Wandoan Coal Project

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 which 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 be 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.
Macro-invertebrate	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 macro-invertebrate 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 PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology for the Environmental Impact Study (EIS) for the Wandoan Coal Project (the Project). There were two study areas for this assessment:

- the MLA study area (the waterways of the Mining Lease Applications (MLAs) 50229, 50230 and 50231; waterways immediately upstream of the MLAs; and Juandah Creek downstream of the MLAs (to approximately 60 km downstream of the MLAs, just upstream of its confluence with the Dawson River), and
- the gas supply pipeline study area (including each of the waterways crossed by the proposed pipeline route, these waterways eventually flow to Juandah Creek).

The scope of this study included an assessment of aquatic habitat, flora and fauna distribution, biological values of the waterways and the sensitivity of aquatic flora and fauna to changes in flow regime, water levels and water quality in the Project areas. Likely impacts further downstream of the study areas (e.g. the Dawson River) were also assessed based on literature review and local knowledge.

A brief field trip was undertaken in August 2007, to describe the aquatic habitats of the MLAs, and to inform survey site selection. Aquatic floral and faunal surveys and collection of water quality data was then undertaken during the late wet season (autumn) in the MLA study area, and during the dry season (winter) in the gas supply pipeline study area. At each site, habitat descriptions and observations were recorded, and photographs taken. Based on these descriptions, each site was given a habitat assessment score and condition rating following the River Bioassessment Program scoring system. Water quality was measured at each site using a TPS 90 FLMV water quality meter and WP88 turbidity meter. Aquatic macrophyte, macro-invertebrate, fish and turtle communities were surveyed using standard techniques, and their distribution and habitat associations within the study areas were described. Aquatic flora and fauna communities of the region were also described, to provide a regional context for the results of the present study, and to determine the biological values of the waterways affected by the Project. In order to describe seasonal patterns in flora and fauna abundance, and the likely presence of species throughout the year, a second survey is planned for the 2008/2009 wet season, after the first significant rainfall event of the season. A supplementary report will be provided documenting the results of this survey.

Surrounding land uses and their associated impacts, including vegetation clearing, cattle grazing and cropping, have negatively affected the aquatic habitat of the study area and the wider catchment. Water quality is relatively poor, and reflects the predominantly agricultural nature of the region and the ephemeral or intermittent nature of the creeks.

Biodiversity in the study area is slightly lower than that found in the more permanent waters of the region (such as the Dawson River). Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area; that is, communities are typically have a low sensitivity to changes in water levels and water quality. However, macro-invertebrate and fish communities found within the MLAs are likely to contribute to the success of downstream populations through movement/migration. Flow is an important cue for migration and reproduction in many of the species recorded in the study areas. One species of freshwater turtle (the Krefft's river turtle) was found downstream of the MLAs in Juandah Creek; however turtles are unlikely to be abundant in the ephemeral creeks of the study areas at any given time. No rare or threatened aquatic floral or faunal species were found in the study areas, or are considered likely to occur, based on the habitats present.

The coal resources of the Project will be developed as an open-cut mine and related local infrastructure. Construction and mining activities, including: the operation of vehicles and other equipment; vegetation clearing and earth moving; creation of wastewater in association with the required infrastructure; management of stormwater runoff; creation of dams; construction of creek crossings; creation of stream diversions; and the loss of catchment area, each have the potential to impact on aquatic ecology.

The potential impacts of fuel handling, vegetation clearing, dam operation and stormwater discharge on the creeks within the study areas (and downstream waterways) can be minimised if current best practicable practice environmental management programs are followed.

The Project is highly unlikely to have an impact on boggomoss springs, the Great Barrier Reef World Heritage Area or the Shoalwater and Corio Bays Ramsar site. The Project is unlikely to impact on any threatened aquatic species or ecological communities (as listed under State or Commonwealth legislation), as these species and communities are unlikely to occur in the waterways of the MLAs or along the gas supply pipeline. In summary; the Project is not likely to impact on Matters of National Environmental Significance (MNES) with respect to aquatic ecology.

Of the potential impacts of the Project on the creeks of the study areas, the diversion of creek channels, and the construction of creek crossings (which can affect fish movement) could result in the greatest impact to the aquatic environment. However, the significance of any potential impacts can be reduced if appropriate mitigation measures are followed. In particular, the channel morphology and aquatic habitats of the creeks to be diverted should be surveyed in detail, so that the diversion channels can be constructed so that they replicate the natural channels in terms of channel morphology, sediment type, instream physical habitat and riparian vegetation. Creek crossings should be constructed in accordance with the recommendations in the DPI&F Fish Habitat Guideline FHG 001, *Fish Passage in Streams, Fisheries guidelines for design of stream crossings* (Cotterell 1998).

Taking into account the low existing biological values of the aquatic environments of the study area, in general, the impact assessment demonstrates that there will be only a low magnitude of impact to the local aquatic environments of the MLAs and gas pipeline route, and negligible regional impacts to aquatic ecosystems. However, future water quality and aquatic ecology monitoring will be required to determine the impact of the Project on aquatic ecology, in order to inform adaptive management of the Project.

1 Introduction

This report has been prepared for PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology for the Environmental Impact Statement (EIS) for the Wandoan Coal Project (the Project). The purpose of the report is to:

- Describe the aquatic flora and fauna occurring and likely to occur in areas affected by the Project (including wetlands and matters of National Environmental Significance identified in the *Environment Protection and Biodiversity Conservation Act 1999*);
- Discuss potential direct and indirect effects of the Project on aquatic flora and fauna; and
- If potential impacts to rare or threatened species are identified, propose strategies for protecting these species (including any obligations under legislation or policies of the Queensland and Australian Governments).

1.1 Project Background

The Project comprises the development of thermal coal resources situated immediately west of the Wandoan township, located in Dalby Regional Council. The Project is located approximately 350 km northwest of Brisbane and 60 km south of Taroom as shown in Figure 1.1. The coal reserves for this Project exist within three Mining Lease Applications (MLAs), MLA 50229, 50230 and 50231 as shown in Figure 1.2. The Project covers an area of approximately 32,000 ha.

The mining of the coal resources will be undertaken using a combination of truck, shovel, dozer and dragline mining equipment. Coal will be mined at a rate of around 30 million tonnes per annum (Mtpa) run of mine (ROM) coal. The coal will be crushed, sized and washed before being transported by rail to ports in the Gladstone area.

Due to the existing condition of the power grid in the area compared to power demands of the Project, on-site power generation is being considered as a power supply option. Gas from the nearby Peat-Scotia Gas Line has been identified as a potential fuel source for proposed on-site power generation, which may be constructed as part of the Project. The Peat-Scotia Gas Line is located approximately 20 km to the north-east of the Project. Through the route selection assessment process, a preferred pipeline route was determined for the Project gas supply pipeline (Figure 1.3).

The Project will be developed by the Wandoan Joint Venture. The joint venture partners are Xstrata Coal Queensland Pty Ltd (XCQ), ICRA Pty Ltd and Sumisho Coal Australia Pty Ltd.

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	Figure 1.1 Project location.	
		October 2008

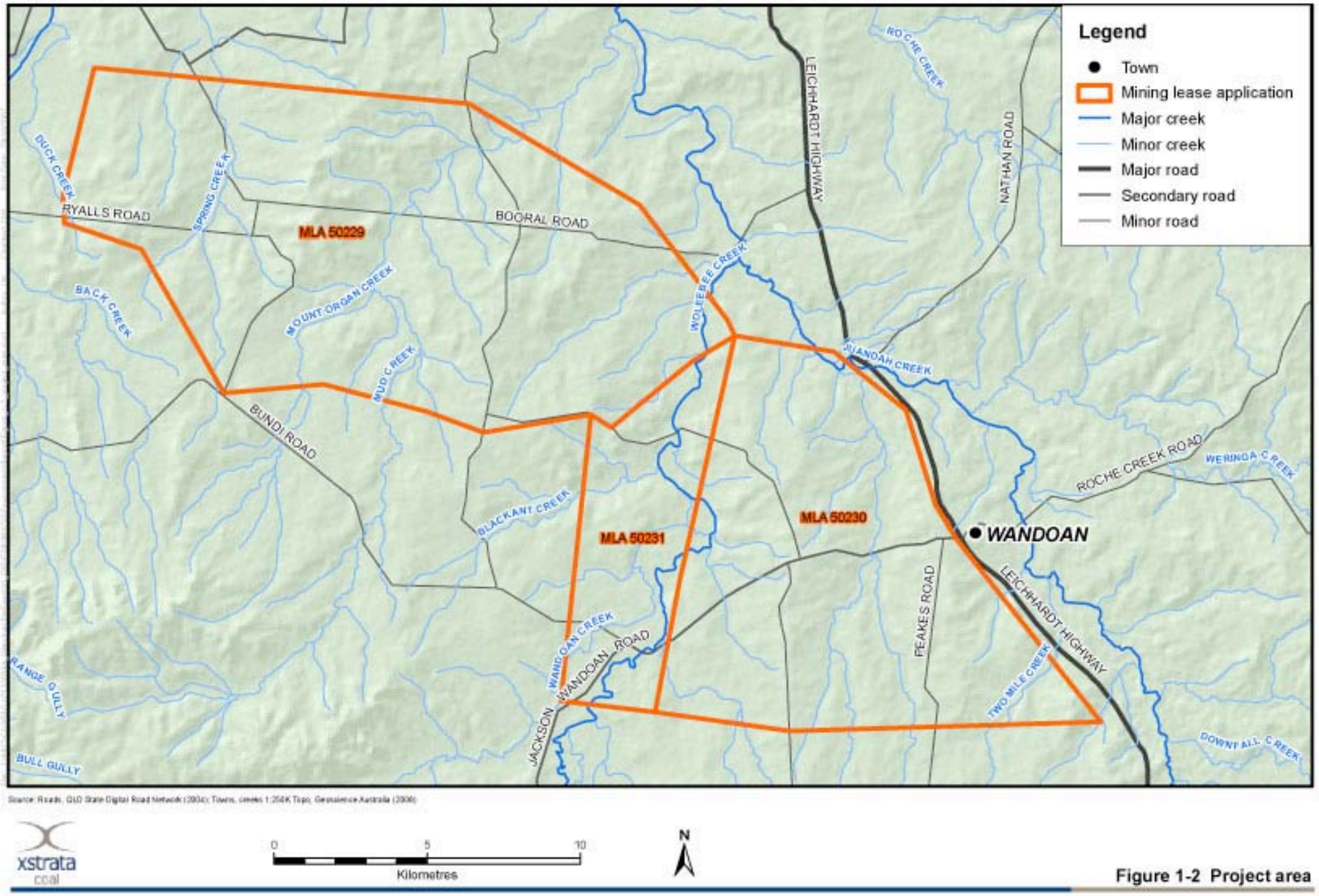

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	Figure 1.2 Project area, showing the location of the MLAs.
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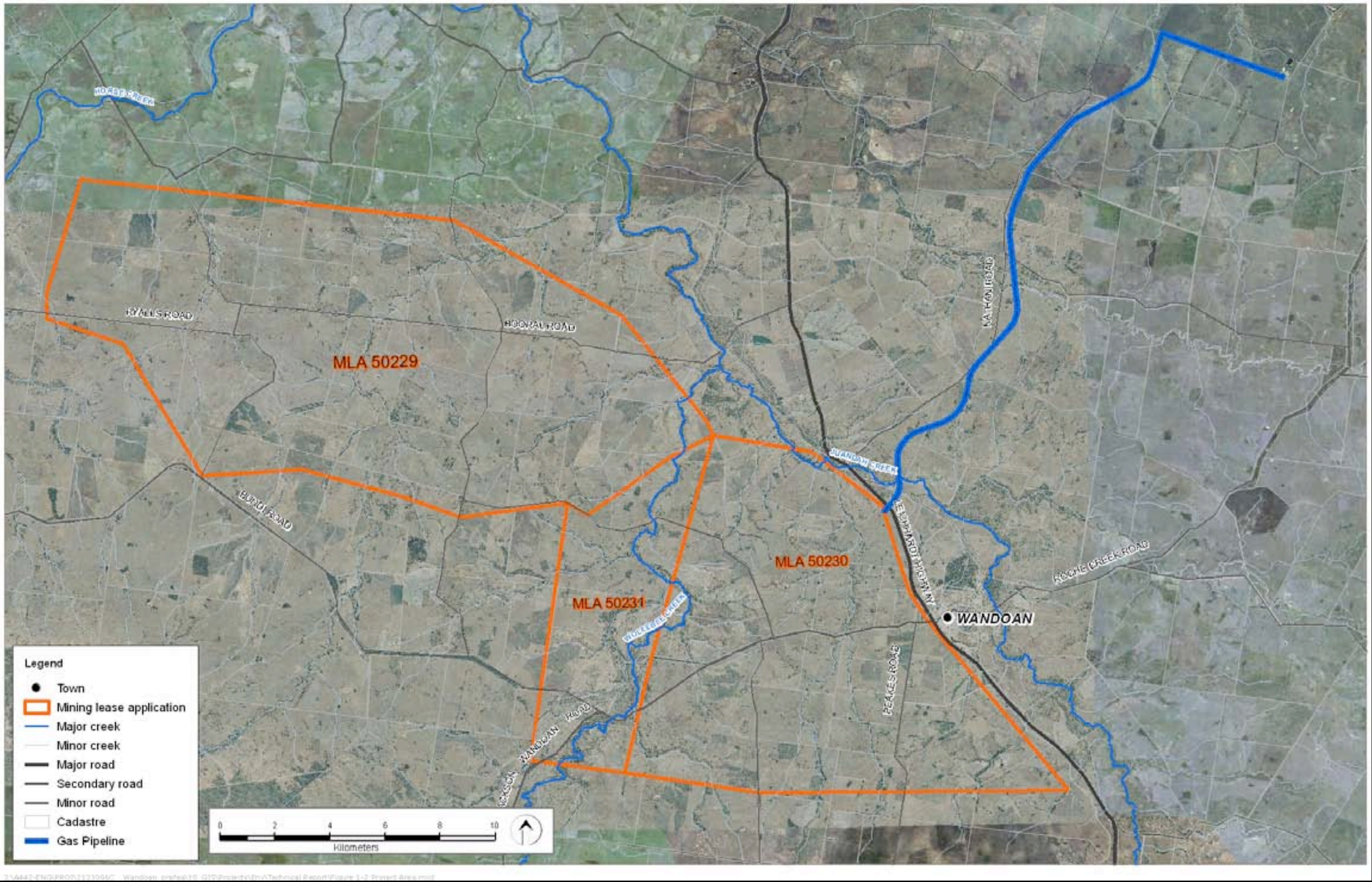

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	Figure 1.3 Location of the gas supply pipeline route.	
		October 2008

1.2 Description of Study Areas

1.2.1 MLA Study Area

The waterways of the MLAs are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment) (Figure 1.4). The major creeks within the MLAs include Spring Creek and Mud Creek, which flow through MLA50229; Halfway Creek, Frank Creek, Two Mile Creek and Juandah Creek, which flow through MLA50230; and Blackant Creek, Wandoan Creek and Woleebee Creek, which flow through MLA50231. Each of these creeks flow into Juandah Creek, which then flows into the Dawson River approximately 64 km north of the MLAs, just south of Taroom. The Dawson River 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 1.4).

The study area for this assessment includes the waterways of the MLAs; waterways immediately upstream of the MLAs; and Juandah Creek downstream of the MLAs (to approximately 60 km downstream of the MLAs, just upstream of its confluence with the Dawson River). Likely impacts further downstream, including the Dawson River, Fitzroy River and the final receiving environment of these waterways (the Great Barrier Reef) were also assessed based on literature review and local knowledge.

1.2.2 Gas Supply Pipeline Study Area

The gas supply pipeline route crosses eleven watercourses, which are also part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment). The major creeks crossed by the pipeline include Stakeyard Creek, Roche Creek and Juandah Creek; along with tributaries of these creeks. Stakeyard Creek flows into Bungaban Creek, which eventually flows into Juandah Creek. Roche Creek flows into Juandah Creek, which then flows into the Dawson River approximately 64 km north of the MLAs, just south of Taroom.

The study area for this assessment includes the waterways crossed by the proposed pipeline route.

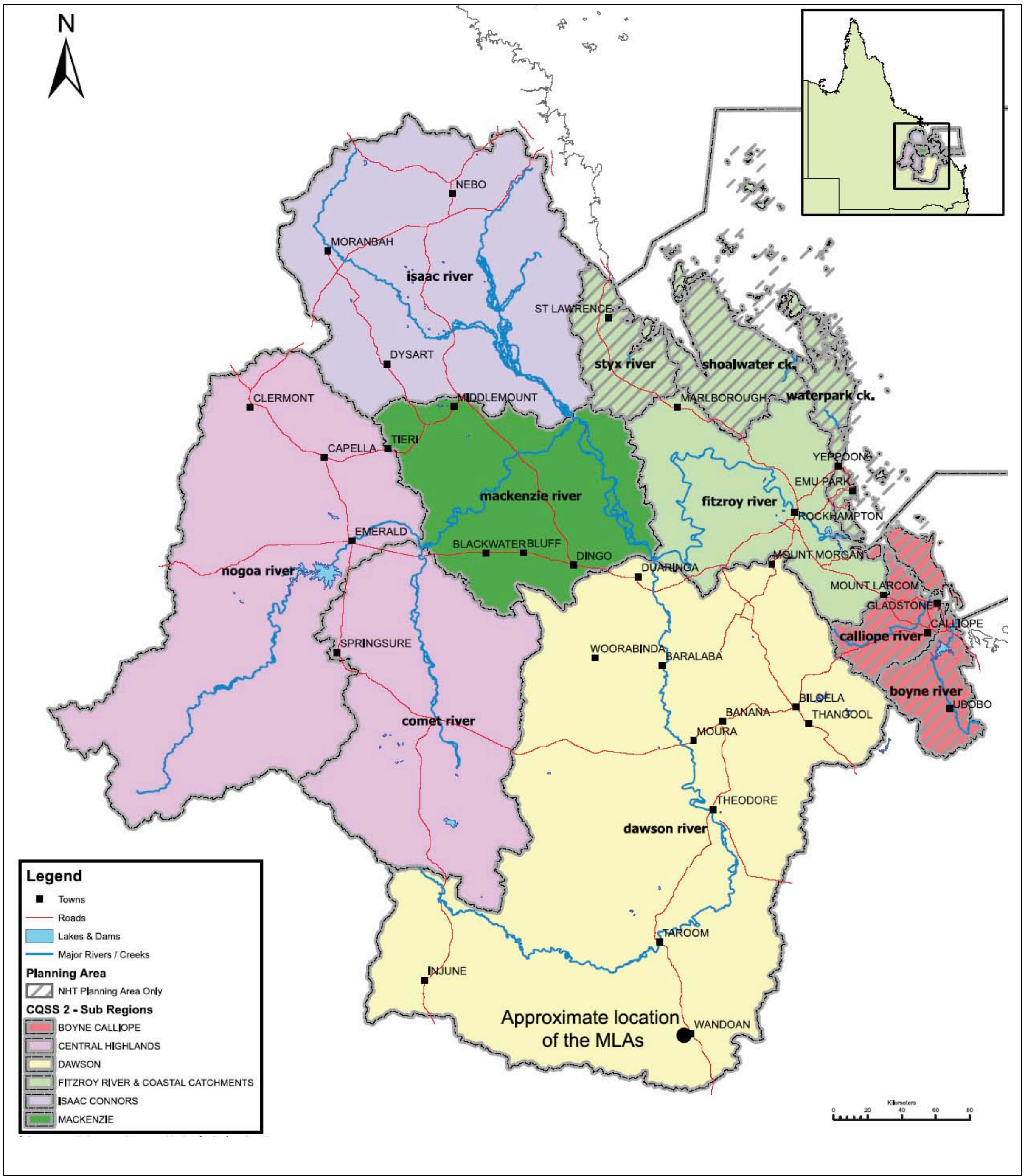

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Figure 1.4 The Fitzroy River Basin, showing the approximate location of the MLAs.

Adapted from FBA 2005 | October 2008

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.

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 600 km downstream from the Project area. The Project is not likely to result in a significant impact to the values of the Great Barrier Reef World heritage Area, as the Project will not impact on water quality or water flows of the area (given that water in the Dawson and Fitzroy rivers is regulated by several weirs and the Fitzroy Barrage).

There are no other World Heritage properties that are likely to be impacted by the Project.

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 Ramsar wetland is approximately 620 km downstream from the Project area, and the Project is not likely to result in a significant impact to the values of the Shoalwater and Corio Bays Ramsar site, as the Project will not impact on water quality or water flows of the site (given that water in the Dawson and Fitzroy rivers is regulated by several weirs and the Fitzroy Barrage).

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 River at Gainsford, approximately 280 km downstream form the Project area (Limpus et al. 2007, EPA 2007b).

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 417 m (Tucker et al. 2001).

Tucker et al. (2001) found that individual turtles exhibit relatively long sedentary periods, ranging from 3 to 24 hours. When active, mean movement was 20 m per day on average, with a range of 0 to 350 m per day (Tucker et al. 2001). Overall, the distribution of movements and positions of turtles was not far from riffle zones, generally regardless of flow conditions (Tucker et al. 2001). However, when the data was conditioned by flow rates, descriptive patterns suggested that turtles: moved slightly upstream of riffle zones under moderate flows; moved downstream of riffle zones under base flows; and showed no obvious directional movement patterns under flood conditions (Tucker et al. 2001). Under low flow events, or as riffle zones became seasonally ephemeral, or dried completely, female *R. leukops* were observed to retreat to deeper sections of pool habitats adjacent to riffle zones (Tucker et al. 2001).

Gordos & Franklin (2002) observed a weakly bimodal pattern of increased surfacing activity during dawn and dusk in *R. leukops*, however this pattern was not consistently observed among individual turtles. At the time of writing no information on diurnal habitat preferences of *R. leukops* was available. No seasonal movement patterns have been observed for *R. leukops*.

The Project is unlikely to result in an impact to this species (Section 6.9).

