of right bank

View of left bank

Turtle trap under a bridge at the site

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	40
Wetted Width (m):	9
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	26.7
pH:	7.36
Conductivity (uS/cm):	241
DO (% Sat):	79.8
Turbidity (NTU):	298

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	2
Sand:	8
Silt/Clay:	90

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 20
Dominant Type:	Eucalypt, casuarina	

Fauna

Krefft's river turtle (*Emydura kreffti*)

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Deep pools
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Large woody debris, man made and banks

Comments: Three bridgees across waterway; one rail bridge upstream of the site; an old disused road bridge and a new road bridge.

frc environmental
deep thinking. science.

08.07.02 GLNG CSG Fields

Survey Date:	9-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	Oct 2008		

Comet River, Comet Catchment

Cond. M

frc site number 30

UTM Zone 55J 655435 E 7388847 N GDA 94

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	5	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Bank Shape:	Sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	5
Rapid:	-	Pebble:	5
Cascade:	-	Gravel:	5
Fall:	-	Sand:	5
Overall Complexity:	Low	Silt/Clay:	80

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 10
Dominant Type:	Eucalypt	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	
Filamentous algae:	None	
Macrophytes:	None	Sub Dominate Cover Type:
Detritus:	10-35%	

Comments: Bitumen road crossing with no culvert.

frc environmental deep thinking. science.	08.07.02 GLNG CSG Fields		Minerva Creek, Comet Catchment	Cond.
	Survey Date: 9-10-08		frc site number 31	P
	Written By: MK	Approved By: AO	UTM Zone 55J 633047 E 7362689 N GDA 94	
	Date Issued: Oct 2008			

				
View upstream through the site	View of right bank	View of left bank	View downstream through the site	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	6	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Bank Shape:	Vertical and sloping		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	-
Rapid:	-	Pebble:	-
Cascade:	-	Gravel:	10
Fall:	-	Sand:	10
Overall Complexity:	Moderate	Silt/Clay:	80

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 4	Right: 5
Dominant Type:	Eucalypt, Casuarina	

Fauna

-

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large woody debris
Filamentous algae:	None	
Macrophytes:	<10%	Sub Dominate Cover Type:
Detritus:	<10%	Small woody debris, overhanging and trailing bank vegetation

Comments: Bitumen road crossing with no culvert.

frc environmental deep thinking. science.	08.07.02 GLNG CSG Fields	Orion Creek, Comet Catchment	Cond.
	Survey Date: 9-10-08 Written By: MK Approved By: AO Date Issued: Oct 2008	frc site number 32 UTM Zone 55J 645367 E 7329830 N GDA 94	P

Appendix B Introduction to the Data Analyses Used

Habitat Bioassessment Scores

The standard Habitat Bioassessment Score datasheets (DNRM 2001) were used to numerically assess 9 criteria in four categories: excellent, good, moderate and poor. The sum of the numerical rating from each category produced an overall habitat assessment score. Each site was given an indicative overall condition category, based on the following total habitat assessment score categories: Excellent >110; Good 75 – 110; Moderate 39 – 74; and poor ≤38. Condition categories were based on minimum possible score required for each criteria to be scored within that condition category (Table B.1).

Table B.1 Habitat assessment scores used to derive overall condition categories (adapted from DNRM 2001).

Habitat Variable	Minimum Possible Score Within Each Condition Category			
	Excellent	**Good**	**Moderate**	**Poor**
Bottom substrate / available cover	16	11	6	0
Embeddedness	16	11	6	0
Velocity / depth category	16	11	6	0
Channel alteration	12	8	4	0
Bottom scouring & deposition	12	8	4	0
Pool / riffle, run / bend ratio	12	8	4	0
Bank stability	9	6	3	0
Bank vegetative stability	9	6	3	0
Streamside cover	9	6	3	0
Total	**111**	**75**	**39**	**0**

Macroinvertebrate Indices

Aquatic macroinvertebrates play a major role in the ecology of rivers. They form a key link in the aquatic food chain, forming a pathway between primary producers and predators (Chessman 1986). Aquatic invertebrates are sensitive to flow conditions, water quality and habitat conditions (Choy & Marshall 1997). They are characteristically not very mobile, and are therefore good indicators of local impacts (Walsh 2006; Choy & Marshall

1997). Aquatic invertebrate diversity is crucial to the maintenance of a healthy ecosystem (Choy & Marshall 1997).

Physical and chemical monitoring of water quality can only provide a snapshot of the conditions in an aquatic ecosystem. Biological monitoring provides a more time-integrated picture of ecosystem health, and may for example, indicate the pollution history of an environment. Macroinvertebrates are often used in biological monitoring as they are widespread; occupy many different niches and are an integral part of the food web; are sensitive to the effects of surrounding landuses such as turbidity, eutrophication, increased salinity and high toxicant levels; and have relatively long life-cycles. The effects of changes in water quality on populations can be long lasting; and impacts can thus be detected for some time after they occur.

A number of indices are effective indicators of ecosystem health (EHMP 2004). Use of multiple indices contributes to the robustness and reliability of any assessment. These indices have all been found to be effective indicators of ecological health (EHMP 2004).

Taxonomic Richness

Taxonomic richness is the number of taxa (typically families) in a sample. Taxonomic richness is the most basic and unambiguous diversity measure, and is considered to be among the most effective diversity measures. It is however, affected by arbitrary choice of sample size. Where all samples are considered to be of equal size, species richness index is considered to be a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare taxa have as much 'weight' as common ones.

PET Richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). The **P**lecoptera (stoneflies), **E**phemoptera (mayflies), and **T**richoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families in sites with good habitat and water quality than in degraded sites, and PET Taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2004). The lower the PET score, the greater the inferred degradation.

SIGNAL 2 Scores

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance, such that the relative abundance of tolerant or sensitive taxa can be taken into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on the total of the SIGNAL grade (multiplied by the weight factor) for each taxa present at the site, divided by the total of the weight factors for each taxa at the site. It is important to note that the DNRW data used in this study only presents abundances of up to 10 specimens per family per site, yet the SIGNAL 2 scores are weighted for abundances of up to 20 specimens per family per site. This may have artificially lowered the SIGNAL 2 scores calculated from the DNRW data. Therefore, these SIGNAL ranges may be used to provide an *indication* of water quality, and should not be deemed conclusive. SIGNAL scores above 6 generally indicate 'good water quality', values between 5 and 6 indicate 'possible mild pollution', whilst indices of less than 4 indicate 'probable pollution' (Chessman 1995, cited in Gooderham & Tsyrlin 2002). Habitat quality can affect macroinvertebrate community structure, and may also affect SIGNAL 2 scores.

SIGNAL 2 scores should be interpreted in conjunction with the number of families found in the sample. This can be achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure B.1). Quadrant boundaries for the SIGNAL 2 / Family Bi-plot used for this study are interim suggested boundaries (Chessman 2001) for Australian freshwaters (excluding the Murray – Darling Basin and rivers east of the Great Dividing Range in Queensland). Recently, an alternative approach has been recommended, which includes boundary setting for each study (Chessman 2003). This technique would require considerable sampling (in effect calibration) within the region. Interpretation of the bi-plot with regard to quadrant boundaries should therefore be approached with caution.

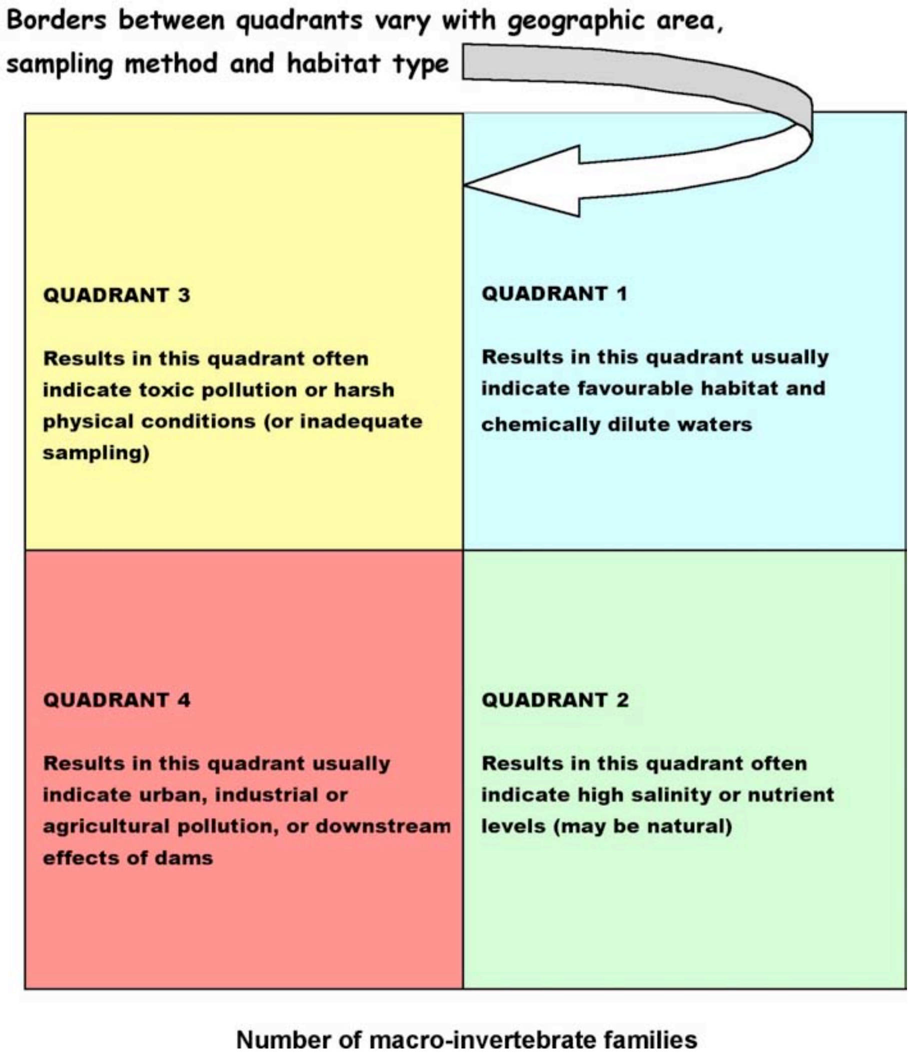

Figure B.1 The quadrant diagram for the family version of SIGNAL 2 (Chessman 2003).

References

Chessman, B. 1986, 'Dietary studies of aquatic insects from two Victorian rivers', *Australian Journal of marine and Freshwater Research*, 37: 129-146.

Chessman, B. 2001, Signal 2 A Scoring System for Macro-Invertebrates ('water-bugs') in Australian Rivers, User Manual Version, 2nd November 2001.

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Choy, S. C. & Marshall, J. C. 1997, ‘Aquatic Invertebrates of the Logan River catchment and their habitat and instream flow requirements’ in *Logan River trial of the building block methodology for assessing environmental flow requirements: background papers,* eds A. H. Arthington, & G. C. Long, Part of Land & Water Resources Research & Development Corporation (LWRRDC) Partnership Research Project GRU18, *Rapid Procedure for Practical Instream Flow Assessments,* Centre for Catchment and Instream Research, Faculty of Environmental Sciences, Griffith University, Nathan, Queensland, Australia, & Department of Natural Resources, Brisbane, Queensland, Australia.

EHMP 2004, Ecosystem Health Monitoring Program 2002-2003, Annual Technical Report, Moreton Bay Waterways and Catchments Partnership, Brisbane.

Gooderham, J. & Tsyrlin, E. 2002, *The Waterbug Book,* CSIRO Publishing, Victoria.