Boggomoss Communities

On the Dawson River, approximately 100 km downstream from the MLAs, mound springs from the Great Artesian Basin (Boggomoss Areas 1 & 2) are listed on the Register of the National Estate. The boggomoss communities form part of the native species dependent on natural discharge of groundwater from the Great Artesian Basin, which are listed as an Endangered Ecological Community under the EPBC Act.

The boggomoss snail (*Adclarkia dawsonensis*), or Dawson River snail, is listed as critically endangered under the EPBC Act. This snail lives in the boggomoss habitat on the Dawson River, approximately 100 km downstream of the creeks within the MLAs (DEWHA 2008b).

No springs have been mapped within the study areas (Figure 2.1). The Project is unlikely to result in an impact to boggomoss communities or the boggomoss snail (Section 6.9).

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. The Project will require approvals under the Water Act for the construction, control and management of works with respect to water conservation and protection, drainage, supply, flood control and prevention. 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.

Creek diversions are proposed as a part of the Project, and the proposed gas supply pipeline route traverses a number of watercourses. Therefore, it is likely that approvals will be required under the Water Act for creek diversions and pipeline crossings of watercourses. Additionally, where waters are to be taken from a watercourse, lake, spring or underground water, for example for use in dust suppression during construction works, 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 that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive of the Department of Primary Industries & Fisheries (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 will be constructed as a part of the Project. 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. An assessment is done by DPI&F staff to see whether or not an approval should be issued, and whether a fishway is required to be built with the structure. 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.

Impacts of the Project on fish passage are addressed in Section 6.7.

2.4 Queensland *Nature Conservation Act 1992*

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

The Project is unlikely to result in an impact to this species (Section 6.9).

2.5 Wetlands of National, State or Regional Significance

Both palustrine and lacustrine wetlands have been identified in the Environmental Protection Agency's (EPA's) recent wetland mapping program (Figure 2.1). Lacustrine wetlands within the study areas are likely to be farm dams (pers. obs.). None of the wetlands within the study areas are recognised by the EPA as being of National, State or Regional Significance.

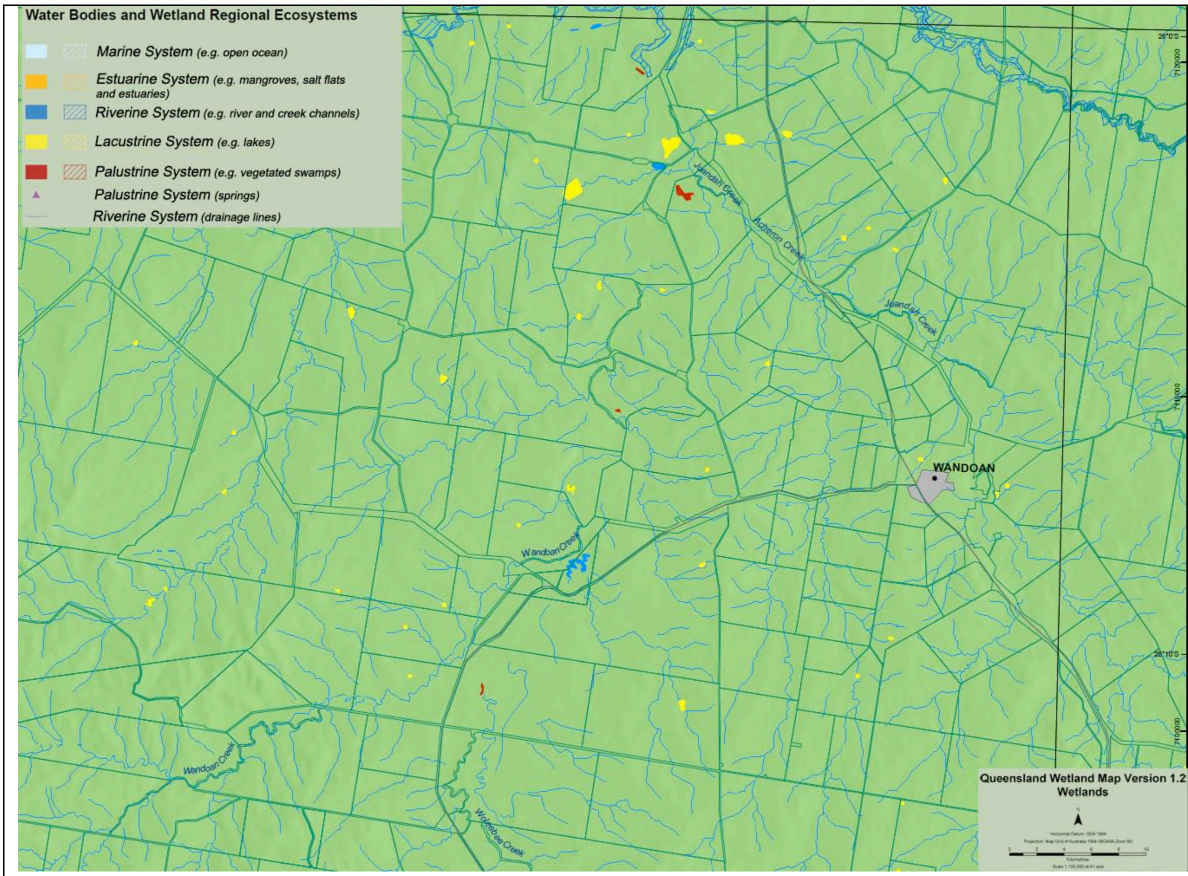

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	Figure 2.1 Waterbodies and wetlands mapped in the vicinity of the Project area by the EPA.	
	Adapted from EPA 2008	October 2008

3 Study Methodology

3.1 Survey Timing

3.1.1 MLA Study Area

The aquatic habitats of the MLAs were initially described during a brief field trip on the 7th and 8th of August 2007. The majority of the creeks were dry at this time, and the weather was fine during the survey.

Aquatic floral and faunal surveys and collection of water quality data was undertaken during the late wet season, from the 10th – 14th March 2008. The weather was fine during the survey. In the months preceding the survey, there had been between 129 and 185 mm of rainfall per month in December 2007, January 2008 and February 2008 (based on rainfall records from the Taroom Post Office, BOM 2008). No rain had fallen in the week prior to the survey (BOM 2008). In order to describe seasonal patterns in flora and fauna abundance, and the likely presence of species throughout the year, a second survey is planned for the 2008/2009 wet season, after the first significant rainfall event of the season.

3.1.2 Gas Supply Pipeline Study Area

Aquatic floral and faunal surveys and collection of water quality data was undertaken during the late dry season, from the 19th to the 28th August 2008. The weather was fine and cool during the survey. Rainfall was relatively low during the months prior to the survey (between 0 mm in April, to 74 mm in July at the Taroom Post Office) (BOM 2008). No rain had fell in the three weeks preceding the survey; however there was relatively heavy rainfall on the 24th of July 2008 (recorded at the Taroom Post Office, BOM 2008). A second survey is planned for the 2008/2009 wet season, after the first significant rainfall event of the season.

3.2 Study Sites

3.2.1 MLA Study Area

Nineteen sites were surveyed for aquatic habitat during the initial field trip in August 2007. Sites were selected to cover a range of stream types, including first order streams

(streams at the top of the catchment) through to larger fourth order streams (more major waterways such as Juandah Creek) (refer Figure 3.1). Stream orders were determined following the Strahler method, as used in AusRivAS models (e.g. two first order streams combine to form a second order stream, two second order streams combine to form a third order stream etc.). 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 (DNRM 2001). Observations were made on water quality, although no samples were taken at that stage.

Site selection for an aquatic flora and fauna survey was based on the aquatic habitat information collected during the initial field trip. Ten sites were selected from the initial nineteen sites, and also at waterways upstream and downstream of the MLAs (Figure 3.2). These ten sites represented the range of aquatic habitats found in the region, and included sites that may be either directly or indirectly impacted by the Project (e.g. on waterways that will be diverted, or those downstream of the Project area that may receive mine runoff / discharge) and comparison sites that are not likely to be either directly or indirectly impacted by the Project.

Table 3.1 Description of sites surveyed during the initial field reconnaissance (August 2007), and the flora and fauna survey (March 2008).

Site Description	Site Number	
	Initial field trip (August 2007)	Flora and Fauna Survey (March 2008)
Frank Creek upstream of Jackson Wandoan Road	S1	–
Unnamed tributary of Juandah Creek at the Leichhardt Highway	S2	–
Frank Creek at Jackson Wandoan Road	S3	1
Halfway Creek, upstream of confluence with Frank Creek	S4	–
Unnamed tributary of Frank Creek near Grosmont Road	S5	–
Unnamed tributary of Woleebee Creek at Jackson Wandoan Road	S6	–
Unnamed tributary of Woleebee Creek at Jackson Wandoan Road	S7	–
One-arm Man Creek at Jackson Wandoan Road	S8	2
Wandoan Creek at Bundi Road	S9	–
Juandah Creek at the Leichhardt Highway	S10	7

Site Description	Site Number	
	Initial field trip (August 2007)	Flora and Fauna Survey (March 2008)
Woleebee Creek at Grosmont Road	S11	3
Woleebee Creek at Boral Road	S12	4
Unnamed tributary of Mud Creek	S13	–
Unnamed tributary of Mud Creek at Booral Road	S14	–
Mud Creek	S15	5
Mud Creek at Grosmont Road	S16	–
Spring Creek at Kabunga Road	S17	6
Unnamed tributary of Spring Creek at Ryalls Road	S18	–
Spring Creek just north of Ryalls Road	S19	–
Mount Organ Creek at Bundi Road	–	8
Juandah Creek at Booral Road	–	9
Juandah Creek at Roma Taroom Road	–	10

A description and photographs of each site surveyed during the reconnaissance and aquatic flora and fauna survey can be found in Attachment A.

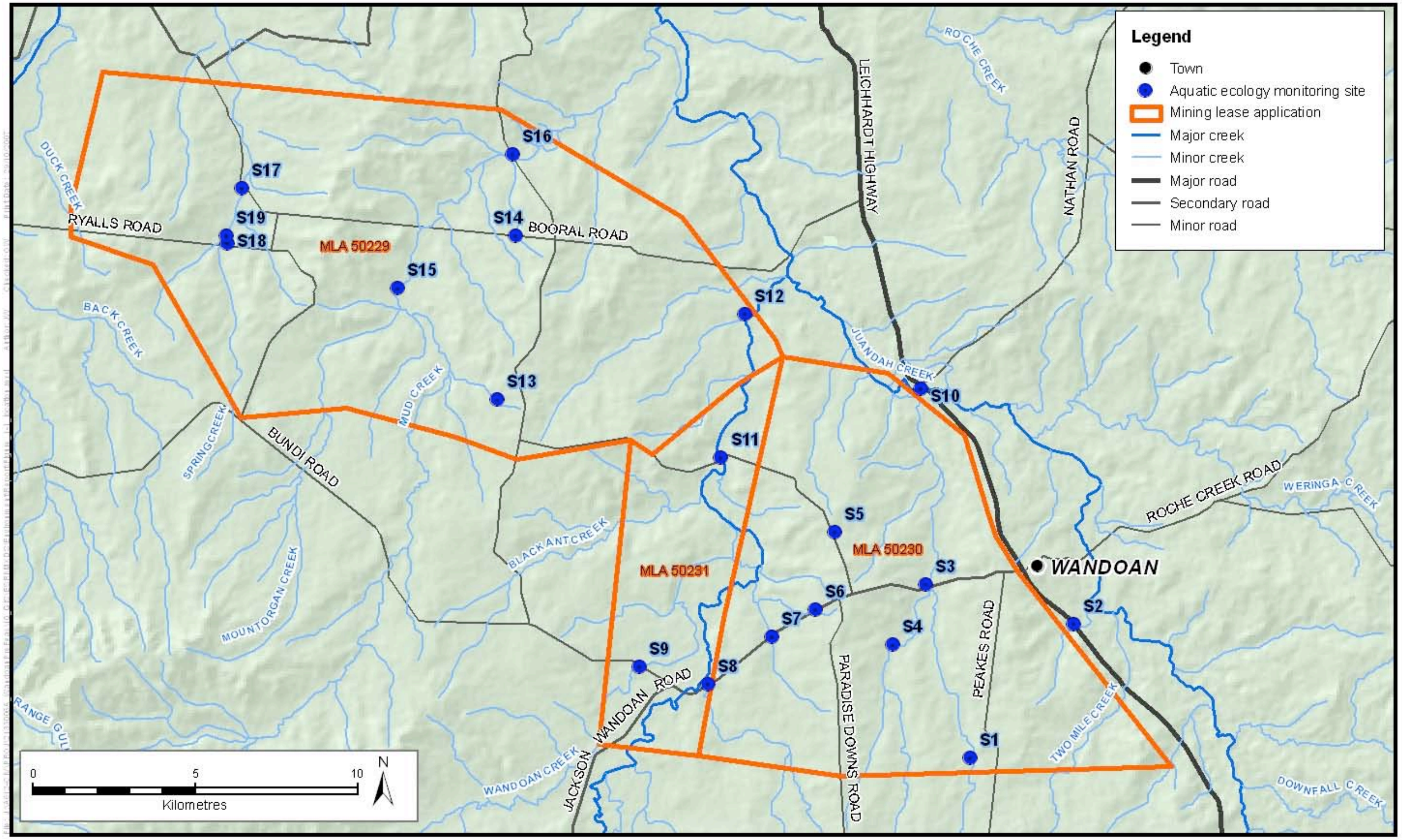

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Figure 3.1 Sites surveyed for aquatic habitat during the initial field trip in August 2007.	
	October 2008

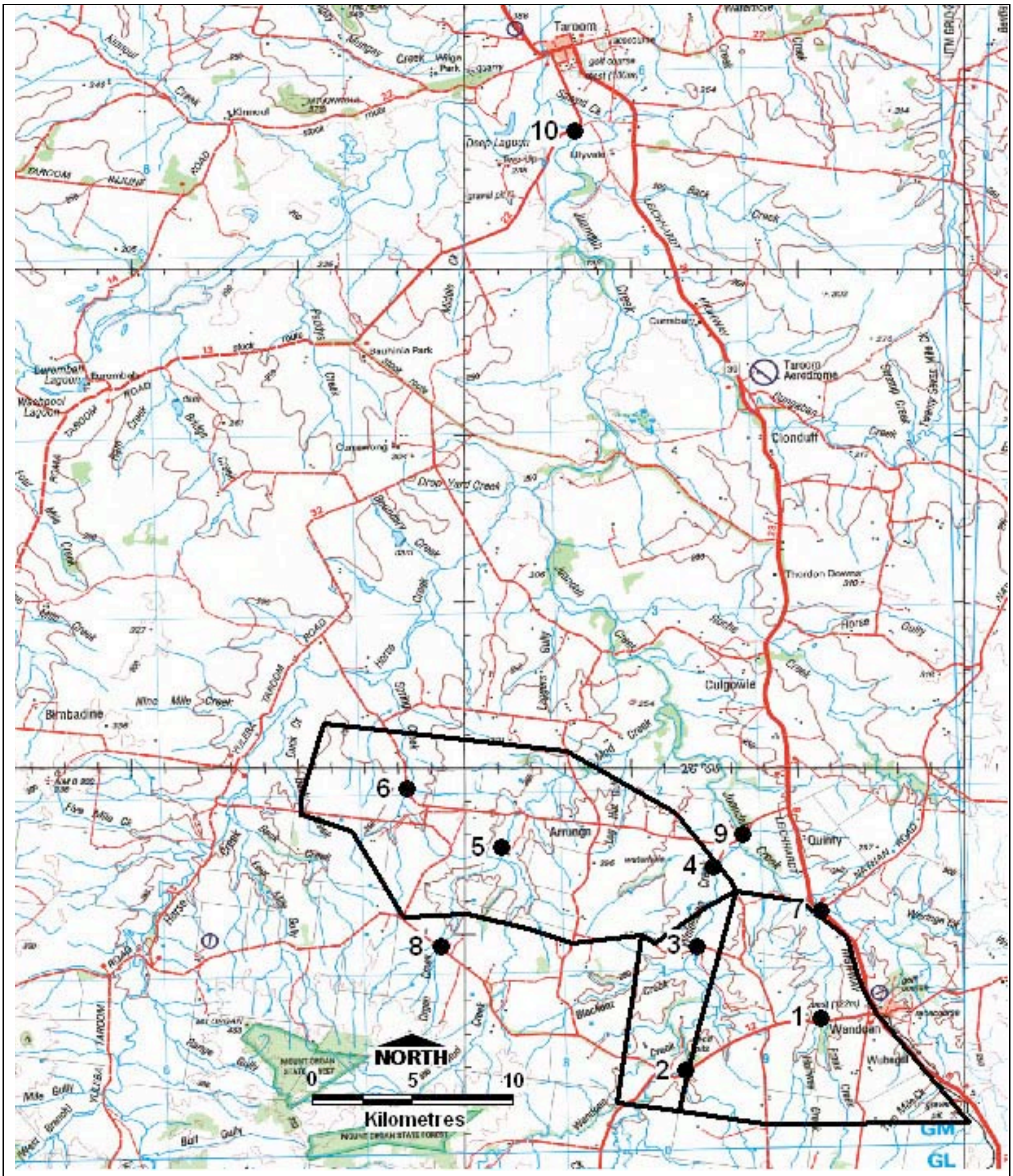

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Figure 3.2 Aquatic flora and fauna survey sites for the MLA study area.

October 2008

3.2.2 Gas Supply Pipeline Study Area

Seven waterways crossed by the proposed pipeline route were surveyed (Figure 3.3). Whenever possible, surveys were completed at the proposed crossing location, however, due to land access issues, some creeks were assessed at nearby road crossings. Stream orders were determined for each creek at the survey site, following the Strahler method, as used in AusRivAS models (e.g. two first order streams combine to form a second order stream, two second order streams combine to form a third order stream etc.).

At all sites, with the exception of site 1, 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 3.3 below). Site 1 was a gully with no defined channel bed or banks; brief observations and photographs were taken here. Flora and fauna surveys were completed at three of the seven sites (Refer to Sections 3.5 to 3.7 below); this is because these sites were the only sites that held water during the survey (Table 3.2).

Table 3.2 Date and type of survey completed at watercourses on the gas supply pipeline route.

		Date Survey Completed			
Crossing Number	**Channel Name**	**Aquatic Habitat**	**Water Quality**	**Macrophyte**	**Fauna**
1	Unnamed tributary to Bullock Creek	20/08/08, brief observations only	Dry	–	–
2	Stakeyard Creek	20/08/08	Dry	–	–
3	Unnamed tributary to Roche Creek	20/08/08	Dry	–	–
4a	Roche Creek	27/08/08	20/08/08	21/08/08	21/08/08
4b	Roche Creek Anabranch	27/08/08	20/08/08	21/08/08	21/08/08
6	Unnamed tributary to Roche Creek	27/08/08	Dry	–	–
7	Juandah Creek	20/08/08	20/08/08	20/08/08	20/08/08

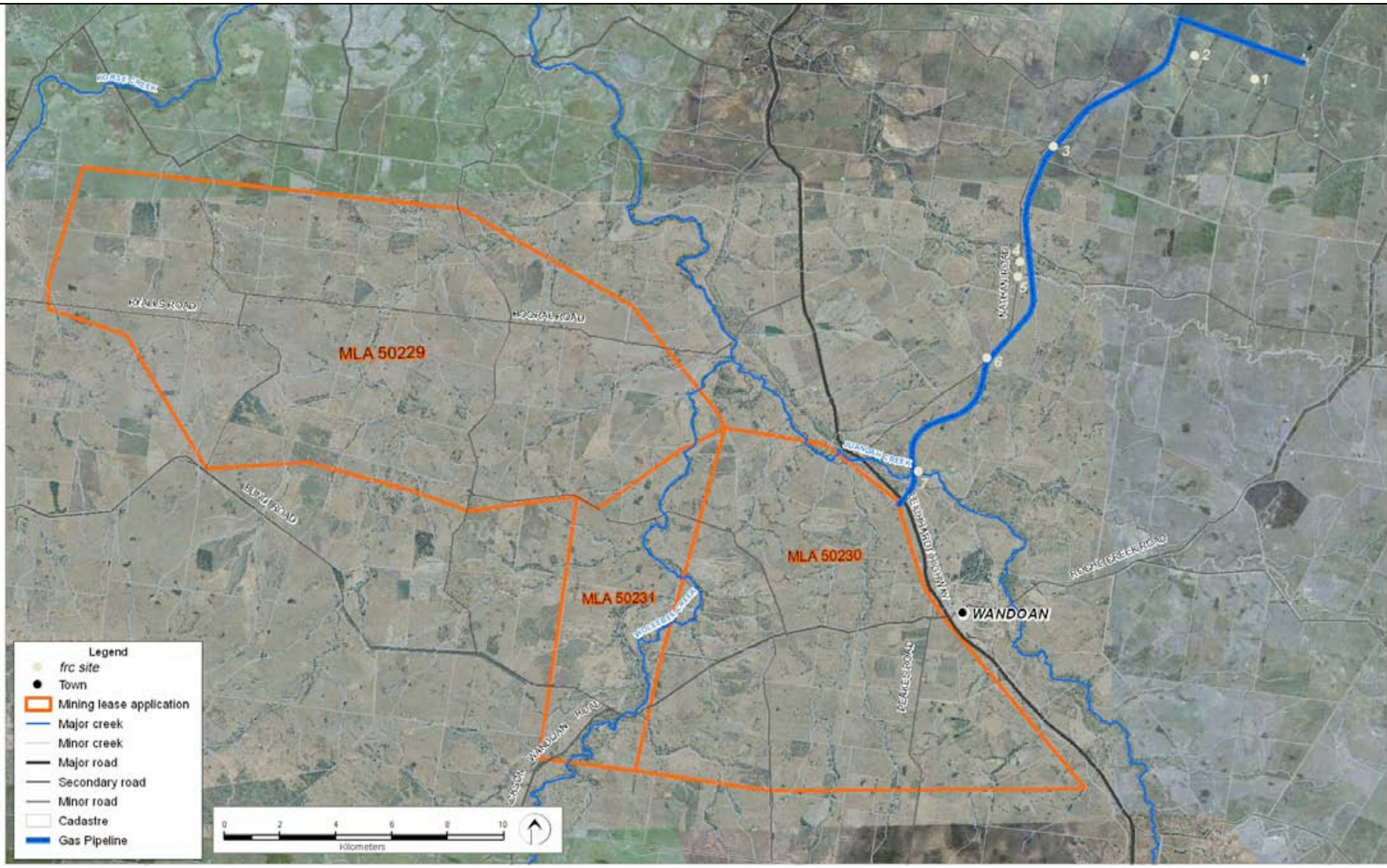

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Figure 3.3 Aquatic flora and fauna survey sites along the gas supply pipeline route study area.