Walsh, C. J. 2006, ‘Biological indicators of stream health using macro-invertebrate assemblage composition: a comparison of sensitivity to an urban gradient’, *Marine and Freshwater Research*, 57:(1) 37-47.

Appendix C Copies of Survey Permits

Queensland Government
Department of Primary Industries and Fisheries

Fisheries Act 1994

General fisheries permit

COPY

LT

10 Sep 2007

JOHN THOROGOOD
FRC ENVIRONMENTAL
185 MAIN ROAD
WELLINGTON POINT QLD 4160

Delegate of the Chief Executive
Department of Primary Industries
and Fisheries

Permit Number	Issue Date	Expiry Date
54790	01/07/2006	15/05/2010

AUTHORISED ACTIVITIES

(1) The permit holder is authorised to collect fish from all Queensland waters other than those waters closed to such apparatus described. The permit holder is permitted to keep and be in possession of a maximum of ten specimens of each species other than those species listed in condition 4 to this permit, taken per year for identifications and other biological research studies. This does not include species that are subject to no-take regulations.

(2) The permit holder is authorised to use:
* gill nets
  - 1 x 10m in length, 25mm mesh
  - 1 x 20m in length, 50mm mesh
  - 1 x 20m in length, 75mm mesh
* seine nets
  - 1 x 70m in length, 2.5m drop, 25mm mesh
  - 1 x 50m in length, 1m drop, 10mm mesh
  - 1 x 10m in length, 3m drop, 2mm mesh
* multi-panel nets
  - 1 x 3x15m panels, 1", 2", 3" mesh
  - 1 x 3x15m panels, 4", 5", 6" mesh
* dip nets
  - 0.1 20mm mesh, up to 600mm mouth diameter
* recreational bait nets
* beam trawl
  - 1 x 0.5m mouth, 12mm mesh
* traps
  - 20 x 0.2m x 0.2m x 0.2m volume, 5mm mesh
  - 40 x 0.2m x 0.2m x 0.2m volume, 1mm mesh
* vessels
  - 4.3m punt, 2.2m wide, 430kg tonnage
  - 3m punt, 1.5m wide, 250kg tonnage
  - 4m hovercraft

Fisheries

- various chartered vessels away from brisbane
* backpack electrofisher
* fyke nets
  - wings up to 10m in length, 2mm, 10mm and 25mm mesh

CONDITIONS

(1) The permit extends to the permit holder, John Thorogood, Carol Conacher, Arthur Hawthorn, Andrew Olds, Lauren Thorburn, Brad Moore, Ashley Morton and Kylie McPherson and any person under their direct supervision on the water involved in the authorised activities.

(2) The following fish species are not to be taken:
- Maori wrasse
- Barramundi cod
- Potato cod
- Red bass
- Chinaman
- Paddletail
- Great white shark, and Grey nurse shark
- Clam
- Helmet Shell
- Trumpet Shell

This permit does not apply to threatened fish as listed under the Environmental Protection and Biodiversity Conservation Act 1999 or that are protected under the Nature Conservation Act 1992 or the Fisheries Act 1994.

(3) The permit holder shall ensure that all apparatus used during permitted activities is marked clearly with the holders name, address and Department of Primary Industries and Fisheries permit number and be in attendance of such apparatus at all times. In attendance means within 100m.

(4) A sign, minimum dimensions of 30cm x 50cm, with the message "Scientific Research in progress under DPI&F permit" is to be located within 15m of collecting activities when nets are in use.

(5) The holder shall ensure that all fish specimens taken are for research purposes only and are not to be sold.

(6) The holder shall ensure that all fish taken unintentionally during permitted activities are returned to the water as soon as practicable with as little harm or injury as possible.

(7) The holder shall ensure that all noxious fish captured during permitted activities are to be destroyed and disposed of appropriately by burying or placing in a bin.

(8) The holder shall notify the local office of the Queensland Boating & Fisheries Patrol not less than 48 hours prior to any activities commencing under this permit.

(9) The holder shall submit a written report one year after the issue of the permit and each subsequent year of the permit outlining the

number of fish taken, apparatus used and days fished to the Chief Executive, Department of Primary Industries and Fisheries, GPO Box 2764, BRISBANE QLD 4001.

(10) The holder must carry this permit (or a copy) during authorised activities and produce it at any time on request for inspection by an officer authorised under the Fisheries Act 1994.

(11) The holder must ensure that the use of electrofishing apparatus is in accordance with the Australian Code of Electrofishing Practice.

Queensland Government
Department of Primary Industries and Fisheries

The Animal Care and Protection Act 2001, Section 57

Scientific Use Registration Certificate

The following person, having satisfied the registration requirements of Section 52 of the *Animal Care and Protection Act 2001*, has this day been registered as a person who can use animals for scientific purposes.

FRC Environmental
185 Main Road, Wellington Point Qld 4160

Registration Number:

47

This approval is valid until: ***14 February 2009***

This registration may be cancelled or suspended pursuant to section 73 of the *Animal Care and Protection Act 2001.*

Dated 13 January 2006

Dr Rick Symons
delegate of
Director-General
Department of Primary Industries
and Fisheries

Queensland Government
Department of Primary Industries and Fisheries

DPI&F Animal Ethics	Form: AE 08
Amendment request for an approved activity	

Please Note:
Any proposed change to an activity must be submitted to an Animal Ethics Committee (AEC) for approval.

If an activity leader carries out an activity other than in accordance with the AEC approval, that person is acting without approval.

Agenda Item 8.4

1. Activity Leader details

Name: John Thorogood		
Organisation: FRC Environmental		Centre:
Postal Address: 185 Main Rd, Wellington Point, QLD, 4160		
Phone: 3207 5135	Fax: 3207 5640	E-Mail: jthorogood@frcenv.com.au

2. Activity Details

Title of the Activity	AEC Approved Application Number
Fisheries Ecological Surveys	**CA 2006/03/106**

3. Amendment

In plain English, describe the proposed amendment:

We propose to include electrofishing in our suite of sampling techniques to conduct freshwater fisheries surveys. To ensure safe operation of the electrofisher, electrofishing will be conducted following the procedures outlined in the *Australian Code of Electrofishing Practice* (1997). We will be using an approved, commercially produced backpack unit from Smith-Root. By following established procedures and the instructions that accompany the equipment, we anticipate that the fish will be stunned by the electrofisher for a very short period (<5 secs), and that they will recover quickly. The senior operator of the electrofisher will be certified by DPI&F to conduct electrofishing. All frc staff are trained in animal welfare and are familiar with our animal ethics permit and responsibilities.

Approximately 100 m of a stream reach will be sampled, incorporating as many habitats as possible (e.g. riffles, runs etc.). Nets will be set (in accordance with our current animal ethics approval) at each end of the reach, to prevent fish movement in and out of the reach during sampling. The operator will sample a variety of habitats as he/she moves upstream along the reach. At each habitat sampled, pulses of current will be passed through the water from the anode ring for a period of 5 – 10 seconds. Stunned fish will be collected from the water by the operator using a net connected to the anode ring, and by a second person using an insulated dip net. The pass of the reach will be repeated heading downstream. It is anticipated that 3 – 4 passes of the reach will be required in order to effectively characterised the fish community.

Amendment request for an approved activity

Only the minimum power necessary to attract and stun the fish effectively will be used. We will not touch the fish with live anodes, and we will not continue electrofishing when within 15 m of a non-target animal standing in or drinking from the water, or if an animal is in contact with a wire fence line that enters the water. Electrofishing will be stopped if there are / we suspect there are native birds, turtles or mammals (e.g. platypus) in the water.

After capture in the nets, all animals will be placed into a 50L nallie bin or 10L buckets half filled with 'fresh' ambient water for identification and counting. All animals not required for further research will be returned to the waters of capture, as soon as possible (once electrofishing of the reach has ceased, although larger fish and eels may be released downstream of the set net straight away, to avoid fouling of the water in the container (e.g. with slime)). Set nets will be removed once the reach has been effectively sampled; any animals caught in these nets will be removed in accordance with the protocols outlined in our current ethics approval.

Some animals may need to be kept for positive identification in the laboratory (e.g. by counting fin rays etc.) or for further analysis, e.g. gut content analysis or otolith ageing. Animals to be kept will be euthanased in a bath of clove oil/water (by adding clove oil at 10 ppt). Deceased animals will be bagged, tagged and frozen for transport to the laboratory for further analysis. Introduced pest species will also be euthanased using the above methods.

In plain English, outline your reasons for the request:

Electrofishing has become an essential sampling tool in the study of freshwater fish ecology. It is successful in catching a range of different species and individuals, such that it is effective in characterising the resident fish communities. Fish surveys are often required by Local and State Governments (through formal terms of reference) in order for these agencies to assess the significance of fisheries habitat against, for example, the likely impacts of urban / commercial / agricultural development of an aquatic environment. In some instances, the use of electrofishing to survey the fish communities is specifically required by these agencies.

Electrofishing is currently used by various government agencies (such as the Department of Primary Industries & Fisheries, and the Department of Natural Resources, Mines & Water) to sample freshwater fish communities. In particular, electrofishing is used in the Ecological Health Monitoring

Program (EHMP) in south east Queensland (using the same model of electrofisher that we intend to purchase). The use of electrofishing will enable us to directly compare our data to data collected by the government agencies. In some instances, this may reduce the amount of sampling that is required, as we will be able to obtain government data for some sites (e.g. data from the EHMP in south east Queensland).
Signature of Activity Leader:
Date:

3. AEC Decision

The amendment has been considered by the AEC and is:

- [x] Approved as submitted
- [ ] Approved subject to modification/conditions*
- [ ] Pending*
- [ ] Rejected*

Any inquiry regarding this response should be directed to the AEC Coordinator, in the first instance. The Coordinator may be contacted via the DPI&F Call Centre on 13 25 23.

* Comments/Reasons:

Name of AEC Chair	**Wal Scattini**
Signature	W J Scattini
Date	**31 July 2006**

Queensland Government Department of Primary Industries and Fisheries	**DPI&F Animal Ethics**	Form: AE 08
	Amendment request for an approved project	

Please Note:
Any proposed change to a project must be submitted to an Animal Ethics Committee (AEC) for approval.

If a person uses or allows an animal to be used for a scientific purpose other than in accordance with the AEC approval, that person is acting without approval and, therefore, unlawfully.

Text boxes will expand automatically to accommodate entry. Please do not delete headers or footers.

1. Applicant details

Name: John Thorogood		
Organisation: FRC Environmental		Centre:
Postal Address: 185 Main Rd, Wellington Point, QLD, 4160		
Phone: 3207 5135	Fax: 3207 5640	E-Mail: jthorogood@frcenv.com.au

2. Project Details

Title of the Project	AEC Proposal Reference Number
Aquatic Ecological Surveys **(proposed change from Fisheries Ecological Surveys)**	CA 2006/03/106

3. Amendment

In plain English, cite each section of your proposal that you wish to amend and then describe the proposed amendment to that section and outline your reasons for the request.

We propose to expand our ethics permit to cover surveys of freshwater turtles as well as fish (which we are currently permitted for). We will conduct turtle surveys on an 'as required' basis, throughout the freshwaters of Queensland. Where required, turtle surveys will be conducted under a Scientific Research Purposes Permit, issued by the EPA.