October 2008

3.3 Aquatic Habitat

3.3.1 Of the Study Areas

At each 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 (Attachment B). Habitat descriptions, River Bioassessment Scores and condition ratings at the aquatic flora and fauna sites built upon information collected during the reconnaissance surveys.

3.3.2 A Regional and Ecological Perspective

The typical aquatic habitat of the streams and creeks in the Southern Tributaries Subcatchment of the Dawson River were described through literature review, to provide a regional context for the condition of the creeks within the MLAs and along the gas supply pipeline route.

3.4 Water Quality

3.4.1 Of the Study Areas

The objective of water quality sampling was to describe water quality at each of the sites at the time of survey, to aid in the interpretation of biological data. For a full description of water quality, refer to the surface water quality impact assessment technical report.

Water quality was measured at each site using a TPS 90 FLMV water quality meter and WP88 turbidity meter. The TPS 90 FLT water quality meter was used to measure:

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

The WP88 turbidity meter measured turbidity in NTU (Nephelometric Turbidity Units).

While specific Water Quality Objectives (WQOs) have been developed for many waterways within south east Queensland, no WQOs have been prescribed for the waterways within the study area. Water quality parameters at each of the sites were compared to Queensland Water Quality Guidelines (QWQG) values for upland (altitude >150 m) streams in the central coast region (EPA 2007a). These QWQG have been used in preference to the national ANZECC & ARMCANZ guidelines because they are specific to the central Queensland region, as outlined in the QWQG document (EPA 2007a; ANZECC & ARMCANZ 2000).

3.4.2 A Regional and Ecological Perspective

The typical water quality of the streams and creeks in the Southern Tributaries Subcatchment of the Dawson River were described through literature review, to provide a regional context for the condition of the creeks within the MLAs and along the gas supply pipeline route.

3.5 Aquatic Flora

3.5.1 Of the Study Areas

The description of aquatic flora (macrophytes) included:

- submerged, floating (free-floating or rooted) and emergent aquatic 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.

3.5.2 A Regional and Ecological Perspective

The macrophytes of the streams and creeks in the Dawson River Catchment were described through literature review, where possible, to provide a regional context for the condition of the creeks within the MLAs and along the gas supply pipeline route.

3.6 Aquatic Macro-invertebrate Communities

3.6.1 Of the Study Areas

Sample Collection

A standard AusRivAS macro-invertebrate sample from each aquatic habitat found was collected at each site. Each site had edge and bed (pool / run) habitats; riffle habitats were not present. 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 macro-invertebrate communities to provide an indication of ecosystem health, as described in Attachment 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 associated with the MLAs and along the gas supply pipeline, and to compare the health of these creeks to other waterways in the catchment.

3.6.2 A Regional and Ecological Perspective

The macro-invertebrate communities of the region were described through literature review. The Department of Natural Resources & Water (DNRW) has previously undertaken macro-invertebrate surveys of the waterways near the MLAs. These surveys included sites on the Dawson River at Taroom (Site 130302A) and Juandah Creek at Sandy Bridge (Site 1303086) (refer Figure 3.4). Site 1303086 on Juandah Creek was sampled during this survey (site 10).

In order to use the macro-invertebrate communities as an indicator of the likely health / condition of the DNRW sites, a number of macro-invertebrate indices were calculated, including taxonomic richness, PET richness and Signal 2 scores.

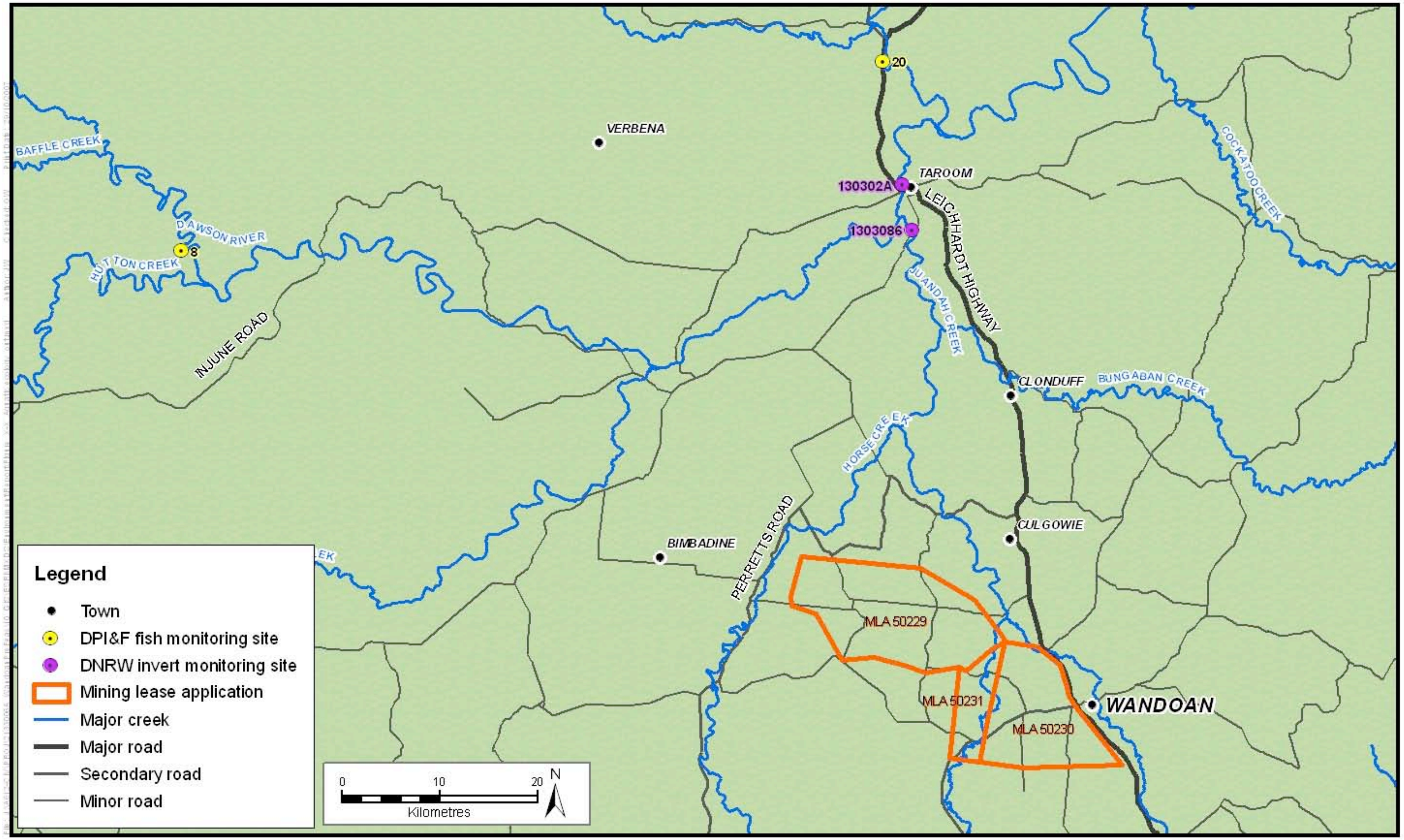

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	Figure 3.4 Location of the sites previously surveyed in the region by others.
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3.7 Fish Communities

3.7.1 Of the Study Areas

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*.

As a minimum at each site (where water depth allowed), five replicate samples were also collected using small (2 mm mesh) baited traps and large cathedral traps, which are designed to capture turtles, but which may also capture fish (mesh size approximately 20 mm). At sites where electrofishing returned few fish, or was not appropriate to the conditions, sampling was also conducted using set nets (multi-panel gill nets of between 2 mm and 150 mm mesh size). Sampling effort is presented in Table 3.3.

Table 3.3 Fish and turtle survey effort at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
MLA Study Area								
1	Small bait traps	pool		13/03/08 15:00	14/03/08 12:00		105 hrs	
	Backpack Electrofishing	pool	13/03/08	13:40	14:15	200 V, 30 Hz, 12%	548 s	shallow, electrofishing effective
	Cathedral traps	pool		13/03/08 15:00	14/03/08 12:00		21 hrs	
2	Small bait traps	–	–	–	–	–	–	too shallow
	Backpack Electrofishing	small pools	13/03/08	11:10	11:30	100 V, 30 Hz, 12%	210 s	

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
	Cathedral traps	–	–	–	–	–	–	too shallow
3	Small bait traps	pools		12:30 12/03/08	09:00 13/03/08		102.5 hrs	
	Backpack Electrofishing	pools	13/03/08	12:37	13:11	200 V, 30 Hz, 12%	502 s	shallow, electrofishing effective
	Cathedral traps	pools		12:30 12/03/08	09:00 13/03/08		102.5 hrs	
4	Small bait traps	–	–	–	–	–	–	too shallow
	Backpack Electrofishing	pools	12/03/08	15:30	16:10	250 V, 30 Hz, 12%	555 s	shallow, electrofishing effective
	Cathedral traps	–	–	–	–	–	–	too shallow
5	Small bait traps	–	–	–	–	–	–	too shallow
	Backpack Electrofishing	pools	13/03/08	11:00	11:40	200 V, 30 Hz, 12%	427 s	shallow, electrofishing effective
	Cathedral traps	–	–	–	–	–	–	too shallow
6	Small bait traps	pool		16:30 11/03/08	10:00 12/03/08		87.5 hrs	
	Backpack Electrofishing	pool	11/03/08	15:30	15:55	300 V, 30 Hz, 12%	292 s	deep, could only fish edges
	Cathedral traps	pool		16:30 11/03/08	10:00 12/03/08		52.5 hrs	
7	Small bait traps	pool		17:30 11/03/08	09:00 12/03/08		87.5 hrs	
	Backpack Electrofishing	pool	12/03/08	09:00	10:00	200 V, 30 Hz, 12%	461 s	

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
	Cathedral traps	pool		17:30 11/03/08	09:00 12/03/08		87.5 hrs	
8	Small bait traps	pool		16:00 13/03/08	09:00 14/03/08		85 hrs	
	Backpack Electrofishing	pool	14/03/08	09:10	10:00	250 V, 30 Hz, 12%	366 s	
	Cathedral traps	pool		16:00 13/03/08	09:00 14/03/08		51 hrs	
9	Small bait traps	pool	–	–	–	–	–	too shallow
	Backpack Electrofishing	pool	11/03/08	12:50	13:30	250 V, 30 Hz, 12%	428 s	
	Cathedral traps	pool	–	–	–	–	–	too shallow
10	Small bait traps	pool	–	17:00 10/03/08	08:00 11/03/08		75 hrs	
	Backpack Electrofishing	pool	–	–	–	–	–	too deep
	Cathedral traps	pool	–	17:00 10/03/08	08:00 11/03/08		75 hrs	
	Multi-panel Gill Net	pool	–	17:00 10/03/08	08:00 11/03/08	–	15 hrs	across pool at bridge
Gas Supply Pipeline Study Area								
4a	Small bait traps	pool	–	–	–	–	–	too shallow
	Backpack Electrofishing	pool	21/08/08	08:00	09:00	300 V, 30 Hz, 12%	570 s	
	Cathedral traps	pool	–	–	–	–	–	too shallow
4b	Small bait traps	pool	–	–	–	–	–	too shallow

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
	Backpack Electrofishing	pool	21/08/08	10:30	11:00	300 V, 30 Hz, 12%	558 s	
	Cathedral traps	pool	–	–	–	–	–	too shallow
7	Small bait traps	pool	–	–	–	–	–	too shallow
	Backpack Electrofishing	pool	20/08/08	10:45	11:30	300 V, 30 Hz, 12%	208 s	
	Cathedral traps	pool	–	–	–	–	–	too shallow

At each site, the species present, the abundance of each species by life history stage (juvenile, intermediate, adult) and the apparent health of individuals was 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 (Attachment 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 fish communities of the region have been described through literature review. The most recent available fish surveys within the region were done by the Department of Primary Industries & Fisheries (DPI&F) (Berghuis & Long 1999), who sampled two sites on the Dawson River (Sites 8 & 20) (refer Figure 3.4). Waterways further downstream on the Dawson River (in the vicinity of Glebe Weir) were also surveyed in November 2007 (frc environmental 2007). No data were available for Juandah Creek or any other creeks within the MLAs or along the gas supply pipeline route.

3.8 Turtles

3.8.1 Of the Study Areas

At sites where water depths were suitable, five large baited cathedral traps were set along the bank and adjacent to cover (vegetation, snags etc.) for a minimum of two hours (Table 3.3). The design of the traps was consistent with traps used by the Environmental Protection Agency's (EPA's) turtle research group, and consisted of a series of collapsible chambers (totalling approximately 3.5 m in height, 0.7 m in diameter) with two one-way entrances in the lower baited chamber. Traps were deployed so that the top of the chamber was positioned to allow turtles access to the surface to breathe.

Traps were closely monitored by team members, to ensure that no turtles or other air-breathing species became entangled or trapped below the surface. Turtles were occasionally captured by other techniques or observed and recorded outside traps.

Turtles captured or observed were identified to species level and a photographic record was kept. The sampling of fishes was conducted under Scientific Purposes Permit WISP05080608 and Animal Ethics Approval No. CA 2006/03/106 issued to frc environmental (Attachment C).

3.8.2 A Regional and Ecological Perspective

The turtle communities of the streams and creeks in the Dawson River Catchment were described through literature review, where possible, to provide a regional context for the condition of the creeks within the MLAs and along the gas supply pipeline route.

3.9 Other Aquatic Vertebrates

The likely presence of other aquatic vertebrates in the region was described through literature review and database searches, specifically: the Commonwealth *Protected Matters Search Tool* (DEWHA 2008a); and the State *Wildlife Online* database (EPA 2007b).

3.10 Limitations

The waterways in the study area are ephemeral, and are dry for much of the year. Due to a lack of water during the survey period, the results of this study are based on one field survey only. However, faunal communities within ephemeral waterways are highly variable over time, with community structure strongly linked to flow conditions (Smith et al. 2004). To account for this expected high temporal variability in community structure in the sampling design, at least two survey events are required to adequately assess and describe seasonal variations in the aquatic communities of the study area, and to determine the species likely to be present in the study areas throughout the entire year. A second survey event is scheduled for each study area, to occur following the first significant rainfall event of the 2008 – 2009 wet season. A supplementary report will be provided documenting the results of this survey, and will form part of a Supplementary EIS submission for the Project.

The sites chosen for survey within the MLA study area generally represent the range of aquatic habitats present throughout the MLAs (based on the results of the field reconnaissance of aquatic habitats). The waterways surveyed include those that will be diverted during the Project. However, it should be noted that site access and the location of water holes limited the positioning of sites during the survey (for example, no first order streams were able to be surveyed within the MLAs due to both a lack of water, and private property access restrictions).

Within the gas supply pipeline study area, Roche Creek and an anabranch of Roche Creek could not be surveyed at the proposed pipeline crossing location, due to private property access restrictions during the field survey. These waterways were surveyed where they are crossed by Nathan Road, 200 – 300 m downstream of the proposed pipeline route. In addition, a turbidity meter could not be sourced for the field survey of the gas supply pipeline study area.

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

4 Existing Environment

4.1 Aquatic Habitat

4.1.1 MLA Study Area

The sites surveyed within the MLA study area during the initial field trip and the aquatic flora and fauna survey typically had a moderate River Bioassessment Program habitat assessment score (Figure 4.1 & Figure 4.2). Generally, these relatively low scores were related to low habitat variability (with no riffles observed), moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt.

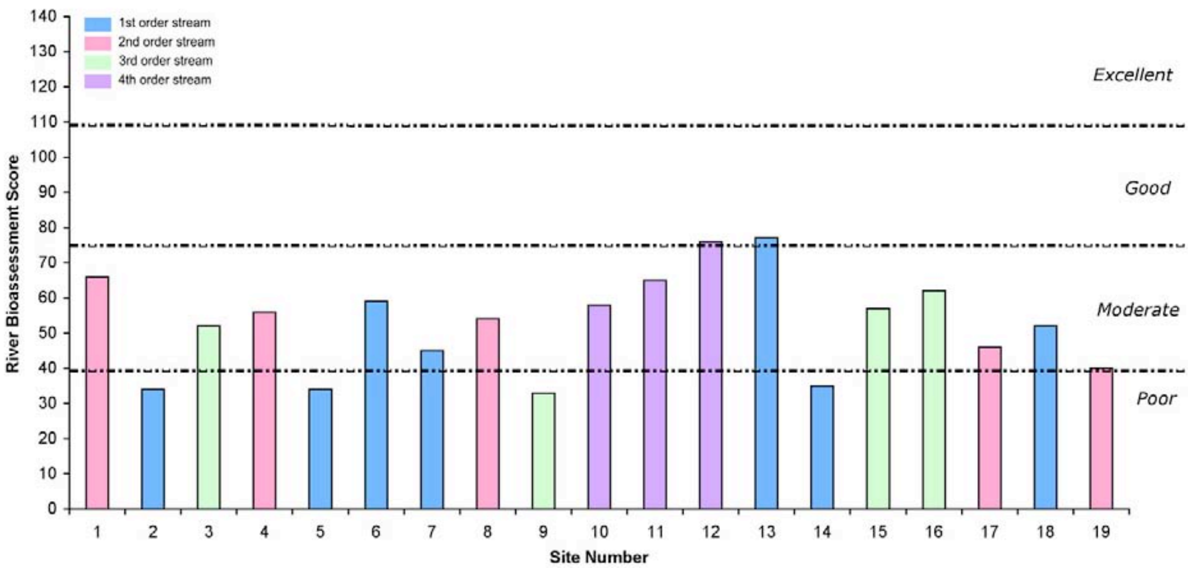


Figure 4.1 River Bioassessment Scores at each of the sites surveyed during the initial field trip in August 2007.

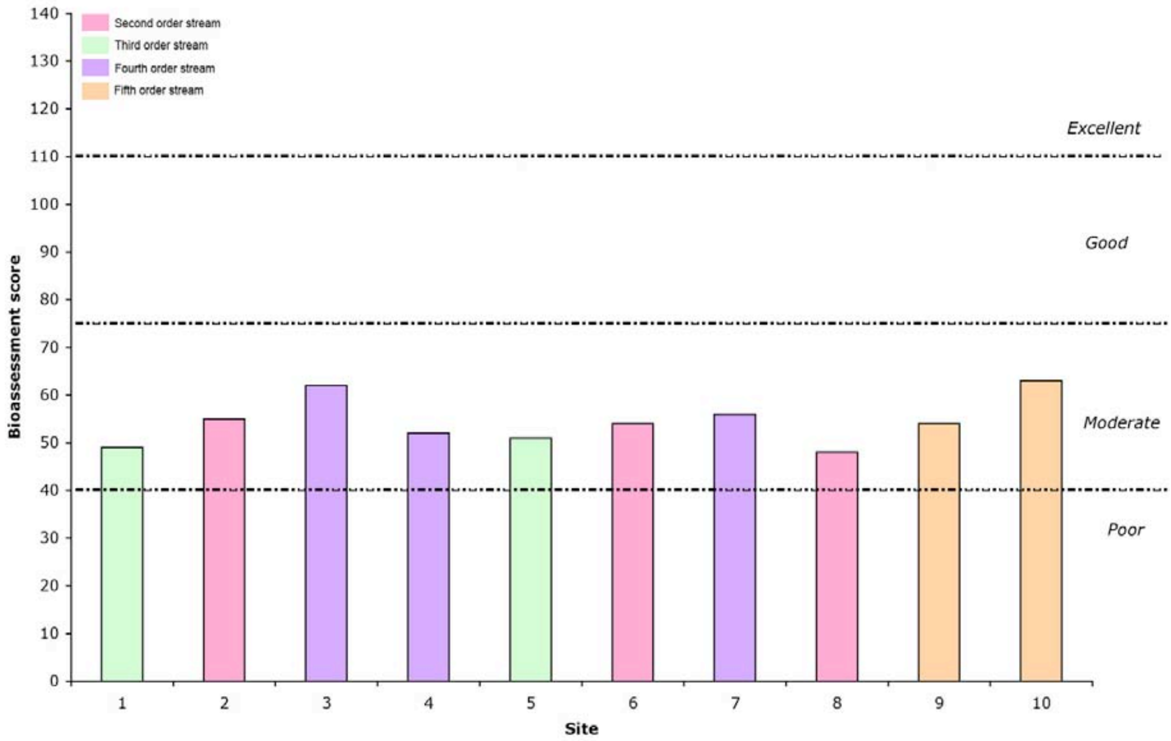


Figure 4.2 River Bioassessment Scores at each of the sites surveyed during the flora and fauna survey in March 2008.

In general, first order streams in the MLAs had a relatively low habitat value compared with higher order streams. This was generally because the creeks at these sites were relatively straight and shallow, with little riparian vegetation to provide canopy cover to the channel or terrestrial debris for in-stream habitat. The notable exception to this was a tributary to Mud Creek (reconnaissance site 13), which had the highest score of all of the sites surveyed. This was because the site included a variety of substrate types; it would contain riffle habitats when flowing; it was not adversely affected by channel alteration or scouring; and it had relatively stable banks. Although canopy cover of the channel was relatively low (as was typical of the first order streams surveyed), there were still fallen logs in the channel that would provide in-stream habitat for fauna when the site holds water. This site could not be surveyed during the flora and fauna survey, due to private property access issues.

Figure 4.3

Site 13 had a variety of substrate types, including cobbles, and fallen branches that would provide in-stream habitat.