Freshwater turtles species in Queensland include: the broad-shelled river turtle, *Chelodina expansa*; the eastern snake-necked turtle, *C. longicollis*; the northern snake-necked turtle, *C. rugosa*; *C. novaeguineae*; the northern snapping turtle, *Elseya dentata*; the Burnett River turtle, *E. albagula*; the saw-shelled turtle, *E. latisternum*; the Krefft's river turtle, *Emydura krefftii*; the Murray turtle, *E. macquarii*; *E. signata*; *E. subglobosa*; *E. victoriae*; and the Fitzroy River turtle, *Rheodytes leukops*. Each of these species may be caught depending on the particular area surveyed. Surveys of freshwater turtles (including population numbers, and the size / age distribution and sex ratios of the population) will provide valuable information on the populations of these turtles in various waterways throughout Queensland, and will add to our current understanding of the population dynamics of freshwater turtles. Knowledge of these populations is likely to become increasingly important in the face of increasing water resource development throughout Queensland, which can impact on turtle populations, including threatened species. Knowledge of current freshwater turtle populations will provide essential information for impact assessments of proposed dams, weirs, water extraction and other development on freshwater creeks and rivers.

Turtles will be captured so that they can be accurately counted, as well as measured, weighed and sexed. This will provide important information regarding the population dynamics of the turtle populations. Knowledge of the population dynamics of each species (e.g. size distributions, sex ratios) is an important information requirement for developing management plans that "address population numbers, population dynamics, habitats and sustainability… as a whole" (Hamman et al. 2007). For example, a bias towards adult animals in the wild is indicative of poor survival of clutches laid in the wild, and would lead to a focus on managing habitats to improve hatchling survival (Hamman et al. 2007).

Turtles will be caught following the methods used by the EPA in similar turtle surveys (e.g. Hamann et al. 2004). Specifically, we will use capture turtles a combination of seine nets, dip nets, traps and by hand using snorkel. Discrete sites along the waterway will be sampled in a single sample event. Each of the sampling apparatus will be thoroughly cleaned between sites, to minimise the risk of translocation of aquatic plant or algae species, and any potential diseases.

With the exception of the traps, all sampling apparatus will have an operator in immediate attendance to prevent the accidental drowning of turtles. Traps will be fitted with an ‘air chamber’ to ensure that no turtles drown during our surveys. Our trap design follows the ‘Cathedral Trap’ design used by the Queensland EPA for freshwater turtles surveys (Hamann et al. 2004). As per the EPA methods, traps will be checked every 24 hours at a minimum (Hamann et al. 2004). During sampling, every effort will be made not to disturb the aquatic habitat of the creek or river, which may provide habitat for turtles and fish (e.g. logs, macrophytes etc.). Any fish caught during our surveys will be handled and released unharmed, as per our existing ethics approval.

Once caught, the turtles will be carefully removed from the sampling apparatus. The turtle will be held firmly by its shell in a quite and controlled manner by one team member to minimise stress, while another team member measures the animal with a clean measuring tape, and sexes the animal (if possible) via a brief visual inspection of their tail. Animals will also be weighed by placing them in a bag suspended from a scale. The dark environment of the bag will calm most animals (NSW DPI 2007). It is anticipated that each individual will be handled for a period of less than 5 minutes. The turtles will then be released back to the environment at the point of capture. However, turtles will only be released once the waterway is clear of all nets and traps. If necessary, prior to release, turtles will be held in 50 L Nallie Bins half-filled with ambient river water until the waterway is cleared of sampling apparatus. As each site will only be sampled once, the chance of recapture of individuals is considered to be extremely low. No native turtles will be kept.

The red-eared slider turtle (*Trachemys scripta elegans*) is a listed Class 1 pest in Queensland, and cannot be returned to the environment or kept. This turtle can be readily identified by the distinctive red stripe behind its eyes (which may fade with age, however pale stripes will remain) and the fact that it can retract its head straight back into its shell (native turtles withdraw their heads to the side). If the red-eared slider turtle is caught, a Department of Natural Resources and Water Lands Protection Officer will be contacted for advice. We will either surrender the animals to DNRW, or If advised to do so, we will euthanase turtles of this species.

Euthanasia will be done in accordance with the publication *Euthanasia of Animals Used for Scientific Purposes* (ANZCCART 2001). Specifically, we will cool the animal (by 3–4 ºC) to facilitate handling and injection of a euthanasia solution. Sodium pentobarbitone (at a dose of 60 mg/kg of body weight) will be injected intravenously. The needles and syringes used will be sterile and only used once. We do not anticipate having to euthanase any native turtles. However, if a turtle has unforseen serious injuries, it will be allowed to recover in a 50L nallie bin filled with ambient water that also contains a ‘dry’ rest areas (e.g. exposed rock). If the turtle remains stressed and its condition does not improve (to the point where it can be released) it would be humanely euthanased using the methods described above.

All frc staff are trained in animal welfare and anatomy, and are familiar with our animal ethics permit and responsibilities. Each of the senior frc staff responsible for the turtle surveys have had previous experience in handling freshwater turtles during previous studies, including during their university studies under the supervision of experienced academics and researchers.

References

ANZCCART 2001, *Euthanasia of Animals Used for Scientific Purposes,* ed. J.S. Reilly, Australian and New Zealand Council for the Care of Animals in Research and Teaching, Adelaide.

Hamman, M., Schäuble, C. S., Limpus, D. J., Emerick, S. P. & Limpus, C. J. 2007, *Management Plan for the Conservation of Elseya sp. [Burnett River] in the Burnett River Catchment*, Environmental Protection Agency, Brisbane.

NSW DPI 2007, *Model Standard Operating procedures for the Humane Research of Pest Animals*, New South Wales Department of Primary Industries [online] http://www.dpi.nsw.gov.au/aboutus/resources/majorpubs/guides/model-sops-research-pest-animals.

[signature]	Lauren Thorburn (Senior Environmental Scientist, FRC Environmental)	15/10/07
Signature of the Applicant (or its duly authorised agent).	**Please print name if signing as a duly authorised agent.**	**Date**

4. AEC Decision

The amendment has been considered by the AEC and is:

☒ Approved as submitted

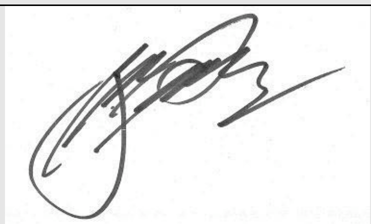
☐ Approved subject to modifications

☐ Pending

☐ Rejected

Any inquiry regarding this response should be directed to the AEC Coordinator, in the first instance. The Coordinator may be contacted via the DPI&F Call Centre on 13 25 23.

Comments/Reasons:

Name of AEC Chair	Geoff Smith
Signature	
Date	29 October 2007

Permit[1]

This permit is issued under the following legislation:

S12(E) Nature Conservation (Administration) Regulation 2006

Scientific Purposes Permit

Permit number: **WISP05080608**

Valid from: **12-MAR-2008** **to** **12-MAR-2013**

Parties to the Permit

Role	Name	Address
Principal Holder	JA Thorogood Pty Ltd (t/a FRC Environmental) 72 002 896 007	185 Main Road WELLINGTON POINT QLD 4160
Joint Holder	Mr Andrew Olds	185 Main Road WELLINGTON POINT QLD 4160
Joint Holder	Ms Lauren Thorburn	185 Main Road WELLINGTON POINT QLD 4160

Permitted Location Activity Details

Location (s)	Activity (s)
Non Protected Areas - Queensland	Research on non-protected areas for scientific purposes

1 Permit includes licences, approvals, permits, authorisations, certificates, sanctions or equivalent/similar as required by legislation administered by the Environmental Protection Agency and the Queensland Parks and Wildlife Service.

Permit Details

Species Details

Location	Activity
Non Protected Areas - Queensland	Research on non-protected areas for scientific purposes

Schedule	***Category***	***Quantity***
Turtles and tortoises (family Chelidae) Nature conservation (Wildlife) Regulation 2006	Live	Unlimited Animal/s

Conditions of Approval

Agency Interest: Biodiversity

PB1 The Principal Holder must obtain permission from the landholder prior to commencing activities.

Environmental impact is to be kept to a minimum.

This permit (or a copy plus proof of identity of Principal Holder) must be carried while engaged in any activity authorised by the permit.

This permit is issued subject to the Principal Holder holding the current approval of a registered animal ethics committee.

All collecting activities are to be effected away from public view.

The Principal Holder may trap animals by methods as outlined in the application. Animals are to be released unharmed at the point of capture within 24 hours of capture. Any mortality during capture or subsequent handling is to be reported immediately to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba. The Queensland Museum has first refusal of any material resulting from mortality.

To prevent the risk of spreading disease, all traps, items of clothing (including footwear), vehicles and handling equipment must be cleaned before and after each separate collection activity.

Two (2) specimens of possible new or undescribed species may be kept as voucher specimens and must be deposited with the Queensland Museum.

Upon completion of field work, a detailed list is to be supplied to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba, showing numbers of specimens of each species, the type of habitat and locality or localities where they were collected. Separate data returns and reports must be provided for each survey.

A copy of any resulting report/publication must be forwarded to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba.

All practices and procedures undertaken pursuant to this permit are to be in accordance with those details contained in and attached to the Application for a Scientific Purposes Permit signed by the Principal Holder on 22 January 2008.

Signed

Ian Bryant
Delegate
Environmental Protection Agency

Appendix D Description of the Artesian Spring Sites Surveyed

				
View upstream through the spring.	View upstream along the Dawson River.	*Lugwigia peploides* at the spring.	*Juncus usitatus* at the spring.	

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	-	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Discharge (l/s)	-		

Flora and Fauna

Vegetation

Riparian Width (m): -	Left: -	Right: -
Dominant Type:	Grass & Sedge	

Fauna

-

Comments: Spring is a dry soak on the right bank. Water remains only in cattle pugs. Macrophyte species present are typical of the riverbank. No fauna recorded.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number Spring 1
	Survey Date:	02-12-08			UTM Zone 55J 719356 E 7158490 N WGS 84
	Written By:	MK	Approved By:	AO	
	Date Issued:	08-12-08			

				
View of the spring.	*Hydrocotyle* sp. at the site	Cattle damage in the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	-	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Discharge (l/s)	-		

Flora and Fauna

Vegetation

Riparian Width (m): -	Left: -	Right: -
Dominant Type:	Grass & *Callistemon* sp.	

Fauna

-

Comments: Spring is small damp soak in right bank of the Dawson River, approximately 1.5 m from the channel. It is heavily cattle damaged. Water remains only in cattle pugs. Macrophyte species present are typical of the riverbank. No fauna recorded.

frc environmental deep thinking. science.	**08.07.02 GLNG Coal Fields**	
	Survey Date: 30-10-08	frc site number Spring 2
	Written By: MK Approved By: AO	UTM Zone 55J 718122 E 7156857 N WGS 84
	Date Issued: 08-12-08	


View of the spring.


Cattle damage at the spring.


Hydrocotyle sp. at the site.

Channel Habitat

Morphology

Pattern:	-
Flow Regime:	Ephemeral
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Dry
Discharge (l/s)	-

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (% Sat):	-
Turbidity (NTU):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Grass & Sedge	

Fauna

-

Comments: Spring is a dry soak on the right bank. Macrophyte species present are typical of the riverbank. No fauna recorded.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	30-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 3

UTM Zone 55J 717713 E 7156764 N WGS 84


View upstream along the Dawson River.


View downstream along the Dawson River.


Blyxa sp. from the river bank.


Pig wallows on the river bank

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Dry
Bank Shape:	Sloping
Discharge (l/s)	0

Water Quality

Temperature (C):	24.7
pH:	6.8
Conductivity (uS/cm):	325
DO (% Sat):	62.1
Turbidity (NTU):	25.9

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 8	Right: 10
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Spring originate in the bed of the Dawson River. Therefore, it is likely to support flora and fauna typical of the river. Water quality was taken in the river. Pig wallows were a major disturbance on the riverbank.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	30-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 4

UTM Zone 55J 714229 E 7158129 N WGS 84

View of the spring.