The higher order streams generally had higher River Bioassessment scores. This was mainly because there was more riparian vegetation at these sites, including a higher cover of large trees in the riparian zone. This vegetation provided shading of the channel; roots, fallen branches and logs for in-stream physical habitat; and stabilised the banks at some sites. The exception to this trend was Wandoan Creek at Bundi Road (reconnaissance site 9), a third order stream, which had the lowest score of all of the sites surveyed. This was due to human impacts on bank stability and riparian vegetation at this site, potentially related to nearby road maintenance. It appeared as though sandy material had been pushed down the bank of the channel by a dozer, adjacent to the bridge crossing. This meant that the bank was devoid of vegetation and quite unstable, with the loose material falling into the bottom of the channel (Figure 4.4).

Figure 4.4

Sandy material appeared to have been pushed over the bank of the creek at Site 9.

Reach Environs

Overall, the reach environs of the creeks surveyed have been moderately impacted by human activities. Land-use within the MLAs, and across the broader study area, is dominated by cattle grazing on native and improved pastures, together with some cropping. There has been some riparian vegetation clearing across the study area, although large trees still grow on the creek banks at many sites (and in particular at sites on higher order streams). Cattle access to the creeks has also caused some disturbance.

Road crossings were a mix of dirt crossings (fords) without culverts, bitumen/concrete crossings with culverts, and bridges. Lower order streams tended to have dirt crossings without culverts (e.g. Spring Creek at Kabunga Road), or bitumen / concrete crossings with culverts (e.g. Frank Creek at Jackson Wandoan Road and Woleebee Creek at Grosmont Road). Higher order streams tended to have bridge crossings (e.g. Juandah Creek at the Leichhardt Highway, Booral Road and Roma Taroom Road). However, at Juandah Creek at the Roma Taroom Road, there was a dirt crossing with a single pipe culvert directly downstream of the bridge, which was restricting water flow at the time of survey (Figure 4.7).

Existing road crossings are likely to cause alterations of flow and may prevent or restrict fish and turtle passage in some instances. Ford crossings are likely to restrict aquatic fauna passage during low flow events, as the road forms a physical barrier (Figure 4.5). During periods of medium to high flow, the creek would flow over the road. Crossings at sites with undersized culverts (e.g. Woleebee Creek at Grosmont Road) are likely to restrict aquatic fauna passage during periods of low to moderate flow, as the water must flow via relatively small pipes (Figure 4.6).

Existing bridge crossings and crossings with large culverts (e.g. Frank Creek at Jackson Wandoan Road) are generally less inhibitive to aquatic fauna movement, although during flood events, pylons and large culvert can alter flow patterns and trap debris that potentially restricts aquatic fauna passage (Figure 4.8 & Figure 4.9). Paddock fences also cross several sites and are likely to restrict water flows, and potentially aquatic fauna passage, at times if they become blocked with debris (Figure 4.10) (although they are unlikely to completely restrict fauna passage).

Figure 4.5

The dirt crossing of Kabunga Road at Spring Creek forms a physical barrier to water flows and aquatic fauna passage during periods of low flow.

Figure 4.6

The undersized culverts on Grosmont Road at Woleebee Creek are likely to restrict aquatic fauna passage during periods of low to moderate flow.

Figure 4.7

The dirt crossing directly downstream of the Roma Taroom bridge over Juandah Creek was restricting flows at the time of survey.

Figure 4.8

The bridge pylons on Roma Taroom Road at Juandah Creek are unlikely to restrict aquatic fauna movements.

Figure 4.9

The large box culverts on Jackson Wandoan Road at Frank Creek are unlikely to restrict aquatic fauna movements.

Figure 4.10

On Frank Creek at Jackson Wandoan Road, a corrugated iron fence crossed the creek and trapped debris, which may restrict aquatic fauna passage in some conditions.

Riparian Vegetation

Across the study area, riparian zones were generally 5 – 10 m wide but ranged from < 2 m at Mount Organ Creek (Figure 4.11) to 20 m at Juandah Creek at Roma Taroom Road (Figure 4.12). Grasses typically dominated the riparian zone of the creeks, although shrubs and trees also grew at most sites. There was a substantial increase in grass coverage across the study area between the initial field reconnaissance in August 2007 and the flora and fauna survey in March 2008 (particularly at Spring Creek and Juandah Creek). The cover of trees was generally ≤ 20%, but was 40% at Juandah Creek at Roma Taroom Road (downstream of the MLAs).

Figure 4.11

At Organ Creek at Bundi Road, the riparian zone was < 2 m wide and dominated by grasses.

Figure 4.12

At Juandah Creek at Roma Taroom Road, the riparian zone was 20 m wide and included several shrubs and large trees.

Riparian vegetation throughout the study area was dominated by native species, including Eucalypt and Acacia species, although exotic grasses were found at all sites. Prickly pear, a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock*

Route Management) Act 2002, was noted at several sites including sites 4, 5 & 8. Giant sensitive tree (*Mimosa pigra*), a declared Class 1 pest, was noted throughout the study area and particularly along the roadside. The class 2 declared pest parthenium (*Parthenium hysterophorus*) is likely to grow adjacent to Mud Creek and its tributaries, and adjacent to Juandah Creek and its tributaries towards the north of the MLAs.

Bank Stability

There was some bank erosion at each of sites in the study area, apart from very small first order streams, which had very low banks. Steep banks were common in larger-order creeks, 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 (Figure 4.13). At some sites, disturbance caused by cattle access (Figure 4.14) or riparian vegetation clearing had negatively affected bank stability.

Figure 4.13

Juandah Creek generally had steep banks that were stabilised by vegetation along most of its length.

Figure 4.14

Cattle had accessed the creek bed at Mud Creek.

Bed and Bar Stability

Overall, stream beds throughout the study area were relatively stable. However, there was some scouring at bends or downstream of obstructions, and some deposition of sediments in pools or upstream of obstructions. For example, fine sediments had been deposited in the pool upstream of the road crossing at Woleebee Creek at Grosmont Road.

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. No run or riffle habitat was observed during the survey.

Aquatic Habitat

The overall habitat condition of the creek systems was moderate, with some physical aquatic habitat found at most of the sites. At most of the sites, habitat was generally in the form of undercut banks, trailing bank vegetation and some terrestrial leaves and sticks where there was overhanging vegetation (Figure 4.15). At sites surveyed in higher order 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 4.16). For example, previous high flows in Woleebee Creek appeared to have created large log jams (Figure 4.17), which increased habitat diversity.

Figure 4.15

Trailing bank vegetation provided instream habitat at Frank Creek.

Figure 4.16

Undercut banks, tree roots and terrestrial debris provided habitat at Juandah Creek at the highway.

Figure 4.17

A large log jam at Woleebee Creek at Grosmont Road.

4.1.2 Gas Supply Pipeline Study Area

Similar to the sites in the MLA study area, the sites surveyed along the gas supply pipeline route typically had poor to moderate River Bioassessment Program habitat assessment scores (Figure 4.18). Similar to the creeks in the MLA study area, these relatively low scores were related to low habitat variability (with no riffles observed), moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt.

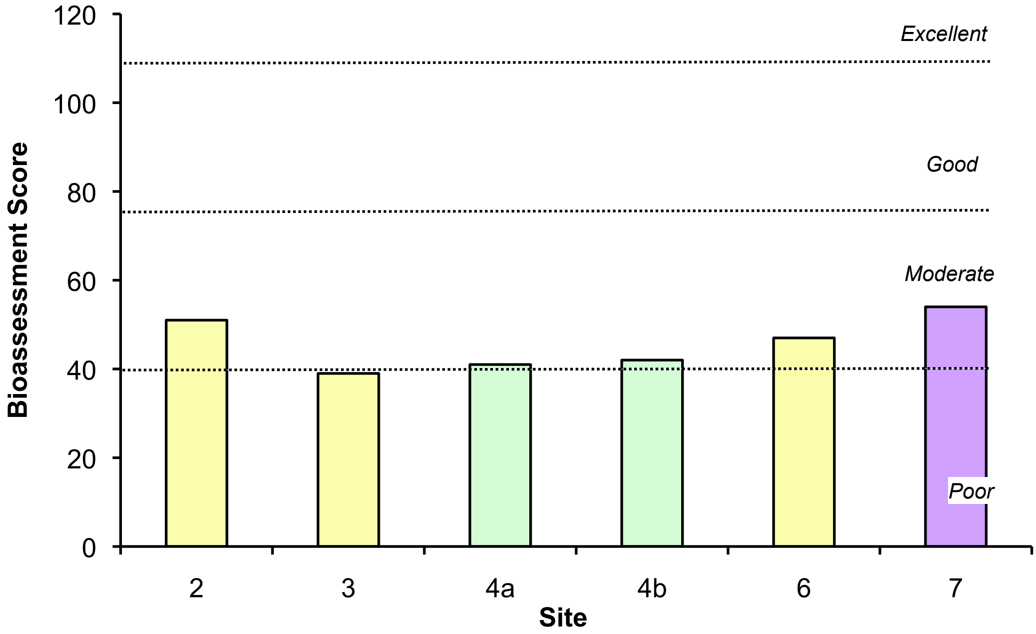


Figure 4.18 River Bioassessment Scores at each of the sites sampled in the gas supply pipeline study area.

Reach Environs

Overall, the reach environs of the creeks surveyed along the gas supply pipeline route were similar to the reach environs of the creeks within the MLAs. Cattle grazing on native pastures and crops was the dominant land use. There has been some riparian vegetation clearing across the study area, although large trees still grew on the banks of Roche Creek and Juandah Creek. Cattle access to the creeks has caused some disturbance to the creek bed and banks at all sites surveyed.

Road crossings within the gas supply pipeline study area were a mix of dirt fords, bitumen / concrete crossings with culverts, and bridges. Farm track crossings of all creeks were dirt fords; there were also ford crossings of Nathan Road over smaller-order streams. These fords are likely to restrict aquatic fauna passage during low flow events. There are culverts where Nathan Road crosses Roche Creek, and there is a bridge where the Leichhardt Highway crosses Juandah Creek. These crossings are unlikely to greatly restrict fauna passage, unless they become blocked with debris.

Riparian Vegetation

Across the study area, riparian zones were generally 5 – 15 m wide, but were up to 20 m at Slatehill Creek (Figure 4.12). Grasses typically dominated the riparian zone of the creeks, although shrubs and trees (including some large Eucalypts) also grew at most sites.

Riparian vegetation throughout the study area was dominated by native species, including Eucalypt and Acacia species, although exotic grasses were noted at all sites. Prickly pear was noted at Roche Creek (site 4a).

Bank Stability

There was some bank erosion at each of sites in the study area, apart from very small first order streams such as Slatehill Creek (site 2) and a tributary of Roche Creek (site 6), which had very low banks. Steep banks were common in larger-order creeks, 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, particularly in Juandah Creek, where many large Eucalypts lined the banks (Figure 4.13). At some sites, disturbance caused by cattle access (Figure 4.14) had negatively affected bank stability.

Bed and Bar Stability

Overall, stream beds throughout the study area were relatively stable. However, there was some scouring at bends or downstream of obstructions, and some deposition of sediments in pools or upstream of obstructions. For example, fine sediments had been deposited in Roche Creek in the pool upstream of the Nathan Road crossing, whereas scouring was evident downstream of the culvert.

Channel Diversity

Similar to the MLA study area, channel diversity was extremely low across the gas supply pipeline 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. No run or riffle habitat was observed during the survey.

Aquatic Habitat

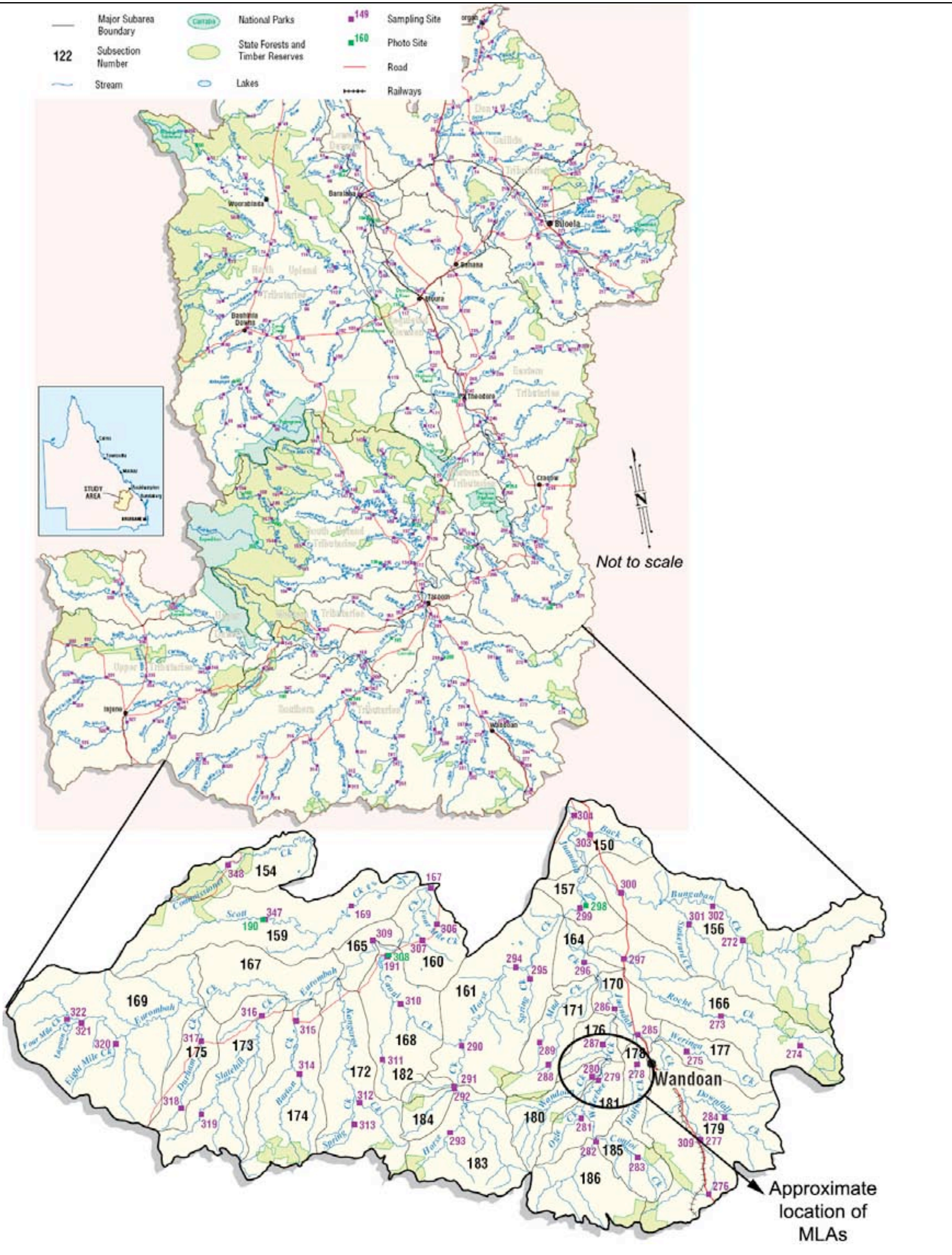
The overall habitat condition of the creek systems was moderate, with some physical aquatic habitat found at most of the sites. Physical aquatic habitat was more abundant in the larger order creeks in the study area (Roche Creek and Juandah Creek) than in the small (first order). At most of the sites, habitat was generally in the form of undercut banks, expose tree roots and terrestrial debris, including some branches and logs where trees were abundant in the riparian zone (Figure 4.15).

4.1.3 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 Southern Tributaries Subcatchment of the Dawson River (Telfer 1995) (Figure 4.19). The Southern Tributaries Subcatchment includes several sites within, or directly adjacent to, the MLAs and the gas supply pipeline route (sites 278 – 280 and sites 285 – 289) (Telfer 1995).

Reach Environs

The Southern Tributaries subcatchment covers 8,689 km^2, and includes the minor catchments of Juandah Creek in the east (Figure 4.19). There are approximately 2,258 km of streams in the subcatchment, and approximately 89% are in poor to moderate condition. Of the fifty-four sites surveyed within the subcatchment, 43% were highly 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) and 15% were extremely disturbed (the land of both sides of the stream was cleared or had a significant weed presence). Similar to the land use in the MLAs, most of the land adjacent to the sites surveyed in the *State of the Rivers* assessment had been cleared, and were 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 current study areas are in a similar condition, and are affected by similar factors, to sites typical of the subcatchment.



Wandoan Coal Project EIS	
Figure 4.19 The Dawson River Catchment, showing sites surveyed in the Southern Tributaries Subcatchment during the *State of the Rivers* assessment.	
Adapted from Telfer 1995	October 2008

Bank Stability

Similar to the banks of the creeks within the MLAs, most stream banks in the Southern Tributaries Subcatchment were rated as stable. Bank aggradations were observed at 57% of sites and eroding banks were observed at 96% of sites. The presence of grazing stock, land clearing, man-made structures, flood scouring and eroded walking tracks negatively affected bank stability throughout the subcatchment. Similar impacts were seen throughout the current study area.

Bed and Bar Stability

Bed aggradations and erosion throughout much of the subcatchment is indicative of a dynamic stream. Bars were present at 46% of sites and many of these had formed around obstructions (26%) or channel points (26%). This is similar to the pattern of sediment deposition in the MLAs.

Factors reducing stream bed stability throughout the subcatchment included the presence of stock, bank erosion and bed deepening, while fallen trees, rock outcrops and man-made structures provided stream bed stabilisation. Bed stability in the MLAs, and broader study area, had been affected by similar factors.

Channel Diversity and Habitat Types

Similar to the low channel diversity recorded in the creeks in the current study areas, channels across the subcatchment lacked diversity (diversity ratings ranged from low to moderate). The average depths of pools, runs and riffles throughout the subcatchment (measured from the watermark) were 1.0, 0.5 and 0.1 m, respectively. Average widths of pools, runs and riffles were 8.4, 8.5 and 7.4 m, respectively. Pools within the current study areas were slightly shallower and narrower than the average size of pools across the subcatchment. Riffles were not recorded in the current study areas.

Sediments in the upper banks and stream beds varied from boulders to fine silt, and lower banks were composed of sand and fine silt. Organic matter made up between 5 – 20% of the sediment in pools, runs and riffle habitats. This is generally similar to the sediment composition recorded in the creeks within the MLAs and throughout the study area (refer to Attachment A for the sediment composition at each survey site).

Riparian Vegetation

Across the subcatchment, riparian vegetation included trees, shrubs, vines, rushes, grasses, and mosses. The most dominant structural types were grasses (97%), trees 10 – 30 m (85%), trees <10 m (81%), rushes (62%) and herbs and forbs (59%). Native species included *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Melaleuca* spp., *Brigalow* spp. and *Callistemon* spp.. Riparian vegetation within the MLAs and across the study area, was also dominated by grasses but included fewer trees, rushes and herbs and forbs than other sites in the subcatchment.

Most of the riparian zones in the subcatchment were in very poor condition (70%), due to agricultural clearing and grazing. Weed species were recorded from 92% of sites; and within sites, weeds comprised an average of 23% of the vegetation. These were mostly burrs, milk weeds, Mexican poppies, thistles, rag weeds, rhodes grass, buffel grass, green panic and prickly acacia. Riparian zones within the present study area were generally also in poor to very poor condition and supported several of the same weed species.

Aquatic Habitat

Across the subcatchment, most aquatic habitats were rated as poor or very poor (69%). Stream cover was provided by forest canopy (16.4% of bank length), vegetation overhang (22.5%), root overhang (6.1%) and bank overhang (3.0%). 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 of our survey sites, although there was a moderate amount of aquatic habitat at some of the higher stream order sites such as sites on One-Arm Man Creek, Woleebee Creek and Juandah Creek.

Conservation Values

Aquatic, riparian and wildlife corridor habitat was assessed as being of high conservation value at 15%, 7% and 13% of sites, respectively. Only 2% of sites were deemed to have aquatic habitats of very high conservation values and no sites were regarded as very high value for riparian habitat or wildlife corridors. Approximately 40 – 46% of sites were deemed to be of low conservation value for aquatic habitat, riparian habitat or as wildlife corridors.

Overall, 7% of the subcatchment was in very poor condition (ratings for most categories were very low, and the bed and bank habitats were very unstable); 63% was in poor condition (ratings for most categories were low, and the bed and bank habitats were unstable); 23% was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable); 7% was in good condition (ratings for most categories were high, and the bed and bank habitats were stable) and no sites were regarded as being in very good condition. Generally, the aquatic habitats of the sites surveyed during the present study were in moderate condition.

4.1.4 Summary

The study areas are in the Southern Tributaries or Taroom Subcatchment. This catchment comprises approximately 17% of the Dawson River catchment, and 6.1% of the Fitzroy Catchment.

All sites surveyed were scored as poor to moderate using the River Bioassessment Program habitat assessment protocol. Poor to moderate habitat assessment scores reflect low habitat variability, moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt.

Overall, the reach environs of the creeks surveyed have been moderately affected by human activities. Cattle grazing on native pastures dominated the surrounding land-use. Cattle access to the creeks has also caused some disturbance. There has been some riparian vegetation clearing across the study area, although large trees still grow on the creek banks at many sites. Many road crossings and fence crossings of creeks in the study area are likely to cause alterations of flow and restrict aquatic fauna passage under particular flow regimes. Similar impacts were observed throughout the Southern Tributaries subcatchment.

Riparian zone condition throughout the study area was poor and characteristic of the region. Riparian zones were generally 5 – 10 m wide and dominated by grasses. Riparian vegetation was dominated by native species, although similar to sites surveyed during the State of the Rivers assessments, exotic species were found at all sites. Erosion is a typical feature of the waterways throughout the region, and there was some bank erosion at most sites in the study area. However, a relatively high cover of bank vegetation often maintained bank stability.

Stream beds were relatively stable; however, there was some scouring at bends or downstream of obstructions, and deposition of sediments in pools or upstream of obstructions in places. Bars forming around obstructions or channel points are also a common feature of the streambeds in the region. Channel diversity is generally low to moderate in the region, and was extremely low across the study area; isolated pools were the dominant habitat category. Pools within the study area were slightly shallower and narrower than the average size of pools across the subcatchment.

Some physical aquatic habitat for fauna was found at most of the sites. In-stream physical habitat was typically in the form of undercut banks and terrestrial debris. In-stream habitat diversity was highest at sites with a higher cover of trees in the riparian zone and a higher cover of bank overhang vegetation. Throughout the region, disturbances to the riparian zone have led to a reduction in the cover and diversity of in-stream habitat such as large woody debris.

4.2 Water Quality

4.2.1 MLA Study Area

Water Temperature

Across the ten sites surveyed, water temperature ranged between 20.8 °C at site 7 to 33.6 °C at site 9 at the time the watercourse was surveyed (Figure 4.20). The majority of sites had water temperatures of between 22.7 and 29.1 °C. There are no guidelines available for water temperature (ANZECC & ARMCANZ 2000; EPA 2007a).

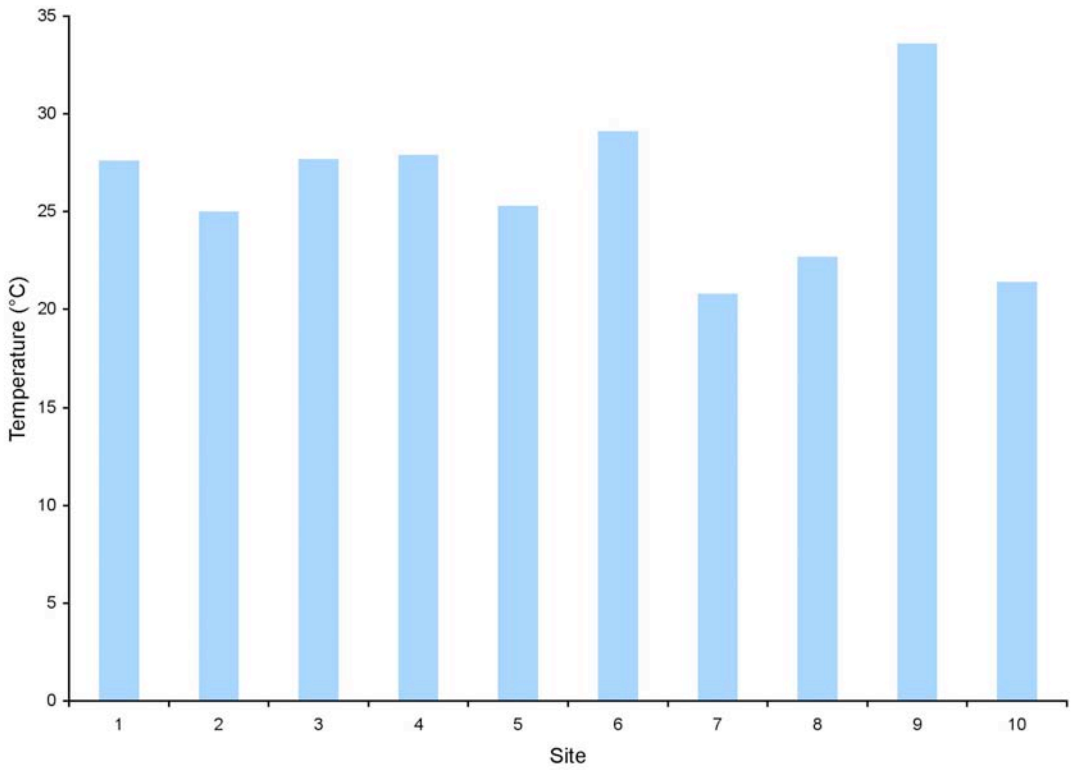


Figure 4.20 Water temperature at each site in the MLA study area.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations at the time the site was sampled were highly variable among sites, ranging from 20.3% saturation (sat.) at site 7 to 112.2% sat. at site 3 (Figure 4.21). Only sites 5 and 6 were compliant with the DO concentration range in the Queensland Water Quality Guidelines (QWQG) (EPA 2007a), although the concentration at site 5 was close to the upper limit. DO concentrations at site 3 exceeded the QWQG, and concentrations at sites 1, 2, 4 and 7 – 10 were below the QWQG. Sites outside of the MLAs (sites 7 – 10) had the lowest DO concentrations. This pattern could not be explained, as there were no obvious links between these low DO levels and aquatic habitat/surrounding land uses at these sites.

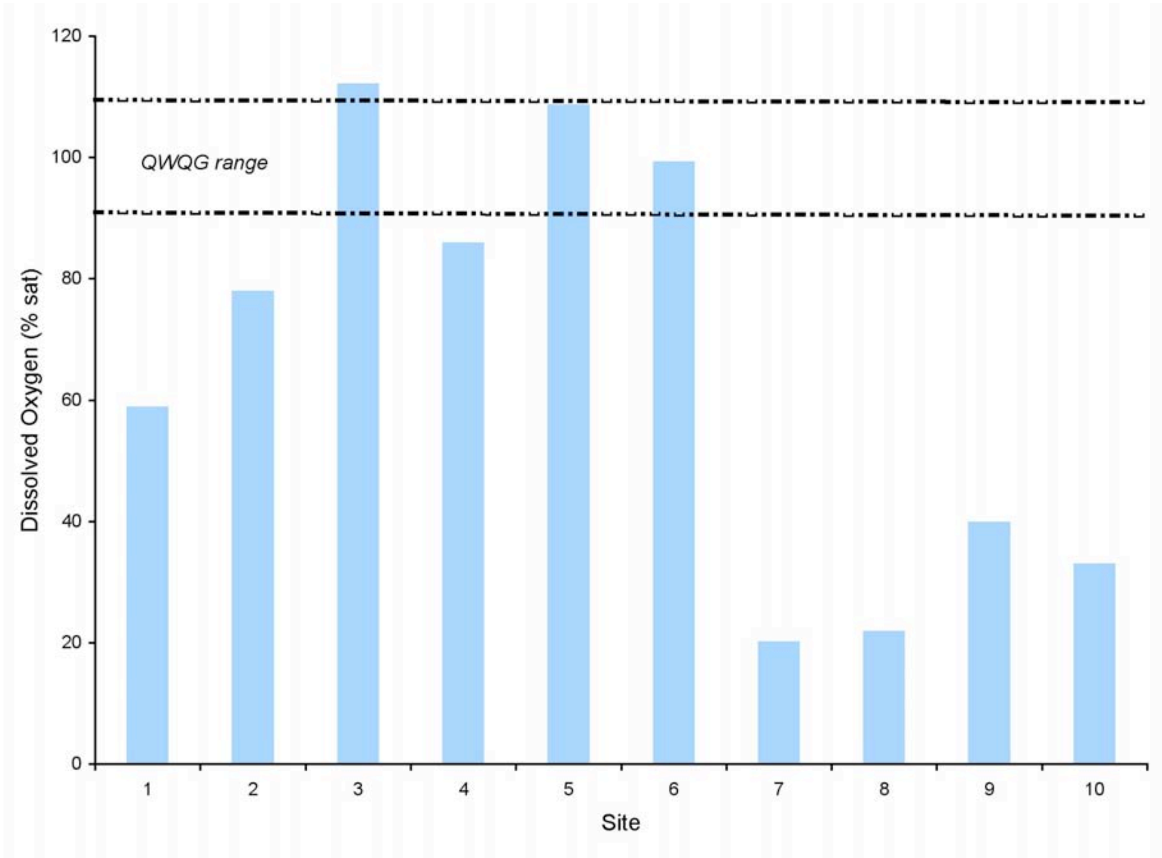


Figure 4.21 Dissolved oxygen at each site in the MLA study area, compared with the QWQG range for central coast upland streams (EPA 2007a).

Low DO concentrations are probably due to high biological oxygen demand and low mixing of the waters. This is likely due to relatively high amount of organic matter and microbial activity within the waters, and sampling in pools, which are not well-mixed.

High diurnal DO concentrations (>100%) measured during the day generally indicate that DO drops to critically low levels for fauna at night. This is because high DO levels during the day usually indicate large quantities of algae and aquatic plants photosynthesising and producing oxygen, which at night respire and consume the DO within the water column (together with all other organisms within the system), thereby creating low DO levels.

pH

pH was fairly similar across sites, ranging from 6.1 at site 3 to 7.4 at site 5 (Figure 4.22). pH at most sites was compliant with the QWQG pH range (EPA 2007a), indicating that the pH was representative of a healthy waterway. However, pH at sites 3, 6 and 10 was slightly below the QWQG range (i.e. the water was more acidic).

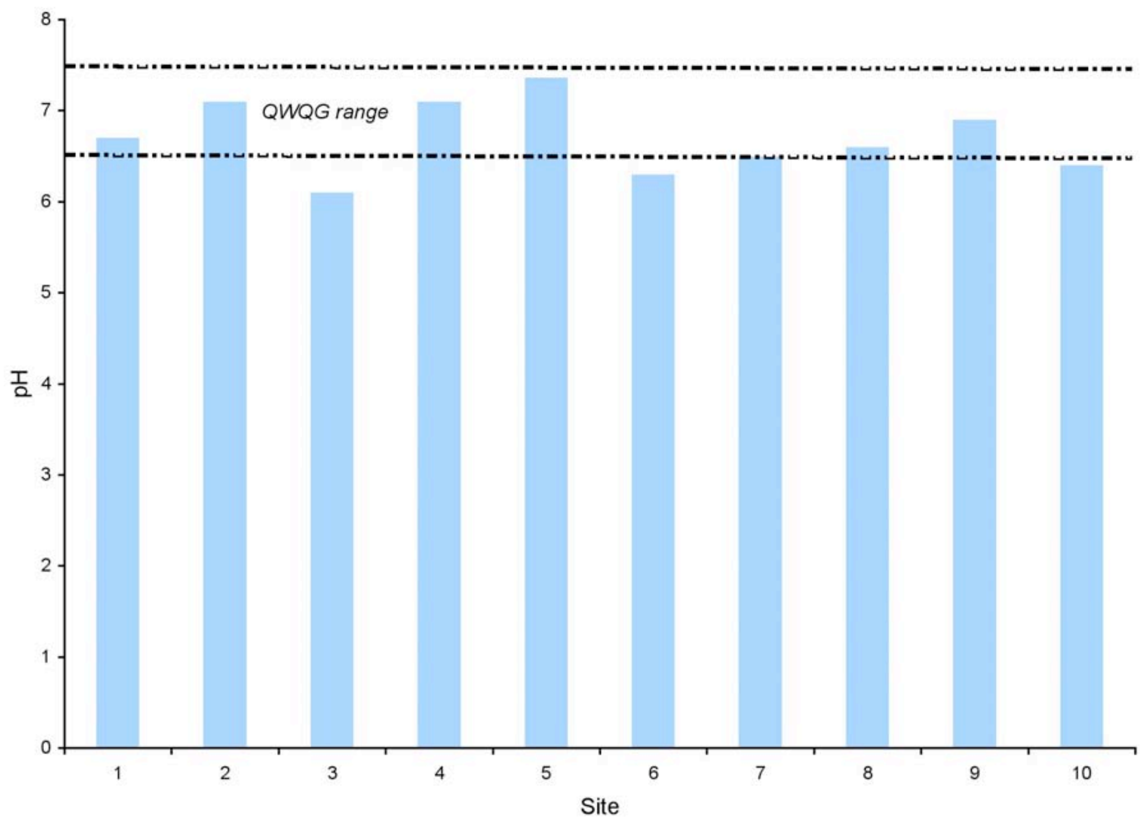


Figure 4.22 pH at each site in the MLA study area, compared with the QWQG range for central coast upland streams (EPA 2007a).

Electrical Conductivity

Conductivity ranged from 129 μS/cm at site 6 to 528 μS/cm at site 2 (Figure 4.23). Conductivity at sites 2, 4, 5, and 9 exceeded the QWQG range (EPA 2007a) and site 6, had relatively low conductivity. It should be noted that the QWQG value of 340 μS/cm for conductivity is a preliminary guideline only (EPA 2007a).

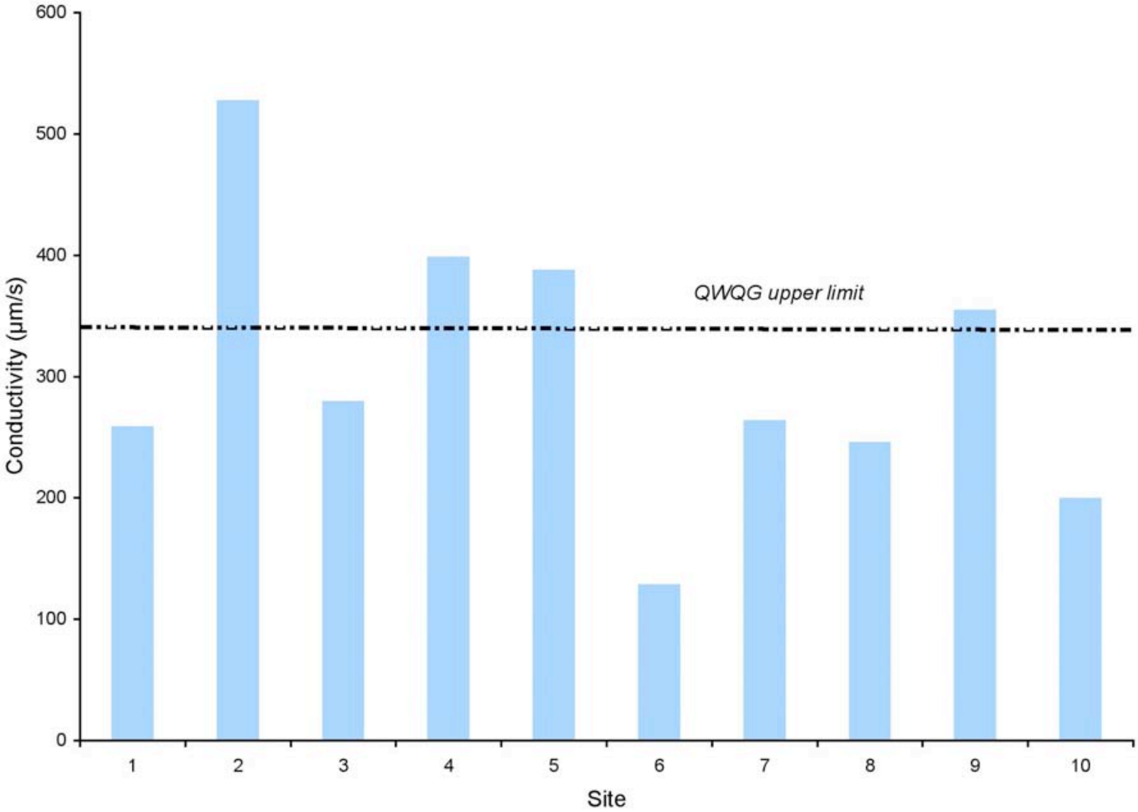


Figure 4.23 Electrical conductivity at each site in the MLA study area, compared with the QWQG upper limit for Fitzroy central region (preliminary guideline based on the 75th percentile of data from the Fitzroy central salinity zone; EPA 2007a).

Electrical conductivity is proportional to the salinity of a water body, i.e. more saline water is more conductive. High conductivity could be associated with evaporation (effectively concentrating the salts in the remaining water): sites 2, 4, 5 & 9 consisted of a series of small (< 10 m long), shallow (≤ 0.5 m mean depth), isolated pools in an otherwise dry creek bed (e.g. Figure 4.24 & Figure 4.25), whereas the pool at site 6 was much larger (> 200 m long and 1 m mean depth) (Figure 4.26).

Figure 4.24

Woleebee Creek at Boral Rd (site 4) was a series of small, shallow, isolated pools in an otherwise dry creek bed.

Figure 4.25

Juandah Creek at Booral Rd (site 9) was a series of small, shallow, isolated pools in an otherwise dry creek bed.

Figure 4.26

The pool at Spring Creek at Kabunga Rd (site 6) was relatively large.

Turbidity

Turbidity was highly variable across sites, ranging from 21 NTU at site 7 to 2,500 NTU at site 4 (Figure 4.27). Site 7 was the only site below the QWQG value (EPA 2007a), although it was only 4 NTUs below the guideline value. Several sites were extremely turbid: site 4 was 100-times the QWQG value; site 10 was 30-times the QWQG value; and sites 2 and 3 were 20-times the QWQG value. High turbidity throughout the study area was likely related to sediment-laden runoff associated with clearing of riparian vegetation, sloped / steep banks and bank erosion.

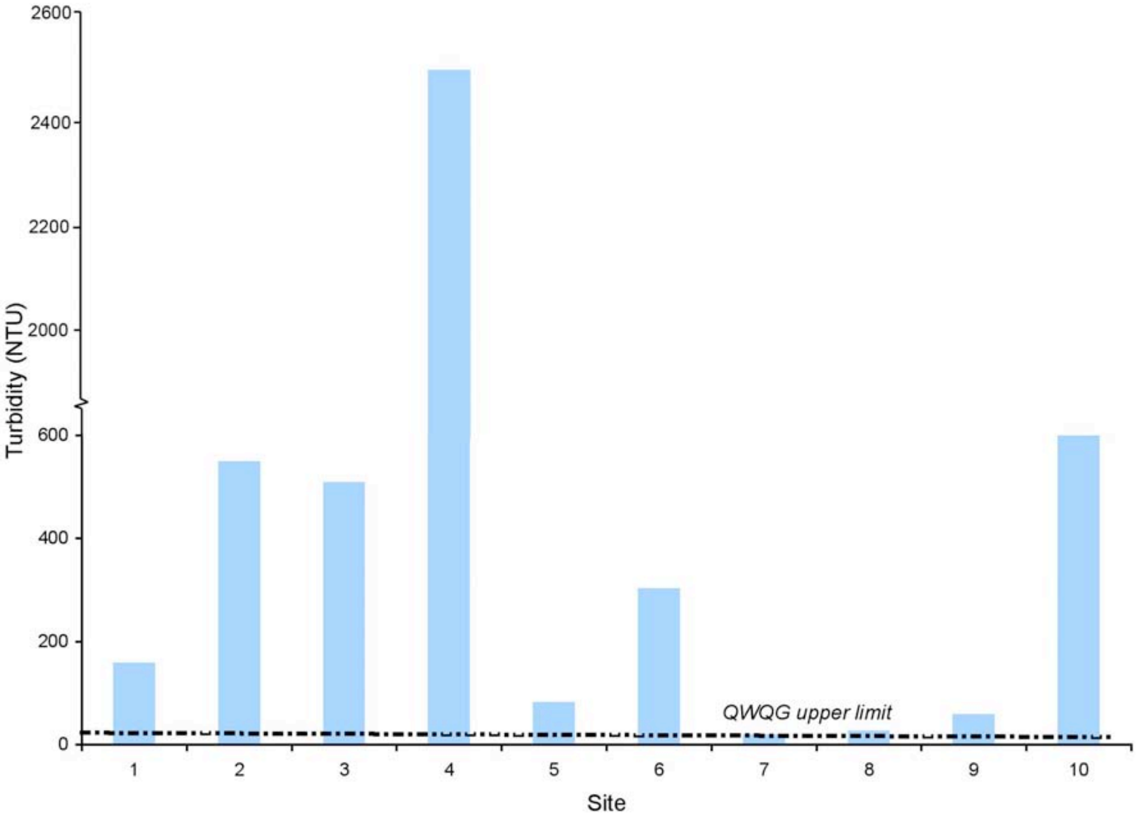


Figure 4.27 Turbidity at each site in the MLA study area, compared with the QWQG range for central coast upland streams (EPA 2007a). Note broken y-axis scale.

Nutrients

Nitrogen and phosphorus concentrations in the waterways of the MLAs exceed guideline values, and are indicative of the surrounding land-use (refer to surface water quality technical report).

Contaminants

Heavy metal concentrations in the waterways of the MLAs are elevated, and the concentration of some metals exceeds the relevant trigger level. Organophosphorus pesticide concentrations are also elevated within the waterways of the MLAs (refer to surface water quality technical report).

4.2.2 Gas Supply Pipeline Study Area

Water Temperature

Water temperature was between 11.5 and 13.4 °C in the sites that held water along the gas supply pipeline route (Figure 4.28). Water temperatures were cooler in the gas supply pipeline study area than the MLA study area, which is likely to be related to survey timing.

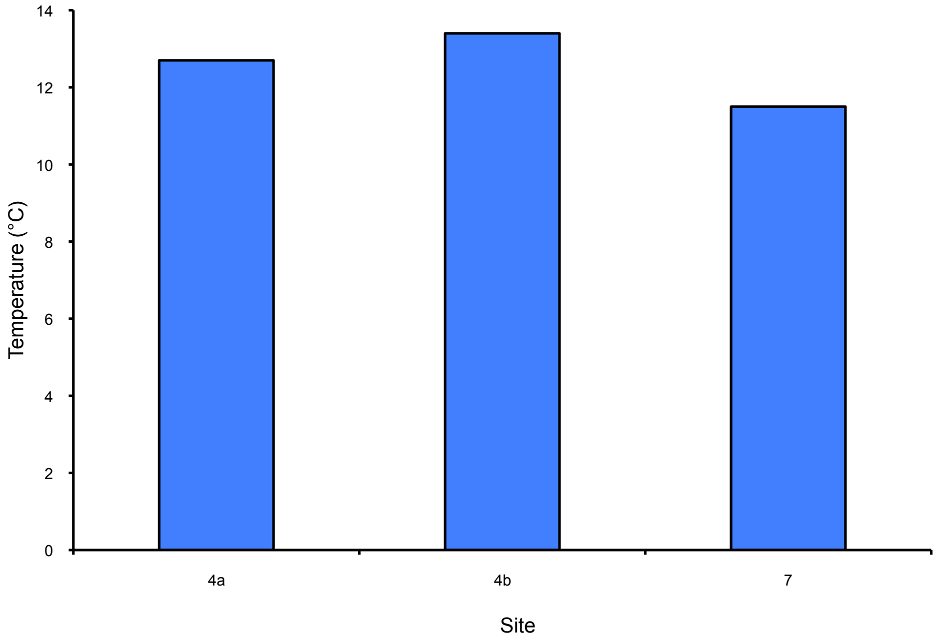


Figure 4.28 Water temperature at each site that held water along the gas supply pipeline route.