View downstream through the spring.

Spring channel up the upper bank of the Dawson River.

Abundant macrophytes at the spring.

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Perennial
Channel Width (m):	0.5
Wetted Width (m):	0.5
Water Level:	Low
Bank Shape:	Sloping
Discharge (l/s)	3

Water Quality

Temperature (C):	24.6
pH:	6.68
Conductivity (uS/cm):	109
DO (% Sat):	71.3
Turbidity (NTU):	19.1

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 50+	Right: 50+
Dominant Type:	Eucalypt, Casuarina	

Fauna

Snails

Comments: Spring originates about 80m from river up a steep gully. The spring extends approximately 100m downstream along the Dawson River in a broad flat soak. It supports abundant macrophytes and snails.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields							
Survey Date:	30-10-08			frc site number	Spring 5			
Written By:	MK	Approved By:	AO	UTM	Zone 55J	714092 E	7158172 N	WGS 84
Date Issued:	08-12-08							

View of the spring origin.

Looking downstream through the spring.

Macrophytes in the spring.

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	26.6
Flow Regime:	Perennial	pH:	5.7
Channel Width (m):	-	Conductivity (uS/cm):	124
Wetted Width (m):	-	DO (% Sat):	7
Water Level:	Moderate	Turbidity (NTU):	2.4
Discharge (l/s)	1.5		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Sprng originates on the right bank of the Dawson River. It supports abundant macrophytes.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				
	Survey Date:	30-10-08			
	Written By:	MK	Approved By:	AO	
	Date Issued:	08-12-08			

frc site number Spring 6

UTM Zone 55J 713813 E 7157950 N WGS 84

				
View of the spring origin.	View downstream through the spring.			

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	24.5
Flow Regime:	Perennial	pH:	6.0
Channel Width (m):	-	Conductivity (uS/cm):	133
Wetted Width (m):	-	DO (% Sat):	12
Water Level:	Moderate	Turbidity (NTU):	35
Discharge (l/s)	2		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Sprng originates on the right bank of the Dawson River. It supports abundant macrophytes.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				
	Survey Date:	30-10-08			frc site number Spring 7
	Written By:	MK	Approved By:	AO	UTM Zone 55J 713678 E 7157776 N WGS 84
	Date Issued:	08-12-08			


View downstream through the spring.


Spring origin from sandstone rocks.


Macrophytes in the spring.


Turtle captured from the headwaters of the spring.

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Moderate
Discharge (l/s)	3

Water Quality

Temperature (C):	29.6
pH:	6.56
Conductivity (uS/cm):	360
DO (% Sat):	65.7
Turbidity (NTU):	42.1

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

White-throated snapping turtles (*Elseya albagula*)
Spangled perch (*Leipotherapon unicolor*)
Eastern rainbowfish (*Melanotaenia splendida*)

Comments: Spring originates from sandstone rocks approximately 150 m from the left bank of the Dawson River. Macrophytes are relatively abundant. No fauna was recorded.

frc environmental deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	30-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 8

UTM Zone 55J 713648 E 7157880 N WGS 84

View through the spring.

Eleocaris sp. in the spring.

Cyperus sp. in the spring.

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	22.4
Flow Regime:	Perennial	pH:	7.14
Channel Width (m):	-	Conductivity (uS/cm):	256
Wetted Width (m):	-	DO (% Sat):	83.2
Water Level:	Moderate	Turbidity (NTU):	4.3
Discharge (l/s)	0.3		

Flora and Fauna

Vegetation

	Left:	Right:
Riparian Width (m):		
Dominant Type:	Eucalypt, Callistemon,	Melaleuca

Fauna

Snails

Comments: Spring covers area of approximately $50m^2$ on the north bank of the Dawson River. Macrophytes and snails are abundant.

frc environmental deep thinking. science.	**08.07.02 GLNG Coal Fields**			
	Survey Date:	30-10-08		
	Written By:	MK	Approved By:	AO
	Date Issued:	08-12-08		

frc site number Spring 8A

UTM Zone 55J 713666 E 7157947 N WGS 84

				
View of the origin of the spring.	View downstream through the spring.	Cattle damage at confuence of the spring and river.	View looking upstream through the spring.	

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Moderate
Discharge (l/s)	1

Water Quality

Temperature (C):	24.8
pH:	6.64
Conductivity (uS/cm):	94
DO (% Sat):	93.9
Turbidity (NTU):	8

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

Snails

Comments: Spring arises on the left bank of the Dawson River, approximately 100m from the river. Moderate abundance of macrophytes and snails. Cattle damage and weeds common.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	02-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 9

UTM Zone 55J 713983 E 7156447 N WGS 84

				
View upstream through the spring.	View of the confluence of the spring and river.	Terrestrial shrubs were common at the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	25.6
Flow Regime:	Perennial	pH:	6.2
Channel Width (m):	-	Conductivity (uS/cm):	219
Wetted Width (m):	-	DO (% Sat):	52
Water Level:	Low/mod.	Turbidity (NTU):	8
Discharge (l/s)	1		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring originates in the right bank of the Dawson River, approximately 15m from the river. It runs down deep ravine and supports few macrophytes and no obvious fauna.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields							
	Survey Date:	02-11-08			frc site number	Spring 10		
	Written By:	MK	Approved By:	AO	UTM Zone 55J	713689 E	7155857 N	WGS 84
	Date Issued:	08-12-08						

View upstream through the spring.

View downstream through the spring.

Schoenoplectus growing in the spring.

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	High
Discharge (l/s)	5

Water Quality

Temperature (C):	25.8
pH:	6.5
Conductivity (uS/cm):	227
DO (% Sat):	16.9
Turbidity (NTU):	5.1

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring originates on the right bank of the Dawson River, approximately 50m from the river. It runs through a ravine to the river and supports few macrophytes and no obvious fauna. Terrestrial weeds are common.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	02-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 11

UTM Zone 55J 713636 E 7155800 N WGS 84

				
View upstream through the spring.	The exotic curled dock in the spring.	Large woody debris in the spring.	Python in the headwaters of the spring.	

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	26
Flow Regime:	Perennial	pH:	6.9
Channel Width (m):	-	Conductivity (uS/cm):	213
Wetted Width (m):	-	DO (% Sat):	60.9
Water Level:	High	Turbidity (NTU):	5
Discharge (l/s)	2.5		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

Snails and snake

Comments: Spring arises under sandstone rocks approximately 120m from the right bank of the Dawson River. There are few macrophytes and snails. Weeds are abundant.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number	Spring 12
	Survey Date:	02-11-08			UTM Zone 55J	713458 E 7155753 N WGS 84
	Written By:	MK	Approved By:	AO		
	Date Issued:	08-1s-08				

View of the spring origin.

View of the confluence of the spring and the river.

Water quality measured directly in the source

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	26.1
Flow Regime:	Intermittent	pH:	6.18
Channel Width (m):	-	Conductivity (uS/cm):	278
Wetted Width (m):	-	DO (% Sat):	7.2
Water Level:	High	Turbidity (NTU):	0.5
Discharge (l/s)	1		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Casuarina, Callistemon	

Fauna

-

Comments: The spring is very small; it originates in the sand of the right bank and flows into the river. It supports very few macrophytes and no aquatic fauna. Filamentous algae is present.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	02-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 13

UTM Zone 55J 709883 E 7153154 N WGS 84

View upstream through the spring.

View downstream through the spring.

Macrophytes and boulders were common.

Cyperus sp. in the spring.

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	26.4
Flow Regime:	Perennial	pH:	6.56
Channel Width (m):	-	Conductivity (uS/cm):	286
Wetted Width (m):	-	DO (% Sat):	33.6
Water Level:	Moderate	Turbidity (NTU):	0.1
Discharge (l/s)	2		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon,	Melaleuca

Fauna

Spangled perch (*Leipotherapon unicolor*)
Eastern rainbowfish (*Melanotaenia splendida*)

Comments: Spring originates from sandstone rocks approximately 1 km from the right bank of the Dawson River. It supports abundant macrophytes and some fish. A dirt track passes over the upper waters of the spring.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	31-10-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring 14

UTM Zone 55J 709850 E 7153201 N WGS 84

				
View of the spring origin.	Larger view of the spring.	Two *Schoenoplectus* plants grew in the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	23.5
Flow Regime:	Ephemeral	pH:	6.2
Channel Width (m):	-	Conductivity (uS/cm):	267
Wetted Width (m):	-	DO (% Sat):	5.6
Water Level:	Moderate	Turbidity (NTU):	2
Discharge (l/s)	1		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Callistemon	

Fauna

-

Comments: Spring is very small, and originates at the base of the right bank under a *Callistemon* in sand. Two *Eleocaris* plants grow at the confluence with the Dawson River. No fauna are present.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number	Spring 15
	Survey Date:	31-10-08			UTM Zone 55J	709742 E 7153519 N WGS 84
	Written By:	MK	Approved By:	AO		
	Date Issued:	10-11-08				

				
View upstream through the spring.	View downstream through the spring.	*Hydrocotle* sp. in the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	25.2
Flow Regime:	Perennial	pH:	6.70
Channel Width (m):	1	Conductivity (uS/cm):	204
Wetted Width (m):	1	DO (% Sat):	52.8
Water Level:	Moderate	Turbidity (NTU):	7.7
Discharge (l/s)	1		

Flora and Fauna

Vegetation		
Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring originates approximately 40m from the right bank of the Dawson River in a large steep gully. Macrophytes are common. No fauna were recorded. Cattle damage was prevalent.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				
	Survey Date:	30-10-08			frc site number Spring A
	Written By:	MK	Approved By:	AO	UTM Zone 55J 713040 E 7155721 N WGS 84
	Date Issued:	08-12-08			

View of the spring origin.

View downstream through the spring.

Macrophytes are abundant and fill much of the spring.

Large woody debris are common.

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	High
Discharge (l/s)	2

Water Quality

Temperature (C):	24.7
pH:	6.08
Conductivity (uS/cm):	220
DO (% Sat):	5.2
Turbidity (NTU):	0

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Spring origniates approximately 80 m from the river right bank of the Dawson River. It supports abundant macrophytes but no fauna. Weeds are alos common.

frc environmental
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08.07.02 GLNG Coal Fields

Survey Date:	01-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring B

UTM Zone 55J 712633 E 7155711 N WGS 84

View of the spring source under boulders.

View across the narrow spring channel.

Filamentous algae in the spring.

Curled dock in the spring.

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Low
Discharge (l/s)	0.30

Water Quality

Temperature (C):	25.1
pH:	7.17
Conductivity (uS/cm):	220
DO (% Sat):	103
Turbidity (NTU):	1

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

Snails

Comments: Spring originates approximately 50 m from right bank under sandstone boulders in a ravine. It supports abundant macrophytes. Weeds and filamentous algae are common.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	01-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring C

UTM Zone 55J 712269 E 7155691 N WGS 84

				
View of the dry spring source.	View downstream through the dry spring.			

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	-	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Discharge (l/s)	-		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Spring is dry, the dry gully extends 10m from the right bank of the river. Macrophytes are typical of the Dawson River bank.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields			
	Survey Date:	01-11-08		
	Written By:	MK	Approved By:	AO
	Date Issued:	08-12-08		

frc site number Spring D

UTM Zone 55J 711621 E 7155323 N WGS 84

View of spring source.

View downstream through the spring.

Grasses in the spring channel.

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	25.3
Flow Regime:	Intermittent	pH:	5.95
Channel Width (m):	-	Conductivity (uS/cm):	187
Wetted Width (m):	-	DO (% Sat):	24
Water Level:	Low	Turbidity (NTU):	50
Discharge (l/s)	0.01		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina	

Fauna

-

Comments: Spring originates in a ravine approximately 8m from the right bank of the river. Few macrophyte are present, no obvious fauna.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	02-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring E

UTM Zone 55J 711133 E 7154899 N WGS 84

				
View of the spring source.	Cattle damage in the spring channel.	Grasses are common in the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	24.15
Flow Regime:	Intermittent	pH:	6.55
Channel Width (m):	-	Conductivity (uS/cm):	193
Wetted Width (m):	0.30	DO (% Sat):	3.24
Water Level:	Low	Turbidity (NTU):	25
Discharge (l/s)	0.25		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon	

Fauna

-

Comments: Spring origniates in the left bank of the river. It flows down a steep gradient of approximately 20%. Ground creepers may indicate that the spring is intermittent.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields									
	Survey Date:	01-11-08			frc site number	Spring F				
	Written By:	MK	Approved By:	AO	UTM	Zone	55J	710880 E	7154659 N	WGS 84
	Date Issued:	08-12-08								

View of the spring source.

View downstream through the spring.

Macrophytes on the site

Macrophytes on the site

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	24.9
Flow Regime:	Perennial	pH:	6.8
Channel Width (m):	-	Conductivity (uS/cm):	174
Wetted Width (m):	-	DO (% Sat):	104.8
Water Level:	High	Turbidity (NTU):	5.7
Discharge (l/s)	5		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina	

Fauna

Spangled perch (*Leipotherapon unicolor*)
Eastern rainbowfish (*Melanotaenia splendida*)

Comments: Spring originates in sandstone approximately 800 m from the right bank of the Dawson River. Abundant fish, macrophytes and filamentous algae. Cattle damage is common near the confluence of the spring and river; weeds are also common.

frc environmental
deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	01-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring G

UTM Zone 55J 710980 E 7153567 N WGS 84

				
View of spring source – note cattle damage.	Macrophytes fill much of the spring.	*Cyperus* sp. in the spring.	Snails in the spring on filamentous algae.	

Channel Habitat

Morphology		Water Quality	
Pattern:	Irregular	Temperature (C):	26.8
Flow Regime:	Ephemeral	pH:	6.4
Channel Width (m):	-	Conductivity (uS/cm):	169
Wetted Width (m):	-	DO (% Sat):	58.5
Water Level:	Moderate	Turbidity (NTU):	10
Discharge (l/s)	0.3		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

Snails

Comments: Spring originates on the right bank, approximately 8m from the river. It supports abundant macrophytes, snails and filamentous algae. Cattle damage is present at the source.

frc environmental deep thinking. science.	**08.07.02 GLNG Coal Fields**									
	Survey Date:	01-11-08			frc site number	Spring H				
	Written By:	MK	Approved By:	AO	UTM	Zone	55J	711149 E	7153262 N	WGS 84
	Date Issued:	08-12-08								

				
View of the spring source.	View upstream through the sspring.	View downstream through the spring.	Dock is abundant in the spring.	

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	24.6
Flow Regime:	Perennial	pH:	6.25
Channel Width (m):	-	Conductivity (uS/cm):	141
Wetted Width (m):	-	DO (% Sat):	23.6
Water Level:	Moderate	Turbidity (NTU):	10
Discharge (l/s)	0.5		

-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon,	Casuarina

Fauna

Comments: Spring originates on the right bank, approximately 10m from the river. It supports abundant macrophytes. Cattle damage is present at the source.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number	Spring I
	Survey Date:	01-11-08				
	Written By:	MK	Approved By:	AO	UTM Zone 55J 711141 E 7153240 N WGS 84	
	Date Issued:	08-12-08				

View of the spring with cattle damage at the junction with the Dawson River.

Jview upstream through the spring.

Swamp lilies in the spring.

Red cottonbush in the spring.

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	1.5
Wetted Width (m):	1.5
Water Level:	Moderate
Discharge (l/s)	0.5

Water Quality

Temperature (C):	23.7
pH:	6.04
Conductivity (uS/cm):	164
DO (% Sat):	11.3
Turbidity (NTU):	9.2

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon,	Casuarina

Fauna

-

Comments: Spring origniates on the right bank of the Dawson River. It is small and filled with lilies *Blyxa* sp.. Cattle damge is common at the confluence with the river. *Persicaria* sp. is abundant.

frc environmental deep thinking. science.

08.07.02 GLNG Coal Fields

Survey Date:	01-11-08		
Written By:	MK	Approved By:	AO
Date Issued:	08-12-08		

frc site number Spring J

UTM Zone 55J 711128 E 7153214 N WGS 84

				
View of the spring source.	Cattle damage was common at the spring.	Grasses were common at the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	23.8
Flow Regime:	Intermittent	pH:	6.6
Channel Width (m):	-	Conductivity (uS/cm):	190
Wetted Width (m):	-	DO (% Sat):	37
Water Level:	Moderate	Turbidity (NTU):	10.2
Discharge (l/s)	0.2		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Callistemon,	Casuarina

Fauna

-

Comments: Spring originates 20m from the right bank of the river. It supports macrophytes (typical of riverbank) but no fauna. Weeds are abundant. Cattle damage is present.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number	Spring K
	Survey Date:	31-10-08			UTM Zone 55J	711112 E 7153187 N WGS 84
	Written By:	MK	Approved By:	AO		
	Date Issued:	08-12-08				

				
View of the spring source.	View downstream through the spring.	Dock is common in the spring.		

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	25.6
Flow Regime:	Intermittent	pH:	6.14
Channel Width (m):	-	Conductivity (uS/cm):	179
Wetted Width (m):	-	DO (% Sat):	23.4
Water Level:	Low	Turbidity (NTU):	7
Discharge (l/s)	0.2		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Callistemon	

Fauna

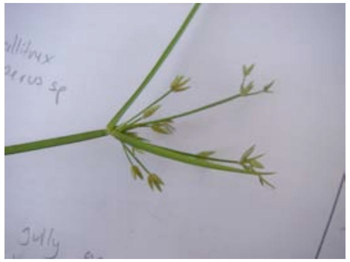
-

Comments: The spring originates in the right bank, approximately 5m from the river. Macropytes are common and typical of riverbank. Weeds and filamentous algae are abundant. Cattle damage is present.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields			
	Survey Date:	31-10-08		
	Written By:	MK	Approved By:	AO
	Date Issued:	08-12-08		

frc site number Spring L

UTM Zone 55J 711109 E 7153168 N WGS 84

				
View of the spring source.	Filamentous algae in the spring.	Cattle damage is prevelent in the spring.	*Cyperus* sp. from the spring.	

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	24.3
Flow Regime:	Intermittent	pH:	6.08
Channel Width (m):	-	Conductivity (uS/cm):	185
Wetted Width (m):	-	DO (% Sat):	24.1
Water Level:	Moderate	Turbidity (NTU):	17.2
Discharge (l/s)	0.5		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring originates in a gully in the right bank, approximately 61m from the Dawson River. Filamentous algae and macrophytes are common. Cattle damage is prevalent.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				frc site number	Spring M
	Survey Date:	31-10-08				
	Written By:	MK	Approved By:	AO	UTM Zone 55J	711025 E 7153027 N WGS 84
	Date Issued:	08-12-08				

				
View of the dry spring.	*Cyperus* sp from the dry spring.			

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	-	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Discharge (l/s)	-		

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring was dry at the time of survey. It supppoted some macrophytes, typical of the Dawson River.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields				
	Survey Date:	31-10-08			frc site number Spring N
	Written By:	MK	Approved By:	AO	UTM Zone 55J 710958 E 7152901 N WGS 84
	Date Issued:	08-12-08			

View of the spring source.

View downstream through the spring.

Cattle damage is common.

Macrophytes are abundant in the spring.

Channel Habitat

Morphology

Pattern:	-
Flow Regime:	Perennial
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Moderate
Discharge (l/s)	0.5

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (% Sat):	-
Turbidity (NTU):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Melaleuca,	Callistemon

Fauna

-

Comments: Spring originates approximately 100m from the right bank of the river. Macrophytes, weeds and filamentous algae are abundant. There is some cattle damage.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields			
	Survey Date:	31-10-08		
	Written By:	MK	Approved By:	AO
	Date Issued:	08-12-08		

frc site number Spring O

UTM Zone 55J 710723 E 7152753 N WGS 84

				
View upstream through the spring.	View of the confluence with the Dawson River.	Macrophytes are abundant.		

Channel Habitat

Morphology		Water Quality	
Pattern:	-	Temperature (C):	-
Flow Regime:	Ephemeral	pH:	-
Channel Width (m):	-	Conductivity (uS/cm):	-
Wetted Width (m):	-	DO (% Sat):	-
Water Level:	Dry	Turbidity (NTU):	-
Discharge (l/s)			

Flora and Fauna

Vegetation

Riparian Width (m):	Left: -	Right: -
Dominant Type:	Eucalypt, Casuarina,	Callistemon

Fauna

-

Comments: Spring was dry at the time of survey. Macrophytes are abundant, but are typical of the riverbank. Cattle damage is prevalent; a road has been constructed acorss the upper waters of the spring.

frc environmental deep thinking. science.	08.07.02 GLNG Coal Fields			
	Survey Date:	31-10-08	frc site number	Spring P
	Written By:	MK	Approved By:	AO
	Date Issued:	08-12-08	UTM Zone 55J 710093 E 7152689 N WGS 84	

Appendix E Assessment of Potential Impacts

Extraction of Associated Water for CSG Production

The abstraction of associated water from wells for CSG production has the potential to result in a localised drawdown of underground aquifers. However, the potential for such an impact would be entirely dependent on the specific location of each well site and the characteristics of the underlying aquifers. As such, a detailed assessment of groundwater at each potential well site would be necessary to model the potential for impacts.

Discharge, Use or Injection of Associated Water

Associated water is recognized as a waste under the EPA's Operational Policy for *Management of Water Production in Association with Petroleum Activities (Associated Water)*(EPA 2007); disposal of associated water is a Level One Environmentally Relevant Activity (ERA) under the Environment Protection Regulation 1998. Santos proposes to manage associated water in accordance with the EPA's operational policy, this may include: the injection of associated water into underground aquifers, onsite reuse, stock watering, irrigation, desalination and discharge, and / or direct discharge (Santos 2008). The discharge of desalinated and / or un-desalinated associated water into waterways in the CSG Fields has the potential to impact on aquatic communities by altering water quality, aquatic habitat and the timing of water availability. However, the nature of any impact is likely to depend on the characteristics of specific discharge location, the quality of the water to be discharged and the timing of the discharge. The discharge of associated water is likely to reduce the seasonality of local catchment flows, increase the availability of water and enhance the level of erosion and scouring at, and immediately downstream of, discharge points. Such changes would be expected to favour the establishment and proliferation of filamentous algae and exotic flora and fauna, such as mosquito fish, and may reduce the diversity of local aquatic communities. The discharge of 'untreated' associated water would likely increase the potential for impact; associated water extracted from the Fairview Field is: warm, low in dissolved oxygen, low in turbidity, high in alkalinity and has a moderate salinity (Santos 2008). Though broadly speaking, aquatic communities in the waterways of the CSG Fields are well adapted to relatively poor water quality and low habitat diversity.