Dissolved Oxygen

DO levels were within the QWQG range in the anabranch of Roche Creek (site 4b), but were below the QWQG range in the main channel of Roche Creek (site 4a) (Figure 4.29). DO levels exceeded the QWQG range in Juandah Creek (site 7), this may have been due to photosynthesis of the periphyton and water column algae that was observed at this site. DO levels were below the QWQG values in Juandah Creek in March 2008 (Figure 4.21). This suggests that DO levels within the creek may fluctuate seasonally, and may rarely be within the QWQG range.

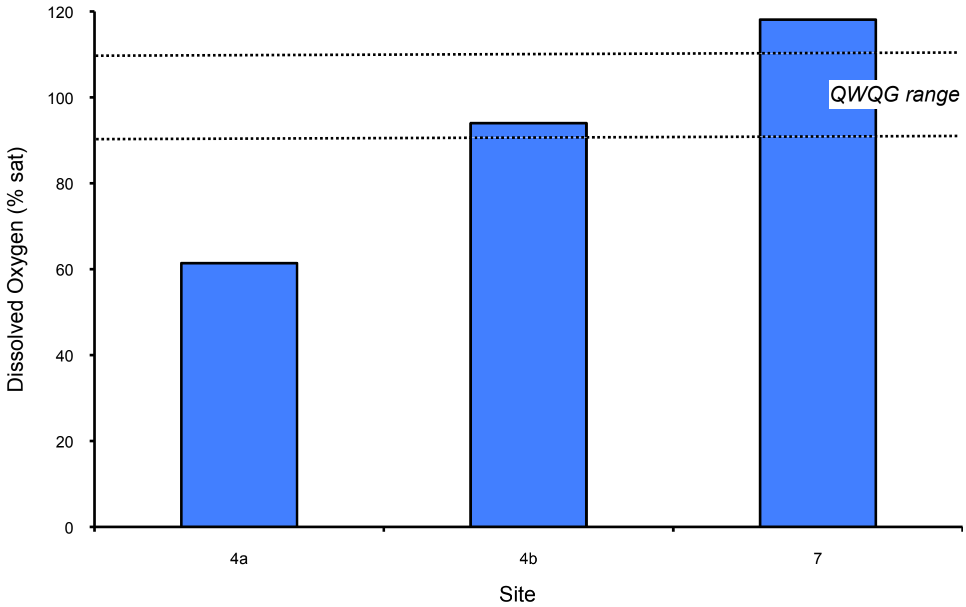


Figure 4.29 Dissolved oxygen at each site that held water along the gas supply pipeline route, compared with the QWQG range for central coast upland streams (EPA 2007a).

pH

pH values were compliant with the QWQG range at each of the sites that held water in the gas supply pipeline study area; that is, pH levels were typical of those found in a healthy waterway.

Electrical Conductivity

Conductivity at each of the sites along the gas supply pipeline route was below the preliminary QWQG upper limit for conductivity (340 µS/cm) (EPA 2007a). Conductivity was particularly low in the anabranch of Roche Creek (site 4b), the reason for this is unknown (Figure 4.31).

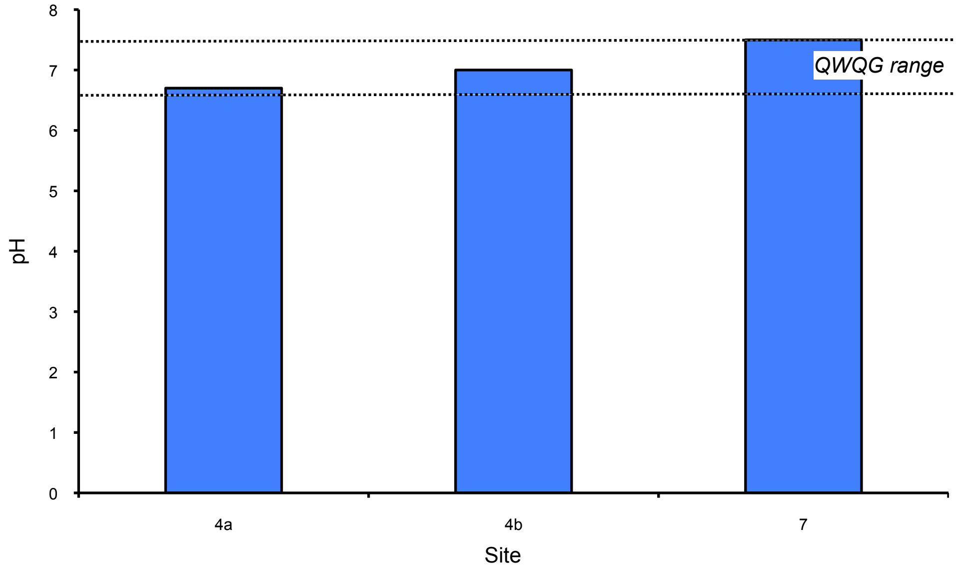


Figure 4.30 pH at each site that held water along the gas supply pipeline route, compared with the QWQG range for central coast upland streams (EPA 2007a).

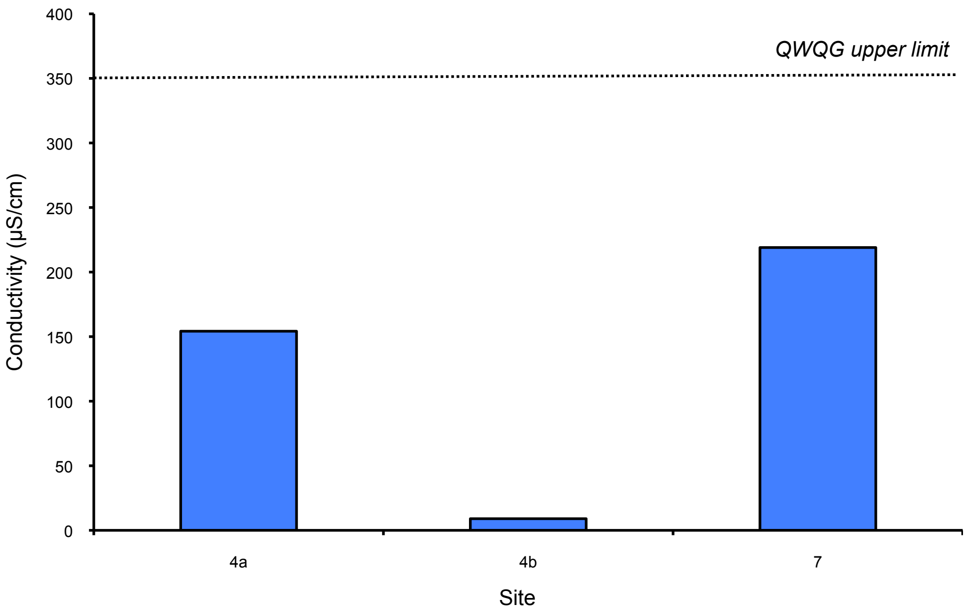


Figure 4.31 Electrical conductivity at each site that held water along the gas supply pipeline route, compared with the QWQG upper limit for Fitzroy central region (preliminary guideline based on the 75th percentile of data from the Fitzroy central salinity zone; EPA 2007a).

Turbidity

No turbidity measurements were recorded at waterways along the gas supply pipeline route, as a turbidity meter could not be sourced for the survey. Turbidity was observed to be variable among sites, and was likely within the range of turbidity levels recorded in the MLA study area.

4.2.3 A Regional and Ecological Perspective

The waterways of the study area are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment) (Figure 4.19). The Dawson River is the largest tributary in the Fitzroy River basin, which eventually feeds into the Great Barrier Reef (GBR) Lagoon.

Dawson River 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 subcatchments, which vary in their aggregate emission rates of nitrogen and phosphorus. In comparison with other Dawson River subcatchments, the Taroom Subcatchment (which contains the study areas) is a moderate emitter of phosphorus and a light emitter of nitrogen (EPA 2001). Total nitrogen emitted from the Taroom Subcatchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001). Based on a subcatchment area of 868,900 ha (out of a total Dawson River catchment area of 5,080,000 ha), the Taroom subcatchment contributes 1.6% and 1.4% of the total nitrogen and total phosphorus exported out of the Dawson River catchment annually.

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 source of second largest source, contributing 12% of the total, and State forests are the source of 4 % of total phosphorus (Joo et al. 2000).

Fitzroy River Catchment

Water quality in the Fitzroy River catchment received a report card score of 'C' (fair) for freshwaters above the Fitzroy Barrage (near Rockhampton), 'F' (fail) for the barrage itself and 'D' (poor) for estuarine waters (when compared to other central Queensland catchments) (Meecham 2003). Water quality in this catchment is compromised by (Meecham 2003):

- pesticide and herbicide contamination, particularly in irrigation areas;
- erosion and runoff increasing sedimentation and nutrients levels in waterways and reaching the GBR;
- high risk of blue-green algal bloom in still waters;
- rising salinity, particularly in stream between Theodore and Rockhampton;
- acid mine drainage in localised areas including Blackwater Creek, Crinum Creek, Don River and Dee River;
- heavy metal contamination, mostly from cadmium and copper in parts in of the Mackenzie, Nogoa and lower Dawson catchments; and
- substantial areas of poor riparian vegetation cover, particularly in the Dawson catchment and Central Highlands.

In the Fitzroy basin, between 1994 and 1996, surface DO concentrations ranged from 51 – 129% sat (Berghuis & Long 1999). The lower concentrations were below the QWQG whereas the upper concentrations were above the QWQG (range of 90 – 110% sat for upland streams Central Coast region) (EPA 2007a). DO concentrations recorded in the study areas during the present survey were lower than those recorded by Berghuis & Long (1999).

In the Fitzroy basin, between 1994 and 1996, water temperatures ranged from 14.1 – 29 °C (Berghuis & Long 1999). Water temperatures recorded during the March 2008 survey of the MLA study area were higher than those recorded by Berghuis & Long (1999), and temperatures recorded during the survey of the gas supply pipeline study area were lower. These differences may be associated with differences in survey timing.

Land use in the Fitzroy River catchment is primarily agricultural; 90% of land is grazed and 6% is cropped (Noble et al 1996). Accordingly, levels of total nitrogen and phosphorus are elevated in the waterways (Noble et al 1996). Nutrient levels exceed the QWQG (EPA 2007a) values at times, especially during periods of moderate and high flows (based on data presented by Noble et al 1996).

Noble (et al 1996) reported the presence of the herbicide atrazine in 43% of streams in the Fitzroy River system. Concentrations were low and within the guidelines at that time. Residual cotton sprays such as endosulfan, prometryne and profenofos were also detected downstream from cotton irrigation areas. However, the results of aquatic invertebrate sampling suggested that the streams within the catchment possessed relatively diverse invertebrate communities. Overall the study by Noble (et al 1996) concluded that life within the river system was fairly healthy, but that the significant flow events moved millions of tonnes of soil into the GBR lagoon, which in turn would carry any nutrients and pesticides present in the soil into the GBR lagoon.

4.2.4 Summary

Across the study areas, DO concentrations and turbidity levels did not generally comply with the QWQG. Low DO concentrations were probably due to high biological oxygen demand and low mixing of the waters. High turbidity was probably related to sediment-laden runoff associated with clearing of riparian vegetation, sloped / steep banks and the preceding flood. 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).

Similarly, water quality across the wider catchments is also characterised by high turbidity and fluctuating DO concentrations. Due to surrounding land uses, waterways within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants. The Taroom Subcatchment, which contains the study areas for the present study, only contributes 1.6% of the total phosphorus and 1.37% of the total nitrogen exported out of the Dawson River catchment each year.

4.3 Aquatic Flora

4.3.1 MLA Study Area

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. Across the study area, aquatic vegetation was native and relatively diverse. At each site, aquatic macrophyte cover was < 38%, but mostly < 15%.

Sixteen species were recorded across the ten sites surveyed (Table 4.1). Fifteen species had an emergent growth form. One species had a floating growth form; free-floating *Azolla* sp. covered 3% of site 7 (Figure 4.32). No submerged species were recorded.

At most sites, two to four different emergent species covered ≤ 15% of the site (with the exception of sites 5, 7 and 8 (Table 4.1, Figure 4.33). The most common emergent macrophyte was *Alternanthera denticulata* (lesser joyweed; Figure 4.34), which grew at all ten sites. Sedges (Family Cyperaceae) and rushes (Family Juncaceae; *Juncus usitatus*) were relatively common and grew at most sites (Table 4.1). Less common species included *Persicaria decipiens* (smartweed), *Lomandra* sp. (rush), *Paspalum distichum* (water couch), *Phragmites australis* (common reed) and *Eragrostis elongata* (clustered lovegrass).

Figure 4.32

Free-floating *Azolla* grew at site 7.

Figure 4.33

Giant sedge and slender knotweed grew on the bank at site 8, together with grasses.

Figure 4.34

Lesser joyweed grew at all ten sites surveyed.

Table 4.1 Percent cover of all macrophytes at each site within the MLA study area, listed by growth form.

GROWTH FORM / Family / ***Latin name***	**Common name**	**Native / Exotic** [1]	**% Cover at Each Site**									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
SUBMERGED												
None												
FLOATING												
Azollaceae												
Azolla sp.	azolla	N							3			
EMERGENT												
Amaranthaceae												
Alternanthera denticulata	lesser joyweed	N	5	3	3	2	8	1	7	2	2	3
Cyperaceae												
Cyperus aquatilis	water nutgrass	N							4		2	
Cyperus difformis	dirty dora	N		4	2					7		
Cyperus digitatus	flatsedge	N										2
Cyperus exaltus	giant sedge	N					1			5		
Eleocharis cylindrostachys	spikerush	N		2						4		

[1] N = native; E = exotic

GROWTH FORM / Family / ***Latin name***	**Common name**	**Native / Exotic [1]**	**% Cover at Each Site**									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Unknown sp. 1	sedge	N					5				4	
Unknown sp. 2	sedge	N								1		
Unknown sp. 3	sedge	N	2									
Gramineae												
Paspalum distichum	water couch	N								10		
Phragmites australis	common reed	N					4					
Juncaceae												
Juncus usitatus	rush	N	2			2		2	1		2	
Lomandraceae												
Lomandra sp.	rush	N	5				2		10			2
Poaceae												
Eragrostis elongata	clustered lovegrass	N					5					
Polygonaceae												
Persicaria decipiens	slender knotweed	N								8		2
TOTAL			**14**	**9**	**10**	**4**	**25**	**3**	**25**	**37**	**10**	**9**

The limited cover of macrophytes, and in particular the lack of submerged species, is likely to be related to the largely ephemeral nature of the waterways and turbid water. Ephemeral waterways do not offer appropriate habitat for submerged macrophytes. Turbidity may not allow sufficient light penetration through the water column for the growth of macrophytes on the substrate. High turbidity could also prevent observation of submerged macrophytes through the water column.

Algae

Filamentous and mat algae grew at several sites, such as sites 8 & 9, although it was less common during the field surveys than during the field reconnaissance in August 2007. The overall reduction in algal growth is most likely associated with flushing of the creeks by flows associated with rainfall, compared to nutrient enrichment of the water (associated with nutrient inputs originating from existing land-uses) in the dry season, as water evaporates from small pools.

4.3.2 Gas Supply Pipeline Study Area

Macrophytes were uncommon throughout the gas supply pipeline study area, and were only recorded in Roche Creek (sites 4a and 4b) (Table 4.2). This may be related to the timing of the survey in winter, as there is typically less water present in the creeks in winter than in other seasons. A similar range of species to those recorded in the MLA study area was found in the gas supply pipeline study area.

Table 4.2 Percent cover of all macrophytes at each site within the gas supply pipeline study area, listed by growth form.

GROWTH FORM / Family / *Latin name*	**Common name**	**Native / Exotic** [2]	**% Cover at Each Site**						
			1	**2**	**3**	**4a**	**4b**	**6**	**7**
SUBMERGED									
None									
FLOATING									
None									

[2] N = native; E = exotic

GROWTH FORM / Family / *Latin name*	Common name	Native / Exotic [2]	% Cover at Each Site 1	2	3	4a	4b	6	7
EMERGENT									
Amaranthaceae									
Alternanthera denticulata	lesser joyweed	N				1			
Cyperaceae									
Cyperus sp.	sedge	N					5		
Eleocharis sp.	spikerush	N				1			
Gramineae									
Phragmites australis	common reed	N							
Juncaceae									
Juncus usitatus	rush	N				1	5		
Lomandraceae									
Lomandra sp.	rush	N				1			
Eragrostis elongata	clustered lovegrass	N				3			
TOTAL						**5**	**10**		

4.3.3 A Regional and Ecological Perspective

Very little information is available regarding macrophytes of the region.

Many *State of the Rivers* (Telfer 1995) sites in the subcatchment were dry at the time of sampling (91%), and sites with water did not support macrophytes. A similar result was obtained during the field reconnaissance of the study area in August 2007.

A recent study in the upper Dawson River catchment (frc environmental 2007) reported a similar result to the survey. frc environmental (2007) reported ten different species of macrophyte from seven sites, with richness ranging from zero to eight species at any one site. All macrophytes had an emergent growth form (there were no floating or submerged species).

4.4 Aquatic Macro-invertebrate Communities

4.4.1 MLA Study Area

Macro-crustaceans (freshwater prawns and crayfish), diving beetles (family Dyticidae) water bugs (families Corixidae, Notonectidae and Veliidae) and non-biting midge larvae (sub-family Chironominae) dominated the invertebrate communities of the MLA study area. The richness and distribution of taxa found within the study area varied according to the aquatic habitats found at each site.

Richness

Taxonomic richness (the number of macro-invertebrate taxa, generally families, per sample) in bed habitats was relatively low, ranging from two to fifteen at the sites surveyed. Richness was highest in the bed habitats in Frank Creek, One-Arm Man Creek, Mud Creek and Juandah Creek (sites 1, 2, 5 & 9) (Figure 4.35), which may be related to high substrate diversity at these sites (for example, these sites contained both soft sediment and hard substrates such as cobbles, boulders or concrete related to culvert installation).

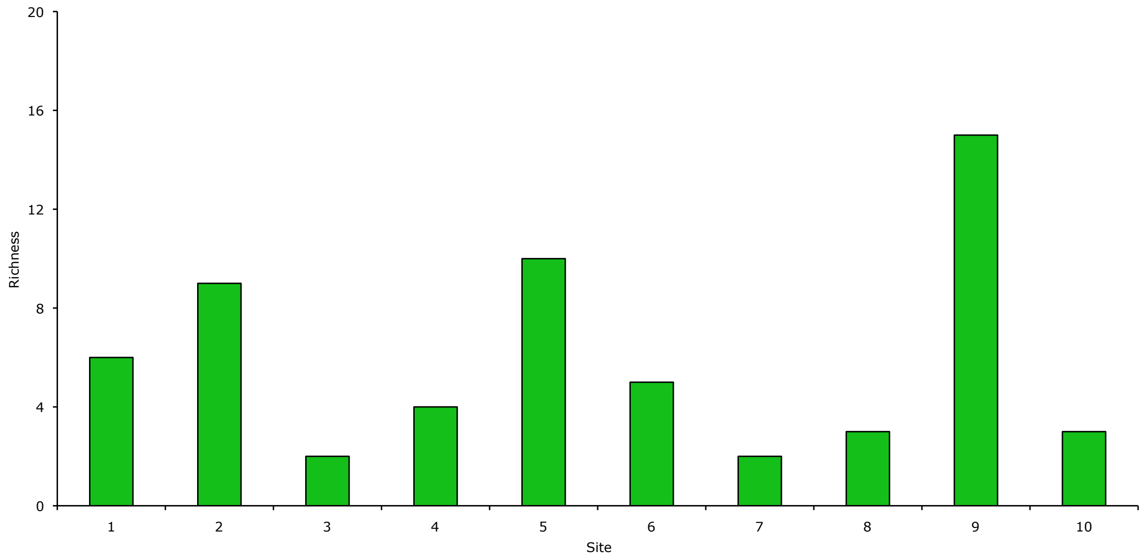


Figure 4.35 Taxonomic richness of macro-invertebrate communities in bed habitats of the MLA study area.

Richness was higher in edge habitats compared with bed habitats, with between seven to eighteen taxa recorded per site. This is to be expected, as edge and bed habitats support different communities. Richness in edge habitats was highest at site 7 on Juandah Creek (Figure 4.36), which may be due to the undercut banks, exposed trees roots and high cover of trailing bank vegetation at this site, which would provide habitat for macro-invertebrates.

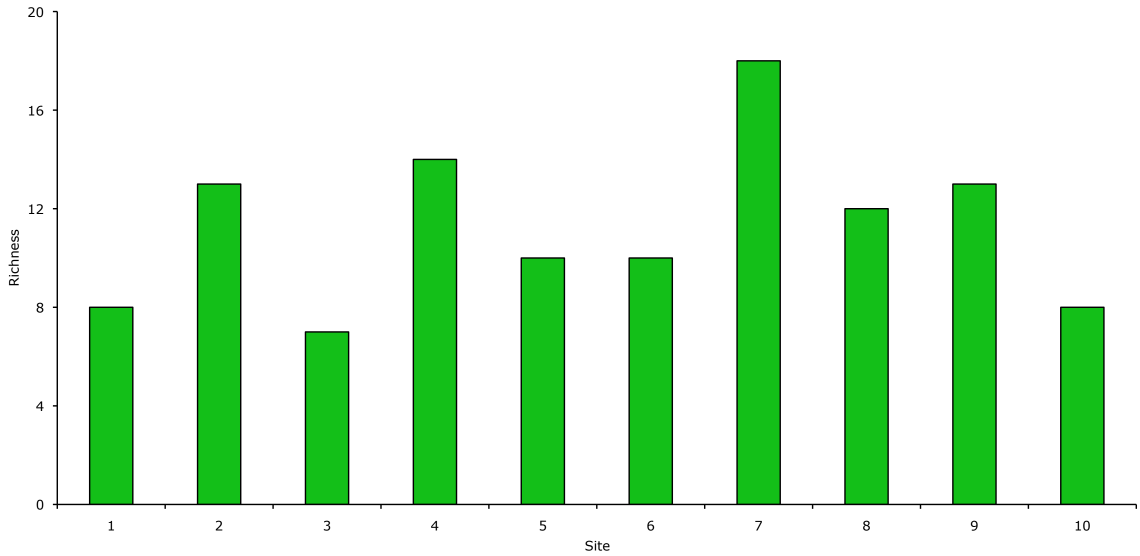


Figure 4.36 Taxonomic richness of macro-invertebrate communities in edge habitats at the MLA study area.