The development of a plan for the ongoing management and monitoring of all associated water discharges in accordance with the EPA's operational policy will minimise the potential for impact.

Operation of Vehicles and Equipment

Fuels and oils required for the operation of construction equipment, present a risk to aquatic ecology if spilt. Both diesel and petrol are toxic to aquatic flora and fauna at relatively low concentrations.

Spilt diesel oil and petrol are both likely to form a layer on the surface of the water. The volatility of both diesel and petrol contributes to substantial evaporative loss, while neither product is likely to form water-in-oil emulsions due to their low viscosity. Lubricating oils, of the kind used in diesel engines and gearing, are of a relatively similar density to diesel oils. As such, lubricants would be expected to behave in a similar fashion to diesel oil, and form a surface layer. Lubricants are much less volatile, however, and thus would not evaporate as rapidly.

Spilt fuel is most likely to enter the creeks and or springs via an accidental spill on the access route near creek crossings; or when there are construction activities adjacent to creeks. A significant fuel spill (in the order of tens or hundreds of litres) to the creeks or springs in the CSG Fields is likely to have a significant impact on both flora and fauna, with the quantity spilt being the most influential factor on the length of stream impacted.

The risk of an impact to aquatic flora and fauna from a fuel or oil spill is lower for ephemeral creeks that are dry or isolated pools for much of the year, as many spills could be effectively cleaned up before they can disperse throughout the waterways.

Vegetation Clearing and Earth Moving

Vegetation clearing and/or sediment disturbance for the construction of wells, roads, compression stations and other facilities can increase sediment, nutrients and other contaminant loads that are transported to creeks and springs in stormwater runoff. This has the potential to drastically increase turbidity within the local drainages, and result in the deposition of sediment and the alteration of aquatic habitat in the waterways.

Increased Turbidity

Increased turbidity may impact on fishes and macroinvertebrates because highly turbid water reduces respiratory and feeding efficiency (Karr & Schlosser 1978: cited in Russell & Hales 1993). Increased turbidity may also adversely affect submerged macrophytes as light availability (required for photosynthesis) is reduced. Reduced light penetration, caused by increased turbidity, can also lead to a reduction in temperature throughout the water column (DNR 1998).

At the time of survey, the majority of waterways in the CSG Fields were generally highly turbid, and substrates were generally dominated by silt. Faunal communities of the study area are adapted to living in turbid water. Given these background conditions, the introduction of small amounts additional sediment is unlikely to have ecologically significant impacts on faunal communities; however, substantial increases may have a significant impact on the aquatic flora and fauna communities. An increase in turbidity in the artesian springs might be expected to have a more significant impact, as the turbidity of these waters was typically very low. Therefore, best practice erosion and sediment controls and stormwater runoff management plans should be implemented to minimise the likelihood of Project-related turbidity and sedimentation (refer Appendix F)

Input of Nutrients or Contaminants

Aquatic biota could also be impacted by nutrients or contaminants washed into the waterways with the sediment. Nutrient inputs can lead to algal or macrophytes blooms, which produce high concentrations of dissolved oxygen (DO) in the water column during the day when photosynthesising, but consume oxygen from the water column at night with respiration. This can cause the DO concentrations of affected waterways be reduced to very low levels at night, which are harmful to fish and biota.

Nutrient levels in the sediments are likely to be relatively low in the study area compared with other areas in the catchment, as high levels of fertilisers are unlikely to be used on grazing and forestry lands. In any case, the highly turbid water of the creeks is likely to prevent significant algae blooms for much of the year. Eutrophication of the waterways is therefore considered to be a low risk to aquatic ecology. The potential for eutrophication of artesian springs in the CSG Fields in considered be a higher risk. Therefore, best practice erosion and sediment controls and stormwater runoff management plans should be implemented to minimise the likelihood of Project-related nutrient-laden runoff (refer to Appendix F).

Decreases in Available Aquatic Fauna Habitat

Vegetation clearing and earth moving near and / or within the creeks or springs for the development of the CSG Fields may decrease the amount of habitat that is available for aquatic fauna. Aquatic fauna use a variety of instream structures for habitat, including: large and small woody debris, bed and banks, detritus, tree roots, boulders, undercut banks, and instream, overhanging and trailing bank vegetation, which were all found in creeks in the CSG Fields.

Instream habitat is an important habitat component and territory marker for many fish and macroinvertebrates. Many species live on or around instream habitat as it provides shelter (from temperature, current and predators); contribute organic matter to the system; and is important for successful reproduction. Australian fish species typically spawn either on instream vegetation or on hard surfaces like cobbles, boulders, and woody debris. The impacts of any decrease in habitat structure are likely to be localised, however the cumulative impact of habitat loss over a large area (such as the CSG Fields) may be unacceptable in both a local and regional context.

The deposition of fine sediments and subsequent decrease in streambed roughness has the potential to completely fill in the existing pools. Within the minor (first order) tributaries throughout the study area, this is unlikely to have a significant impact, as these streams appear to only carry flood flows, and generally do not support water for extended periods. However, in larger watercourses (second order and higher), like the majority of streams surveyed in this survey, sediment deposition may lead to a decline in habitat diversity and a reduction in the number of pools available as 'refuge' habitat in the dry season. Such impacts would be likely to result in a decline in the abundance diversity of both invertebrate and fish communities in the creeks.

After the completion of any works within, or adjacent to, any creeks or springs in the CSG Fields, any newly formed or re-profiled bed and banks may continually erode with the high rate of flows that typically occur in the region during the wet season. The potential impact of such erosion would be expected to be an increase in stream width and a loss of channel definition, which would both contribute to a reduction of flow downstream. The impacts of any decrease in bed and bank stability are likely to be localised, however the cumulative impacts over a large area (such as the CSG Fields) may be unacceptable in both a local and regional context. Therefore, a rehabilitation management plan should be implemented to minimise the impact on available fauna aquatic habitat (refer to Appendix F).

Construction of Creek Crossings

The construction of vehicle and / or pipeline crossings over creeks in the CSG Fields has the potential to significantly disturb bed and bank stability, leading to increases in localised erosion, and potentially resulting in increases in turbidity and sediment deposition (see section 0 above). It also has the potential to obstruct fish passage.

Obstruction of Fish Passage

Many of the fish native to ephemeral systems of central and western Queensland migrate up and downstream and between different habitats at particular stages of their lifecycle. Fish passage is already restricted in creeks in the CSG Fields, both naturally by the ephemeral nature of the waterways, and un-naturally by poorly designed road crossings. The installation of additional poorly designed creek crossings during the development of the CSG Fields has the potential to further impact on fish movement within the study area. Opportunity to minimise the potential impact of future creek crossings on fish passage in the CSG Fields are presented in Appendix F.

Biting Insects

Mosquito eggs are laid in mud or on vegetation associated with shallow pooled water, and hatch when water levels rise (e.g. following rainfall). The larvae and pupae of most species take at least 6 days to develop. Within the study area, creeks, springs, farm dams, stock water troughs and other areas of standing water (for example along roads or in backyards of domestic dwellings) currently have the potential to provide breeding habitat for mosquitoes and biting midge.

Construction activities that result in pooled water have the potentially to increase the extent of mosquito and biting midge breeding habitat in the study area. An increase in the population of mosquitoes and biting midge has the potential to impact on human health. Opportunities to minimise the breeding of mosquitoes and biting midge in the CSG Fields are presented in Appendix F.

Conservationally Significant Habitat

The Great Barrier Reef World Heritage Area, and the Shoalwater and Corio Bays and Narran Lake Nature Reserve Ramsar sites are unlikely to be impacted by the development of the CSG Fields. These habitats are located over 500 km downstream of the project area; water quality that far downstream is not likely to be impacted by the proposed works.

Threatened Ecological Communities

The development and operation of the CSG Fields has the potential to impact on mound springs in the project area. These communities are dependent on the natural discharge of water from the Great Artesian Basin and are listed as threatened ecological communities under the EPBC Act.

The development and operation of the CSG Fields may impact on mound spring communities through: the operation of vehicles and equipment in proximity to the springs; the clearing of vegetation within, or immediately adjacent to, the springs; the discharge of stormwater runoff from project areas to the springs; and the abstraction of ground water from the Great Artesian Basin. The likelihood and specific consequences of any direct physical impact would depend entirely on the precise location of the impacting process. Similarly, the likelihood of any hydraulic impact to the spring communities (through the abstraction of ground water) would depend on both the proximity of the well location, and the volume of water to be abstracted. Where project areas are distant from mound spring communities, and only low volumes of groundwater are to be abstracted, the likelihood of any potential impact is considered to be low. However, where project areas are to be located in close proximity to spring communities, and / or large volumes of groundwater are to be abstracted, there is greater potential for impact. Given that the impacts of such draw-down can be felt across the entire Great Artesian Basin (GAB), not just at the point of extraction, a detailed assessment of groundwater at each potential well site would be necessary to model the potential for impact. Opportunities to avoid, minimise and mitigate potential impacts on aquatic communities are presented in Appendix F.

Threatened Species

The Fitzroy River turtle (*Rheodytes leukops*) has not been recorded within the catchments of the Dawson and Comet Rivers that lie within the area of the CSG Fields. However, the EPA's Turtle Group expects that, with future survey, it will be identified in the upper Dawson River and the middle to upper Comet River (EPA 2007). Indeed, the presence of potential nesting banks and riffle – pool habitat sequences (the preferred habitat for the species) along the upper Dawson River lends support to this hypothesis. If the Fitzroy River turtle is present in the Upper Dawson and Comet Catchments, its distribution is likely to be restricted to the faster flowing waters of the main rivers, and given its relatively small home range, to reaches in relative proximity to potential nesting habitat.

Irrespective of the relative abundance of the species, the likelihood and specific consequences of any impacts from the development and operation of the CSG Fields would depend entirely on the precise location of the impacting process. If streambed and riparian disturbances are not conducted within the upper Dawson and Comet Rivers, and in particular on potential nesting habitat, then the likelihood of any potential impact is considered to be very low. In the event that project-related disturbance is to occur in these waterways, it is difficult to predict the potential for impact on the Fitzroy River turtle with any certainty (reflecting the relative uncertainty on its potential presence, abundance and distribution). However, where such instream disturbance relates to the construction of creek crossings (the most likely scenario in this case), which have been designed and implemented to avoid and / or minimise impact (See Appendix F), the likelihood of any significant impact to the Fitzroy River turtle population is very low.

Murray Cod (*Maccullochella peeli peeli*) have been recorded in the Condamine – Balonne Catchment and may occur in the deeper, larger and more well connected pools of the major waterways in the CSG Fields, such as Tchanning, Bungil and Wallumbilla creeks. Development of the CSG Fields may impact on the species if it is indeed present in these waterways, and if instream habitat, such as boulders, logs, undercut banks and overhanging vegetation, are to be affected. However, the likelihood of an impact is low (due to the low likelihood of Murray Cod being present, and the narrow construction footprint of instream disturbances for the construction of crossings), and the consequence of any impact would also be low and reversible if aquatic habitat is replaced after construction. That is, there is not likely to be any significant impact to the Murray Cod population.

References

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Appendix F Opportunities for Impact Avoidance, Minimisation and Mitigation

Extraction of Associated Water for CSG Production

Risks associated with the abstraction of associated water will be reduced where an assessment of groundwater hydrology is conducted prior the commencement of any drilling works. Positioning well sites away from artesian springs will further minimise the potential for physical and hydraulic impact.

The implementation of a monitoring program aimed at detecting any reduction in the rate of spring discharge will allow for adaptive environmental management should such an impact by detected. The design of the monitoring program would need to be ‘fit for purpose’, that is the specific locations to be monitored, and indeed the frequency of the monitoring itself, would depend on the location, timing and extent of the abstractive process.