PET Richness

In general, PET richness (a measure of pollution-sensitive invertebrate taxa richness) of <1 is indicative of degraded water or habitat quality, PET richness of 1 – 4 is considered to indicate moderate water / habitat quality, and PET richness of >4 indicates good water / habitat quality. PET richness was low and indicative of degraded or moderate water and habitat quality at most of the sites surveyed, and no PET taxa were recorded from sites 5 or 10 (Figure 4.37 & Figure 4.38). However, a relatively high number of PET taxa were sampled from site 9, which is probably indicative of the diversity of substrate types and edge habitat (including undercut banks and trailing bank vegetation) at this site.

While the low abundance of PET taxa throughout the study area may be indicative of poor water and/or habitat quality, the waterways sampled are ephemeral or intermittent systems. 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.

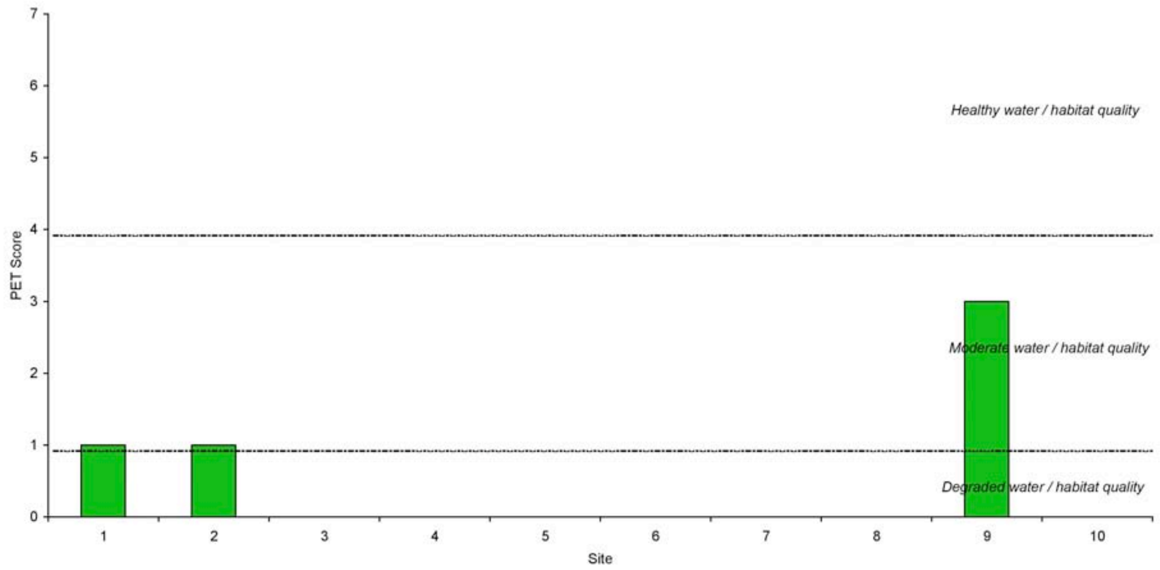


Figure 4.37 PET richness of macro-invertebrate communities in bed habitats of the MLA study area.

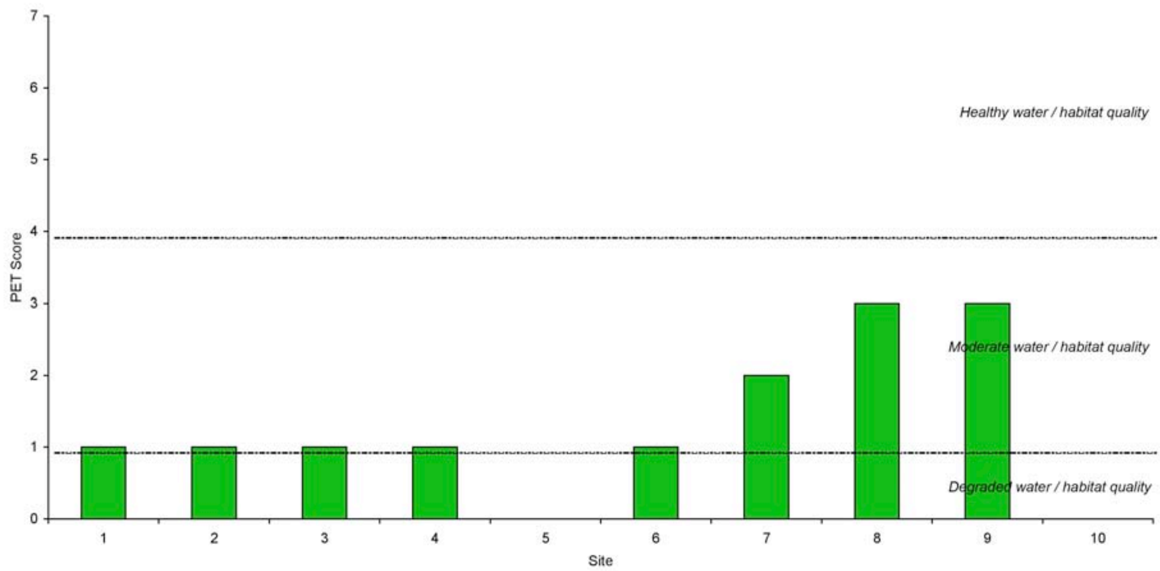


Figure 4.38 PET richness of macro-invertebrate communities in edge habitats of the MLA study area.

SIGNAL 2 / Family Bi-plots

The interpretation of SIGNAL 2 indices in conjunction with the number of macro-invertebrate families recorded, enables the simple characterisation of aquatic macro-invertebrate 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) of unimpacted 'reference' sites within the region, which is beyond the scope of this study. Interpretation of the bi-plot with regard to quadrant boundaries has therefore been approached with caution.

Macro-invertebrate communities surveyed from bed and edge habitats throughout the study area were generally within quadrant 4 of the bi-plot (Figure 4.39 & Figure 4.40),

It is likely that the waterways of the study area are subject to agricultural pollution (such as nutrient enrichment) from the surrounding land uses, as the samples collected fell well-within quadrant 4 of the bi-plot, which indicates that these communities may be impacted by urban, industrial or agricultural pollution (Figure 4.39 & Figure 4.40, Attachment B). The communities sampled from edge habitats at site 7 on Juandah Creek were within quadrant 2, which may indicate that communities here are affected by high salinity or nutrient levels (which may be natural). However, it is important to note that for ephemeral 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).

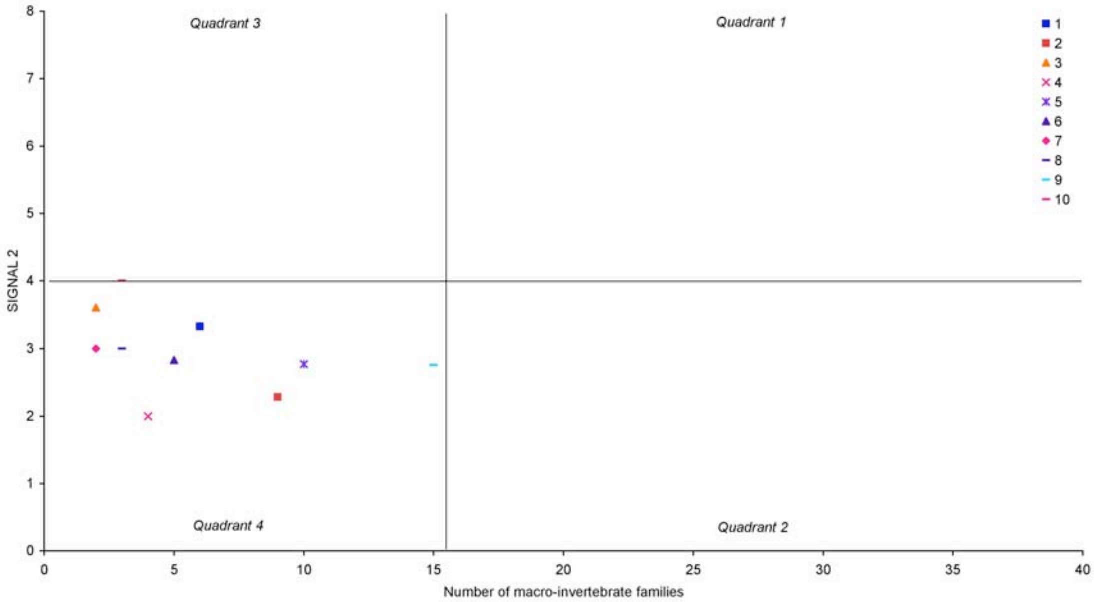


Figure 4.39 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from bed habitats in the MLA study area.

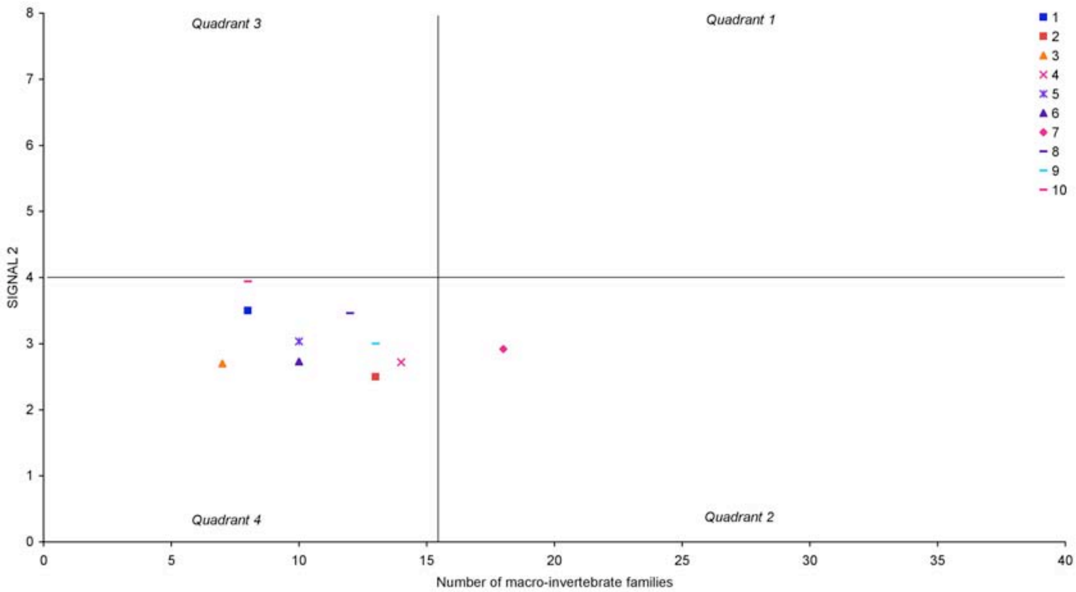


Figure 4.40 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from edge habitats in the MLA study area.

4.4.2 Macro-crustaceans

An estimated 515 macro-crustaceans were captured across the ten sites surveyed in the MLA study area. Macro-crustaceans were caught using a variety of methods, including dip netting for macro-invertebrates, trapping, and observations/captures during electrofishing. Abundance was < 40 individuals per site, however a relatively large number of macro-crustaceans were captured in Mud Creek (site 5) (Figure 4.41). Very few macro-crustaceans were captured in Mount Organ Creek (site 8).

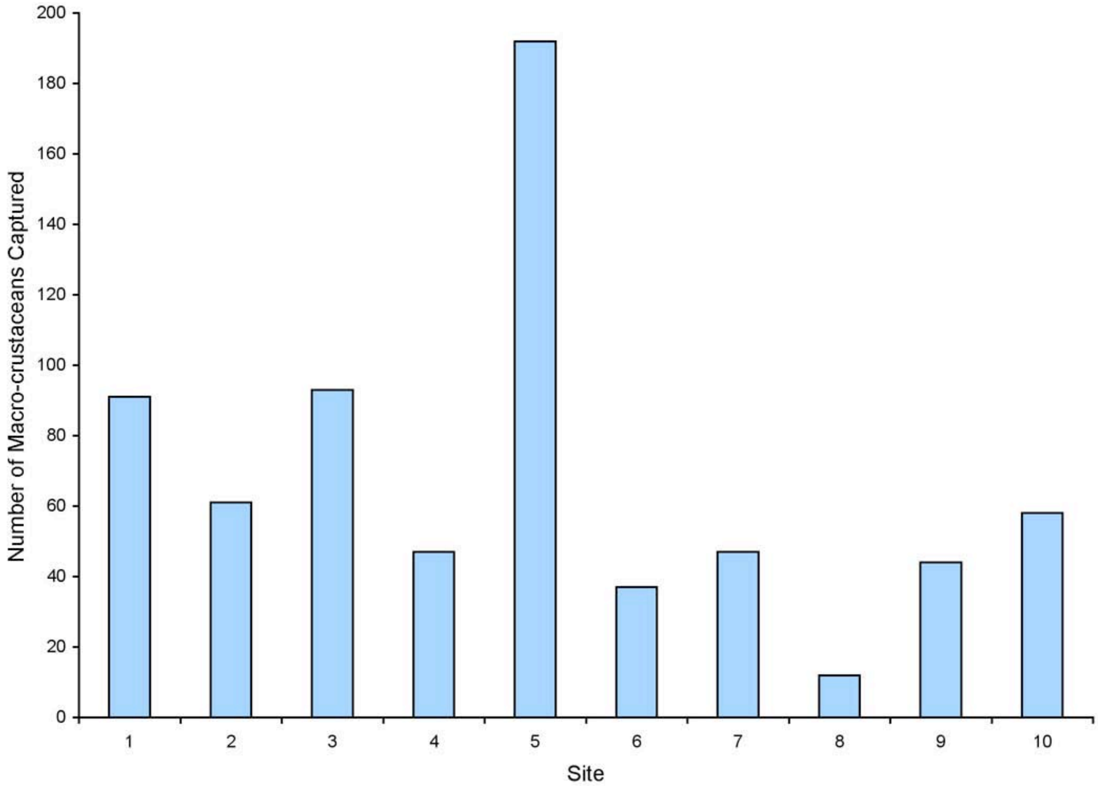


Figure 4.41 Macro-crustacean abundance at each site surveyed in the MLA study area.

Across the ten sites surveyed, three macro-crustaceans species were positively identified. *Cherax depressus* (orange-fingered yabby) was the most common and abundant species, and was recorded at all ten sites surveyed. Adult, intermediate and juvenile orange-fingered yabbies were captured at each site; egg-bearing ('berried') females were captured at several sites, including site 3 (Figure 4.42). *Caridina* sp. (freshwater shrimp) and *Macrobrachium australiense* (common Australian river prawn) were also relatively common; adults, intermediates and juveniles of each species were captured at each site.

Many more river prawns and freshwater shrimp were observed, but not caught, during electrofishing, and additional species may be present.

All three species of macro-crustacean were captured at most sites (Table 4.3). Richness was lowest at site 8, where only orange-fingered yabbies were captured.

The freshwater crab (*Austrothelphusa* sp., formerly *Holthuisana* sp.) is widespread throughout Australia and is well adapted to living in ephemeral streams (Jones & Morgan 1994). However, the present survey did not capture freshwater crabs in the MLA study area.

Table 4.3 Abundance of macro-crustaceans at each site (all survey methods combined).

Family	Latin Name	Common name	Site									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Atyidae	*Caradina* sp.	freshwater shrimp	25	6	28	8	33	20	9	–	4	2
Palaemonidae	*Macrobrachium* sp.	river prawn	20	2	23	4	83	–	25	–	2	54
Parastacidae	*Cherax depressus*	orange-fingered yabby	46	53	42	35	76	17	13	12	38	2

Figure 4.42

An egg-bearing orange-fingered yabby at site 3.

4.4.3 Gas Supply Pipeline Route

Diving beetles (family Dytiscidae), water bugs (family Corixidae), mayfly nymphs (family Baetidae) and non-biting midge larvae (sub-family Chironominae) dominated the macro-invertebrate communities of the sites within the gas supply pipeline study area. These families were also common in the macro-invertebrate communities of the MLA study area.

Richness

Taxonomic richness ranged from 7 to 10 in edge and bed habitats at the sites surveyed, and was generally similar across sites and habitat type (Figure 4.43).

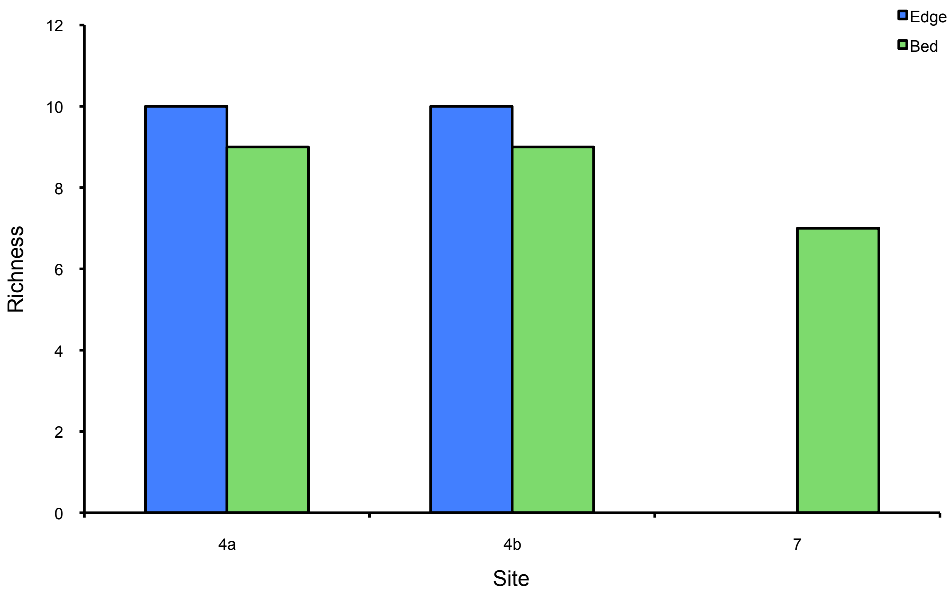


Figure 4.43 Taxonomic richness of macro-invertebrate communities in edge and bed habitats of the gas supply pipeline study area.

PET Richness

PET richness was low and indicative of degraded water and habitat quality in Roche Creek (sites 4a and 4b), and no PET taxa were recorded from Juandah Creek (site 7) (Figure 4.44). PET richness was also low in the MLA study area, and low PET richness is possibly due to the ephemeral or intermittent nature of the waterways throughout the two study areas. PET families are not commonly abundant in these systems due to the natural environmental stresses that they are subject to.

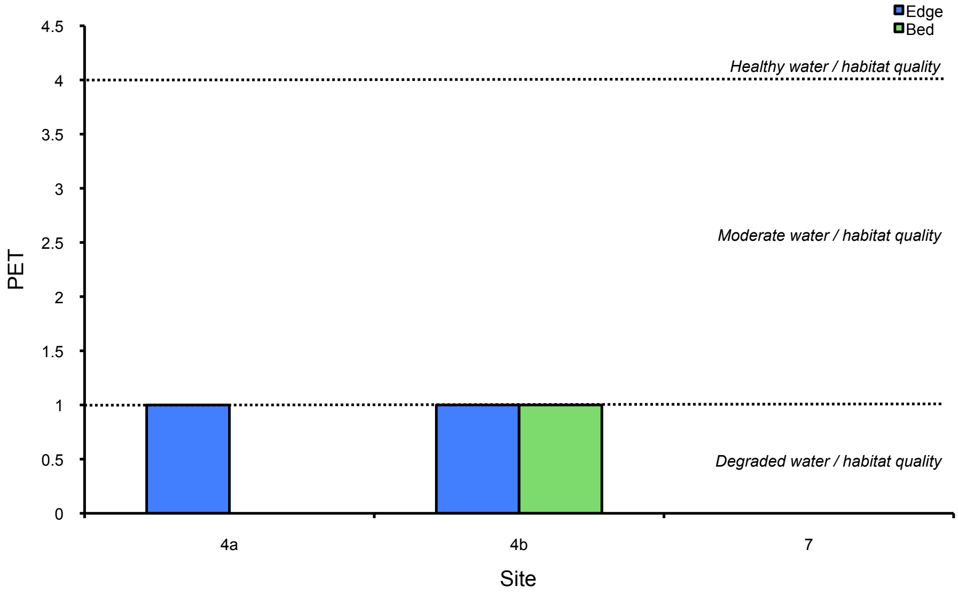


Figure 4.44 PET richness of macro-invertebrate communities in edge and bed habitats of the gas supply pipeline study area.

SIGNAL 2 / Family Bi-plots

Macro-invertebrate communities surveyed from bed and edge habitats throughout the gas supply pipeline study area were within quadrant 4 of the bi-plot (Figure 4.45), which indicates that these communities may be impacted by urban, industrial or agricultural pollution. Communities surveyed from the MLA study area were also predominately within quadrant 4 of the bi-plot. Waterways at both the MLA and gas pipeline are either ephemeral or intermittent in nature. The positions of these sites on their respective bi-plots should be interpreted with caution as the SIGNAL 2 / family bi-plot does not adequately distinguish sites that are affected by nature anthropogenic disturbances.

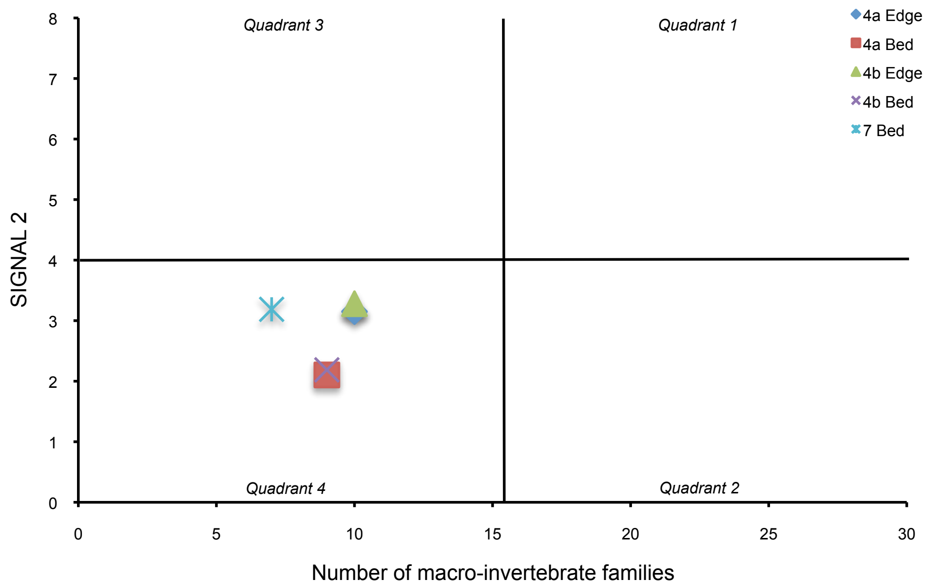


Figure 4.45 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from edge and bed habitats of the gas supply pipeline study area.