Discharge, Use or Injection of Associated Water

Risks associated with the discharge, use or injection of associated water will be reduced where a plan for the ongoing management and monitoring of all associated water discharges is developed. This plan should be developed in accordance with the EPA’s operational policy for *Management of Water Production in Association with Petroleum Activities (Associated Water)*.

Operation of Vehicles and Equipment

Risks associated with the spillage of fuels and other contaminants can be substantially reduced, if not eliminated, where:

- Vehicle maintenance areas and storage of fuels, lube and oil and batteries is undertaken within bunded areas designed and constructed in accordance with AS1940.
- Portable refuelling stations, for refuelling of machinery in the field, are also bunded to meet AS1940, and placed above the Q100 flood level of nearby waterways and dams.

- All spills of contaminants (such as diesel, oil, hydraulic fluid etc.) are immediately reported to the Project's Environmental Officer, or other relevant personnel.
- Appropriate spill containment kits are available, and used for the cleanup of spills in the field. Equipment that is susceptible to spills and/or leakages should have a spill kit within 5 m of the equipment at all times. The kits should contain equipment for clean up of both spill on land or in dry creek beds, and spills to water (such as floating booms).

Vegetation Clearing and Earth Moving

Risks associated with the clearing of vegetation and subsequent erosion may be substantially reduced where an erosion and sediment control management plan is developed (as a part of the Environmental Management Plan (EMP)) to minimise the quantity of sediment run off into waterways. This plan should incorporate the following elements where possible:

- clearing and construction of the creek crossings in the dry season
- use of erosion control matting
- monitoring turbidity during construction
- rehabilitation with native vegetation after clearing, including the establishment of ground cover, and
- rehabilitation of instream aquatic habitat after clearing, including bed and bank rehabilitation.

Timing

The risk of sediment runoff impacting nearby waterways will be further reduced where all clearing and construction of creek crossings (for both roads and pipelines) is done in the dry season.

Erosion Control

During and after construction, water quality and ecosystem health of nearby waterways may be protected by:

- Erosion control matting, placed in ditches and drainage lines running from all cleared areas, especially on slopes and levee banks.

- Contour banks or ditches formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks.
- Monitoring water quality upstream and downstream of crossing point during periods of water flow.

Rehabilitation of Vegetation

After construction, water quality and ecosystem health of nearby waterways may be protected by rehabilitation of the landscape, focusing on the:

- Salvaging clumps of native grass, shrubs and trees prior to clearing.
- Use of native vegetation of local provenance for replanting where possible, and
- Replanting along creek or spring margins following construction of crossings. The width of the replanted riparian vegetation should match the existing riparian vegetation; however, 5 m should be the minimum width. Planted trees in the riparian zone should provide canopy cover and have root systems that can stabilise the banks and disturbed area.

Creek and Spring Crossings

Construction of Permanent Crossings

Impacts associated with the construction of permanent crossings will be minimised if:

Dry Season

- Crossings are located to result in minimal disturbance to wooded areas.
- Construction is undertaken during the dry season (minimising the likelihood of rainfall and runoff carrying sediment and other pollutants into the creeks).
- Stormwater and erosion and sediment control measures are implemented.
- Crossing construction methods minimise disturbance to aquatic habitat and fish passage.

Wet Season

- Where practical, a trenchless crossing method is used (e.g. horizontal directional drill), in accordance with the following recommendations (AE 2001):
  - The drilling be done in a manner that does not cause a disturbance in the water, to the exposed bed or shore of the water body, or to an area of undisturbed vegetation that measures 10 m from each bank of the active channel.
  - Where pressurized drilling fluids[4] or water are used, the waterbody is monitored in case drilling fluids are released into the waterbody. At a minimum, this monitoring should be conducted at a distance of 400 m downstream of the crossing site. Contingency and monitoring measures are put in place, including:
    - instructions to monitor for potential seepage into the water body of drilling fluids or water used, including monitoring and recording drilling fluid volumes on a continuous basis during and after the drilling operation, and
    - instructions on how to mitigate for the effect of any seepage into the water body of drilling fluids or water used.

If a trenchless crossing method is not possible, isolation and open-cut methods are also appropriate under wet conditions. The workspace should be isolated, irrespective of if there is an isolated pool or flowing water. The isolation should be designed such that (AE 2001):

- It is completed within one work-day, to minimise the impact on aquatic fauna.
- Measures are taken to prevent erosion of the area at, and surrounding, the outlet of a bypass/dewatering pump or flume. This can be done by dissipating the energy of the released water using devices that include, but are not limited to, tarps, flip buckets, plates, and appropriately sized granular materials.
- Upstream and downstream dams are installed on the edge of the temporary workspace, to maximise the workspace. These dams should:
  - be constructed of an appropriate material for each creek or spring (e.g. steel plates, flumes, sand bags or aquadam)
  - be made impermeable by using polyethylene liner and sand bags

[4] Drilling fluids can contain drilling muds can consist largely of a bentonite clay-water mixture, and they are not classified as toxic or hazardous substances. However, if it is released into water bodies, bentonite has the potential to adversely impact fish and macroinvertebrates.

- If flowing water is present, 100% downstream flow is maintained by using pumps with a capacity that exceeds expected flows. Backup pumps and generators should be on site and operational if required.
- Pump intakes have a screen, with openings no larger that 2.54 mm, to ensure that no fish are entrapped.
- Fish are salvaged from the isolated workspace and translocated.
- The upstream dam is slowly removed, to allow water to flush the sediment from the workspace area.
- Sediment-laden water is be pumped into sumps or onto vegetation.
- Operation of the clean-water pump to sustain partial flow below the downstream dams is continued until the downstream dam is removed.

Construction of Temporary Crossings

Impacts associated with the construction of temporary crossings will be minimised if they:

- Are constructed during the dry season.
- Follow the guidelines presented below.
- The bed and bank habitat is rehabilitated after removal of the temporary crossing.

Design Crossings to Provide For Fish Passage

Due to the limited water flow within many of the creeks of the region, opportunities for fish to migrate should be maximised. Creek crossings should be designed to provide for fish passage; level crossings should incorporate culverts, bridge crossings should be single span to minimise instream disturbance. Culverts should be designed such that they are:

- as short and wide as possible; whist being designed to allow the passage of anticipated flood volumes and associated debris, and to allow enough water depth within the culvert to facilitate fish movement (estimated at >0.5 m depth for the fish species likely to be present),
- installed without a ‘drop off’ at the culvert outlet or inlet, as this impedes fish migration upstream and downstream, and
- constructed with minimum disturbance to the outer banks on stream bends, as these are usually the most unstable and prone to erosion.

Water Quality Monitoring

Table F.1 outlines recommended water quality parameters for monitoring during the installation of the vehicle and/or pipeline crossings. The aim of this monitoring is to determine whether any sediment-laden runoff during construction is likely to impact upon aquatic fauna. As a guide, Table F.1 presents preliminary water quality objectives for the waterways and springs in the CSG Fields. These guidelines aim to maintain the natural fish communities of the region, based on the water quality recorded during the current studies, and published environmental tolerances (as outlined in Table F.1).

Table F.1 Preliminary water quality objectives for the water quality required in the the CSG Fields, to maintain the natural fish communities.

Parameter	Range Required to Sustain the Fish Communities Sampled During this Study
Temperature (º C)	< 34
Dissolved Oxygen (mg/L)	1.5 – 10.0
pH	6.5 – 8.5
Conductivity (µS/cm)	19.5 – 770
Turbidity (NTU)	< 200*, or 10% above background values, whichever is higher

* However most species found in this study have been recorded from waterways with much higher turbidity (up to 600 NTU; frc environmental pers obs.)

It is recommended that water quality be measured with a hand-held probe:

- immediately upstream of the crossing site immediately prior to construction, to determine background conditions
- daily during construction, at locations both upstream and downstream of the crossing
- daily after construction until water quality returns to background conditions, as established by the initial background monitoring prior to crossing construction.

Where water quality objectives are exceeded, it is recommended that construction cease and that stormwater and erosion and sediment control measures be revised prior to re-commencement of construction.

Rehabilitation of Instream Aquatic Habitat

After the completion of any instream works, and the removal of any temporary waterway crossings in the CSG Fields, impacts should be mitigated by:

- Rehabilitation of the bed and bank structure such that original dimensions and shape of the creek or spring are achieved. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Revegetation of the banks as outlined below.
- Salvaging existing bed material prior to construction and placing it back into the creek or spring at completion of construction. If the existing bed material is unable to be salvaged, a comparable sediment size material is recommended to cover the bed and should be approximately 10 cm thick. If the sediment is fine (mud and/or silt), it is recommended that the bed material be replaced with sand, to prevent future erosion. If the sediment is coarser (gravel, cobble, pebbles and/or boulder), new material must be washed prior to placing in the creek or spring (as usually, new coarse substrate is covered in a fine dust, which will become suspended in the water).
- Replacing aquatic habitat structures within the channel. Prior to construction, any instream structures (woody debris, large cobbles) may be salvaged. Felled trees may also be placed into creeks to create woody debris habitat.

Stranding of Fish and Other Aquatic Fauna

If an isolation method is used, fish and other aquatic fauna will become stranded once the work area is isolated. Stranded fish must be captured and translocated, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004), which recommend that:

- fish should be captured from the creek or spring using gear appropriate to the waterways and species present (this is likely to include electrofishing, cast nets, seine nets and set traps)
- translocation should be done in the cooler months if possible, to minimise stress to the fish (fish are less active in the cooler months)
- fish should be removed from the existing channel before water flow is isolated from the channel, and
- fish should be handled, transported and released so as to minimise damage to the fish (e.g. handle with wet hands, hold fish correctly etc.)

The capture of fish using electrofishing, traps, bait nets or cast nets requires a General Fisheries Permit, issued by the DPI&F. The capture, handling and translocation of fish and other fauna will also require an Animal Ethics approval.

In large pools, traps and seine nets (as appropriate) should be set to capture turtles. If caught, turtles should also be transported and released to a relatively permanent waterhole in the study area, in accordance with ethical handling procedures.

Biting Insects

Mosquito breeding habitat may be minimised through:

- Minimising the area of standing water, and ensuring drainage within 4 days.
- Grading to ensure sufficient drainage.
- During construction, routinely filling incidental depressions and holes that may hold standing water.
- Regularly clearing drainage lines to ensure that water continues to flow and no ponded areas are created.

Threatened Species and Ecological Communities

The Project is unlikely to have a significant impact on any threatened species or ecological communities where each of the mitigation measures described above is adopted (and in particular, where riparian and aquatic habitat is rehabilitated after construction).

References

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EPA 2007a, *Queensland Water Quality Guidelines 2006*, March 2006, Environmental Protection Agency, Brisbane.

Russell, D. J. & Hales, P. W., 1993, 'Stream habitat and fisheries resources of the Johnstone River Catchment', Northern Fisheries Centre, Queensland Department of Primary Industries.

5.2.2 Operation

The discharge of associated water has the potential to reduce seasonality of flows, increase the availability of water, and enhance erosion and scouring at discharge points on watercourses in the CSG Fields. This may favour filamentous algae and exotic flora and fauna and reduce diversity. Discharges should be managed inline with the EPA's operational policy for *Management of Water Production in Association with Petroleum Activities* (*Associated Water*). Where discharges are timed to follow natural flow patterns, and bed stabilising structures are placed at discharge points to reduce erosion, the likelihood of impacts to aquatic ecology is low.

Where fuel storage and handling activities are undertaken in accordance with AS1940 and appropriate stormwater management facilities are implemented to prevent runoff from transporting contaminants to the waterways of the CSG Fields, the risk of impact to aquatic ecology is low.

5.2.3 Decommissioning

Where decommissioning activities are conducted adjacent to artesian springs and watercourses, and the recommended mitigation controls (Table 5.1) are implemented to prevent runoff from entering watercourses and rehabilitate riparian vegetation, the risk of long-term impacts to aquatic ecology is low.

Table 5.1 Summary of potential impacts and mitigation controls for activities in the CSG Fields (Refer to Appendix E and F for more detail).

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Construction			
Roads	Artesian springs	1. Disturbance of threatened ecological communities.	1. Plan roads to avoid artesian springs. These communities are listed as threatened ecological communities under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Where possible, a minumum ecological buffer of 100 m should be retained. Where road construction is required in areas of the CSG Fields that contain artesian springs, further detailed assessments of the potential for impact may be required.
		2. Accidental spillage of fuel and oil from construction equipment.	2. Conduct fuel storage and handling activities in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols). Report any spilt contaminants immediately and contain before they disperse into springs.
	Watercourses	1. Removal of riparian vegetation and disturbance of riparian soils resulting in increased erosion, turbidity and sedimentation.	1. Where possible, locate roads to minimize disturbance to riparian vegetation. Implement silt curtains and erosion control matting below works in riparian zones to prevent runoff from entering watercourses. Monitor turbidity below containment measures. Rehabilitate riparian vegetation after clearing (to ensure bank stability).

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
		2. Removal of instream habitat and increased turbidity and sedimentation with the construction of road crossings.	2. Select construction methods that where practical minimise the disturbance to aquatic habitats, such as: trenchless excavation (using a horizontal directional drill); isolation and open cut excavation. Where crossings traverse flowing wet watercourses, construct containment dams to isolate work areas. Monitor water quality upstream and downstream of containment dams daily during construction to detect changes to: turbidity, dissolved oxygen, pH and conductivity. Where a reduction in downstream water quality is detected, stop or scale back construction and review and revise erosion and sediment control measures, as necessary. Rehabilitate instream habitat and bed and banks following the completion of works.
		3. Temporary damming of watercourses for the construction of road crossings.	3. Appropriate controls for the diversion of watercourses include: • Construct dams of material appropriate to each watercourse (e.g. steel plates, flumes, sand bags or aquadams), make dams impermeable with polyethylene liner and sand bags • If flowing water is present, maintain flow with pumps that have a capacity that exceeds expected flows. Have backup pumps and generators on site to ensure that flow is continuous. • Screen pump intakes (with mesh openings no larger than 2.54 mm) to ensure that no fish are entrapped. • Salvage fish from isolated workspaces and translocate to flowing waters using current best practice. • When construction is complete, remove the upstream dam slowly, to allow water to flush the sediment from the workspace area. Pump the sediment-laden water out of the flooded work area into sumps or onto vegetation.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
			• Operate a clean-water pump to sustain partial flow in the watercourse below the downstream dam until it is removed.
		4. Obstruction of fish passage with the construction of road crossings.	4. Design crossings to provide for fish passage. Where possible, design bridge crossings to be single span (to minimise instream disturbance), and level crossings to incorporate culverts. To facilitate fish passage, design culverts so that they are: • as short and wide as possible, and allow the passage of anticipated flood volumes and debris • deep enough to allow fish movement (a minimum depth of 0.5 m for the fish species present), and • installed without a 'drop off' at the culvert outlet or inlet (these impede fish migration).
		5. Accidental spillage of fuel and oil from construction equipment.	5. As for artesian springs.
		6. Disturbance of threatened ecological species.	6. Where possible, plan roads to avoid disturbance to habitats on major waterways that may support threatened species (as listed under the EPBC Act). This includes: sand banks and riffle – pool sequences on the Dawson and Connors Rivers, which may support Fitzroy River Turtles (*Rheodytes leukops*); and deep, well connected pools in Tchanning, Bungil and Wallumbilla creeks, which may support Murray cod (*Maccullochella peeli peeli*).

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Pipelines	Artesian springs	1. Disturbance of threatened ecological communities.	1. Plan pipeline routes to avoid artesian springs. These communities are listed as threatened ecological communities under the EPBC Act. Where possible, a minimum ecological buffer of 100 m should be retained. Where construction is required in areas of the CSG Field that contain artesian springs, further detailed assessments of the potential for impact may be required.
		2. Accidental spillage of fuel and oil from construction equipment into artesian springs.	2. Conduct fuel storage and handling activities in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols). Report any spilt contaminants immediately and contain before they disperse into springs.
	Watercourses	1. Removal of riparian vegetation and instream habitat, and increased turbidity and sedimentation with the construction of crossings.	1. Where practical, locate pipeline crossings to minimize disturbance to riparian vegetation. Implement silt curtains and erosion control matting below works in riparian zones. Select construction methods to minimise the disturbance to aquatic habitats, such as: trenchless excavation (using a horizontal directional drill); isolation and open cut excavation. Where crossings traverse flowing wet watercourses, construct containment dams to isolate work areas. Monitor water quality upstream and downstream of containment dams daily during construction to detect changes to: turbidity, dissolved oxygen, pH and conductivity. Where a reduction in downstream water quality is detected, stop construction and review and revise erosion and sediment control measures, as necessary. Rehabilitate riparian

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
			vegetation and instream habitat following the completion of works.
		2. Temporary damming of watercourses for the construction of crossings.	2. Appropriate controls for the diversion of watercourses include: • Construct dams of material appropriate to each watercourse (e.g. steel plates, flumes, sand bags or aquadams), make dams impermeable with polyethylene liner and sand bags • If flowing water is present, maintain flow with pumps that have a capacity that exceeds expected flows. Have backup pumps and generators on site to ensure that flow is continuous. • Screen pump intakes (with mesh openings no larger than 2.54 mm) to ensure that no fish are entrapped. • Salvage fish from isolated workspaces and translocate to flowing waters. • When construction is complete, remove the upstream dam slowly, to allow water to flush the sediment from the workspace area. Pump the sediment-laden water out of the flooded work area into sumps or onto vegetation. • Operate a clean-water pump to sustain partial flow in the watercourse below the downstream dam until it is removed.
		3. Accidental spillage of fuel and oil from construction equipment into watercourses.	3. As for artesian springs.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
		4. Disturbance of threatened ecological species.	4. Where possible, plan pipeline routes to avoid disturbance to habitats on major waterways that may support threatened species (as listed under the EPBC Act). This includes: sand banks and riffle – pool sequences on the Dawson and Connors Rivers, which may support Fitzroy River Turtles; and deep, well connected pools in Tchanning, Bungil and Wallumbilla creeks, which may support Murray cod.
Wells (Drilling)	Artesian springs	1. Leases located near artesian springs.	1. Plan drilling leases to avoid artesian springs. These communities are listed as threatened ecological communities under the EPBC Act.
		2. Drawdown effects on aquifers.	2. Conduct a groundwater impact study to assess the potential impacts of drawdown on artesian springs. Monitor the depth of aquifers and the rate of spring discharge over the period of water extraction to enable early detection of drawdown. The specific design of the monitoring program to be dictated by the findings of the groundwater impact study.
	Watercourses	1. Removal of riparian vegetation for drilling operations.	1. Where possible, locate drilling operations to minimize disturbance to riparian vegetation. Rehabilitate any disturbed riparian vegetation following the completion of works.
		2. Increased turbidity, nutrients and sedimentation with runoff from drilling operations.	2. Implement silt curtains and erosion control matting below drilling works to prevent runoff from entering watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
		3. Accidental spillage of fuel and oil from construction equipment into watercourses.	3. Conduct fuel storage and handling activities in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols). Report any spilt contaminants immediately and contain before they disperse into watercourses.
		4. Disturbance of threatened ecological species.	4. Where possible, locate drilling operations to avoid disturbance to habitats on major waterways that may support threatened species (as listed under the EPBC Act). This includes: sand banks and riffle – pool sequences on the Dawson and Connors Rivers, which may support Fitzroy River Turtles; and deep, well connected pools in Tchanning, Bungil and Wallumbilla creeks, which may support Murray cod.
Compressor Stations	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that compressor stations are not constructed in the riparian habitat of artesian springs and watercourses.
Storage Areas	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that storage areas are not constructed in the riparian habitat of artesian springs and watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Administration buildings and accommodation	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that buildings and accommodation are not constructed in the riparian habitat of artesian springs and watercourses.
Gas Processing Facilities	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that processing facilities are not constructed in the riparian habitat of artesian springs and watercourses.
Water Management Facilities	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that water management facilities are not constructed in the riparian habitat of artesian springs and watercourses.
Waste Management Areas	Artesian springs and watercourses	1. Construction in riparian zones. Transport of sediments, nutrients and contaminants to springs and watercourses.	1. Design construction plans so that waste management areas are not constructed in the riparian habitat of artesian springs and watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Operation			
Roads (Operation of Vehicles and Equipment)	Artesian springs and watercourses	1. Accidental spillage of fuel and oil into waterways.	1. Conduct fuel storage and handling activities in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols). Report any spilt contaminants immediately and contain before they disperse into waterways.
Pipelines	Artesian springs and watercourses	1. Leakage of water or gas into waterways, which may alter water quality and enhance erosion.	1. Early detection and reparation of leaks. Assessment of the magnitude of any impact. Rehabilitate any disturbed riparian vegetation or instream habitat, as necessary. Ongoing monitoring of water quality, as required.
Wells (Production)	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from well sites.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.
Compressor Stations	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from compressor stations.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Storage Areas	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from storage areas.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.
Administration buildings and accommodation	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from buildings and accommodation.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.
Gas processing facilities	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from gas processing facilities.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.
Water management facilities	Artesian Springs	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from water management facilities.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
	Watercourses	1. Transport of sediments, nutrients and contaminants to watercourses in runoff from water management facilities. 2. Discharge of associated water to watercourses, resulting in: reduced seasonality of flows, increased availability of water, and erosion and scouring at discharge points. This may favour filamentous algae and exotic flora and fauna and reduce diversity.	1. As for artesian springs. 2. Where possible, time discharges to follow natural flow patterns. Place bed stabilising structures at discharge points to reduce erosion. Implement a plan for the management and monitoring of discharges, in accordance with the EPA's Operational Policy for *Management of Water Production in Association with Petroleum Activities (Associated Water)*(EPA 2007).
Waste Management Areas	Artesian springs and watercourses	1. Transport of sediments, nutrients and contaminants to springs and watercourses in runoff from waste management facilities.	1. Stormwater management facilities will be implemented (in line with the project EMP) to prevent runoff from entering watercourses.

Phase / Activity	Ecological Aspect	Potential Impact	Mitigation Controls
Decommissioning			
Decommissioning of Infrastructure and Equipment.	Artesian springs and watercourses	1. Any decommissioning works conducted adjacent to artesian springs and watercourses have the potential to transport sediments, nutrients and contaminants to these areas.	1. Where decommissioning activities are constructed adjacent to wet springs and watercourses, implement silt curtains and erosion control matting to prevent runoff from entering watercourses. Monitor turbidity below containment measures. Rehabilitate riparian vegetation following the completion of works.
Remediation of Contaminated Areas.	Artesian springs and watercourses	1. Transport of contaminated waters and sediments to springs and watercourses in runoff from contaminated areas.	1. Undertake a risk assessment of site contamination (in accordance with applicable Queensland regulatory requirements and National environmental protection measures at the time of closure) to determine the requirements for remediation.

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