4.4.4 Macro-crustaceans

Seventy-nine macro-crustaceans were captured across the three sites surveyed for fish using back-pack electrofishing. The majority of macro-crustaceans were captured from the anabranch of Roche Creek (site 4b), where 62 macro-crustaceans were collected (Figure 4.46).

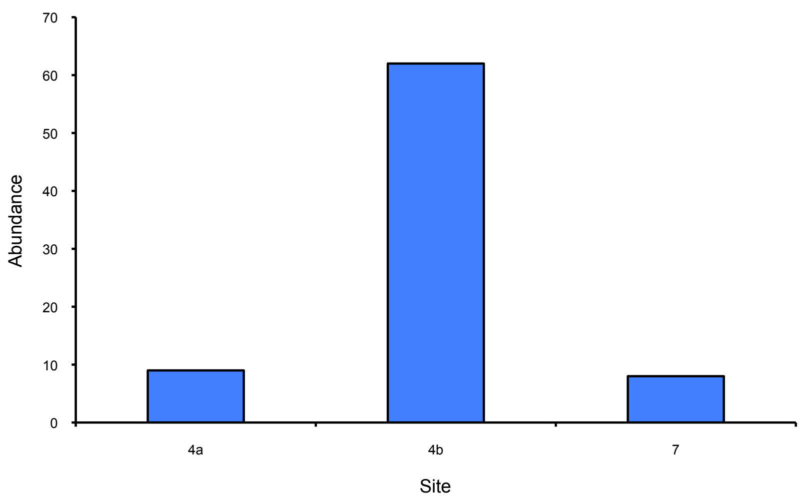


Figure 4.46 Macro-crustacean abundance at each site surveyed in the gas supply pipeline study area.

Cherax depressus was the most prevalent species; it was recorded at all 3 sites surveyed (Table 4.4). Intermediate and juvenile orange-fingered yabbies were captured at sites 4a and 4b, whilst only juveniles were captured at site 7. *Macrobrachium* sp. were also present at all three sites. *Caridina* sp. were collected from sites 4b and site 7, while *Paratya* sp. were collected from sites 4a and 4b.

All four species of macro-crustacean were captured in the anabranch of Roche Creek (site 4b) (Table 4.4). Richness was three species at each of the other site surveyed.

Table 4.4 Abundance of macro-crustaceans at each site surveyed in the gas supply pipeline study area.

Family	Latin Name	Common Name	Site		
			4a	4b	7
Atyidae	*Caradina sp.*	freshwater shrimp	0	14	2
Atyidae	*Paratya sp.*	freshwater shrimp	1	13	0
Palaemonidae	*Macrobrachium sp.*	river prawn	2	7	3
Parastacidae	*Cherax depressus*	orange fingered yabby	6	28	3

4.4.5 A Regional and Ecological Perspective

Richness

Sandy pool habitats in the Dawson River supported between seven to eighteen macro-invertebrate families per sample, and rocky pool habitats supported between ten to twenty-five families per sample (refer Figure 4.47 and Figure 4.48). That is, macro-invertebrate richness was higher at the Dawson River site surveyed by DNRW compared with richness in bed habitats surveyed in the present study. This may be related to the timing of surveys (DNRW surveys were conducted four to thirteen years ago), or the habitat at the survey sites (the site on the Dawson River is perennial, and therefore offers more stable habitat for macro-invertebrates). Bed habitats in Juandah Creek were not sampled by the DNRW (DNRW 2007).

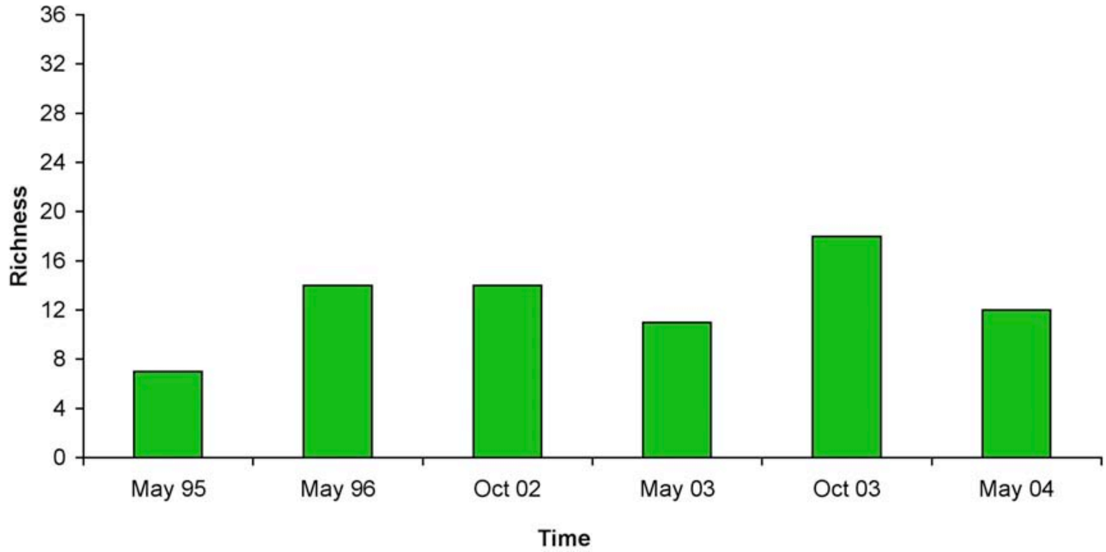


Figure 4.47 Taxonomic richness in sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

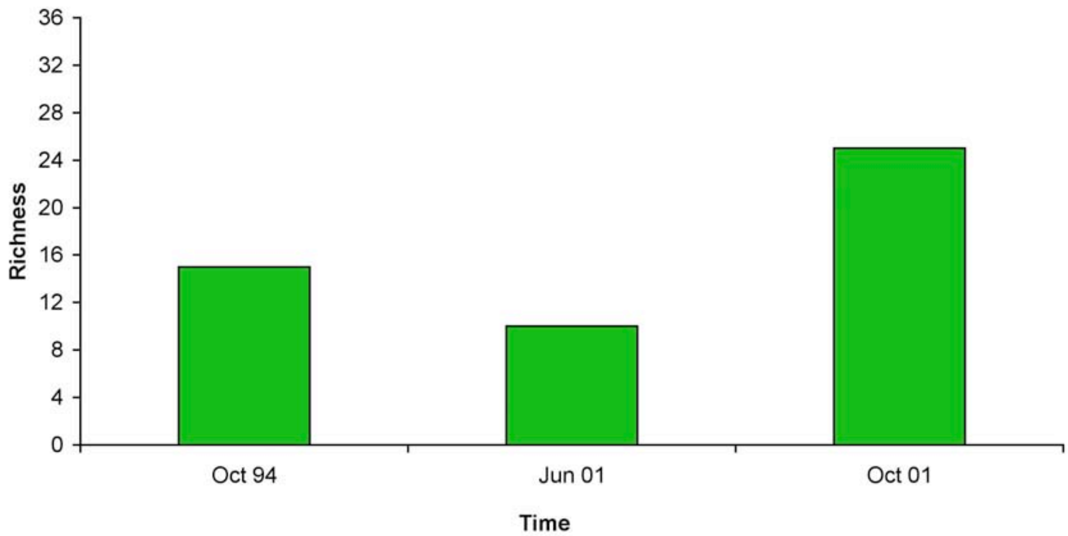


Figure 4.48 Taxonomic richness in rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

Similar to the pattern observed in the study area, macro-invertebrate community richness for edge habitats in the Dawson River was higher than the richness found in bed communities. Taxonomic richness ranged between seventeen and thirty-two at the DNRW sampling site on the Dawson River at Taroom (Site 130302A) from 1994 – 2004 (refer Figure 4.49). This is a relatively high richness, and is indicative of good quality edge habitat and water quality at this site. Similar to bed habitats, edge habitats in the Dawson River supported a higher number of taxa than the edge habitats sampled during the present study.

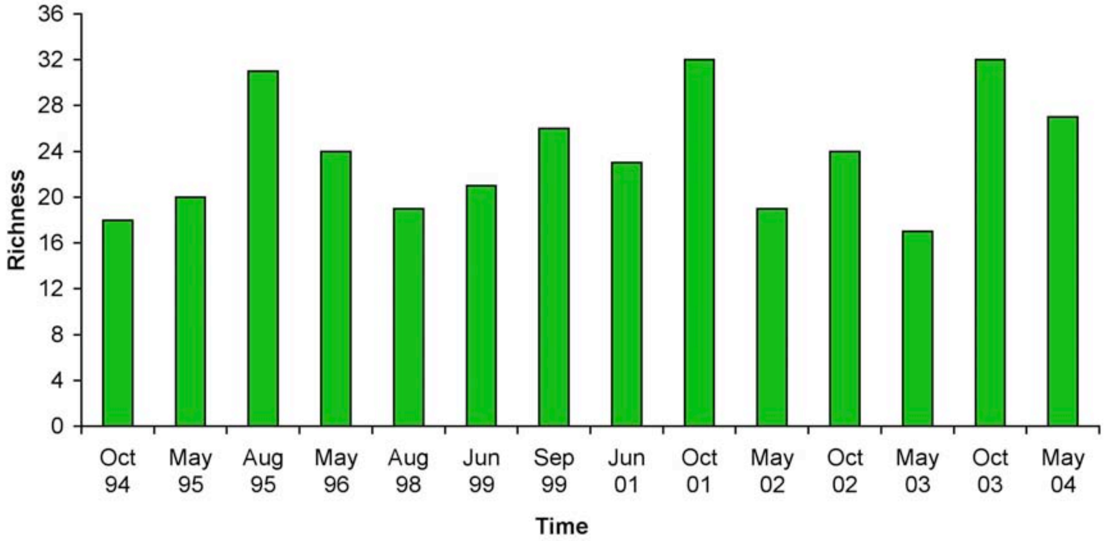


Figure 4.49 Taxonomic richness in edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

In contrast, at the DNRW sampling site on Juandah Creek at Sandy Bridge (Site 1303086), total richness was eighteen in June 1997 and eleven in May 2000 (this site has only been sampled twice in the last ten years) (DNRW 2007). This indicates that Juandah Creek may have lower habitat and/or water quality than the Dawson River. Macro-invertebrates were sampled from this site during the present study; richness was similar to the richness recorded in May 2000 (eight taxa).

PET Richness

The PET Richness of bed and edge habitats in the Dawson River at Taroom was indicative of moderate to good habitat and/or water quality (Figure 4.50 – Figure 4.52). PET Richness varied over time, but was generally higher than the PET richness recorded in the MLA and gas supply pipeline study areas during the present surveys.

In contrast, zero to two PET families were sampled by the DNRW at Juandah Creek (DNRW 2007); and no PET families were sampled from this site during the present study.

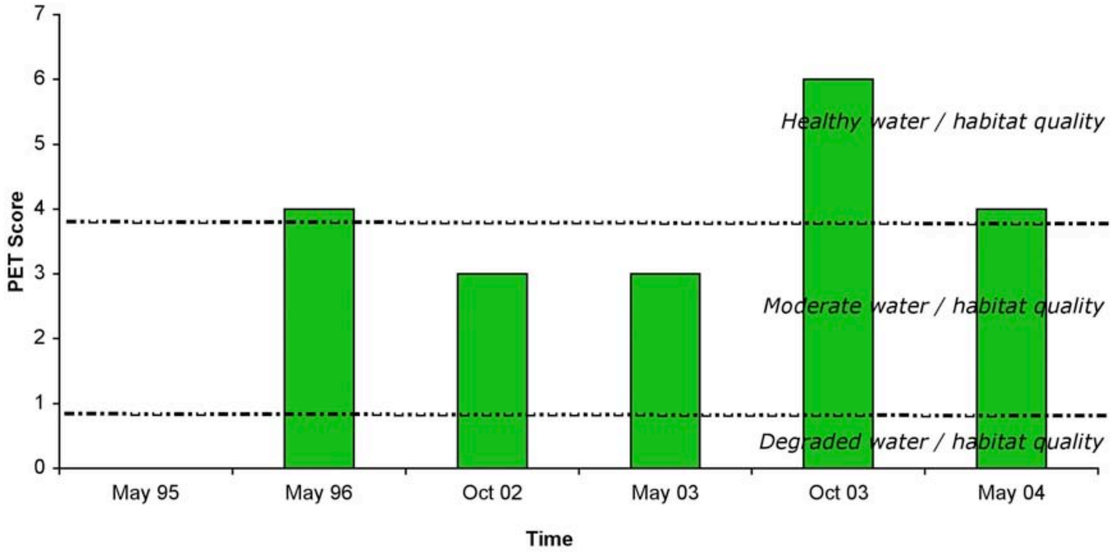


Figure 4.50 PET richness in sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A)

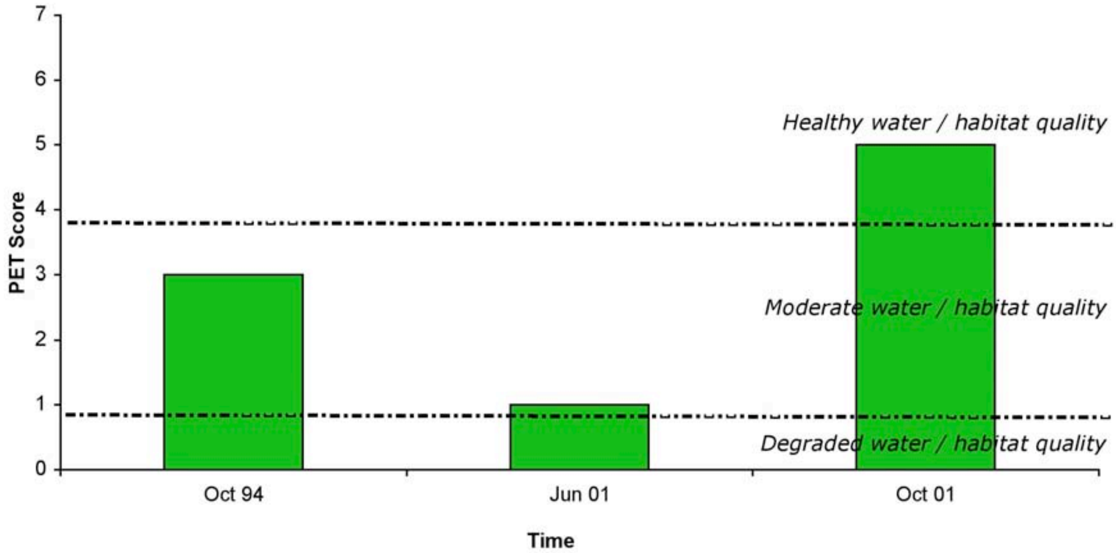


Figure 4.51 PET richness in rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A)

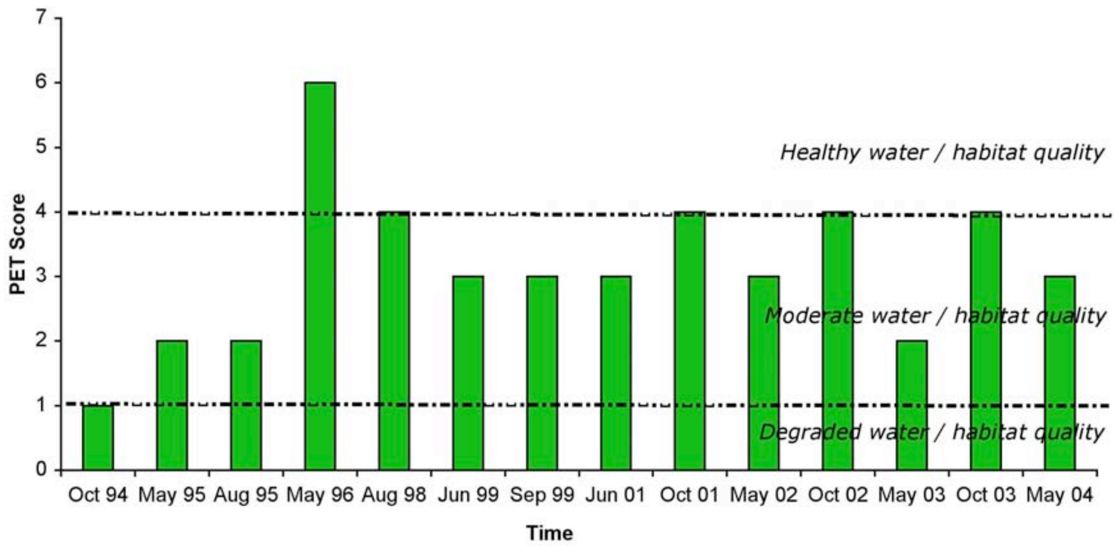


Figure 4.52 PET richness in edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots for communities sampled from the Dawson River are indicative of fair to good habitat and water quality in the Dawson River at Taroom. However, the macro-invertebrate communities may be affected by high nutrient or salinity levels, urban or agricultural pollution, and/or harsh physical conditions (Figure 4.53 – Figure 4.55; Attachment B).

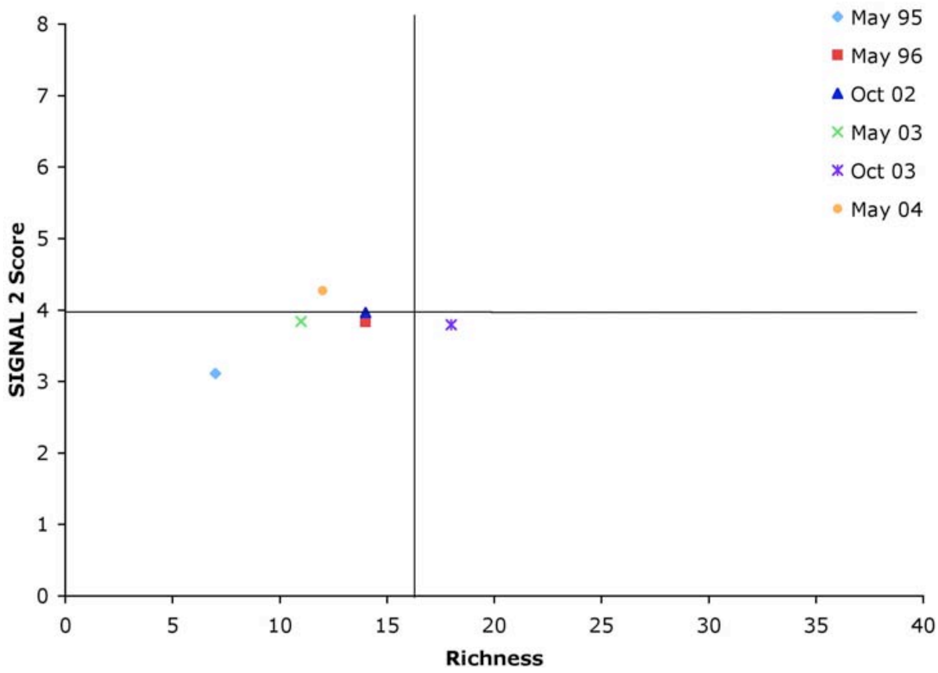


Figure 4.53 SIGNAL 2 / family bi-plot for sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

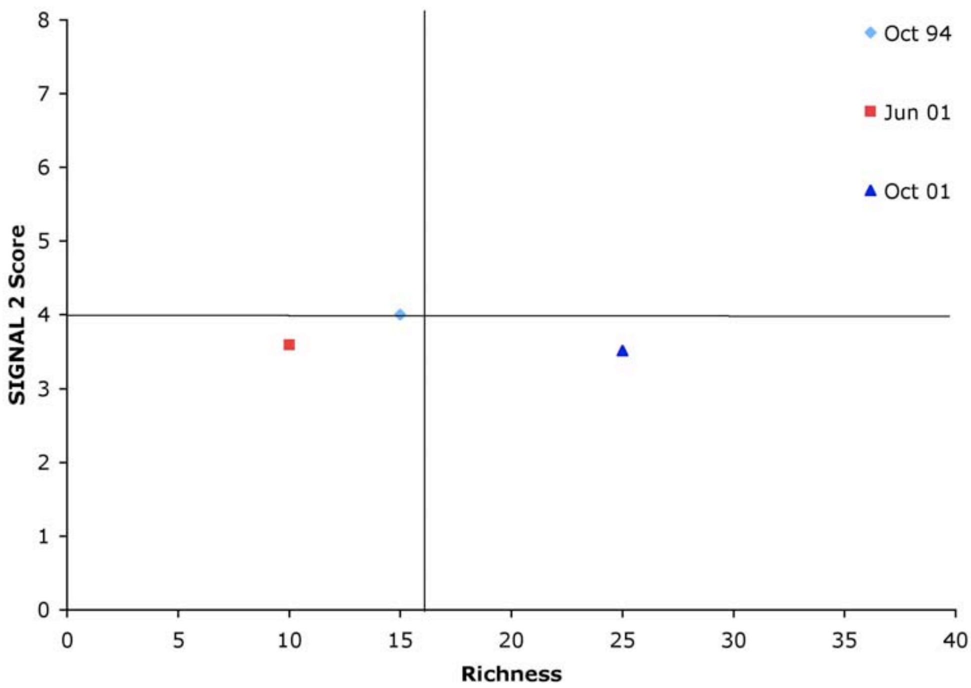


Figure 4.54 SIGNAL 2 / family bi-plot for rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

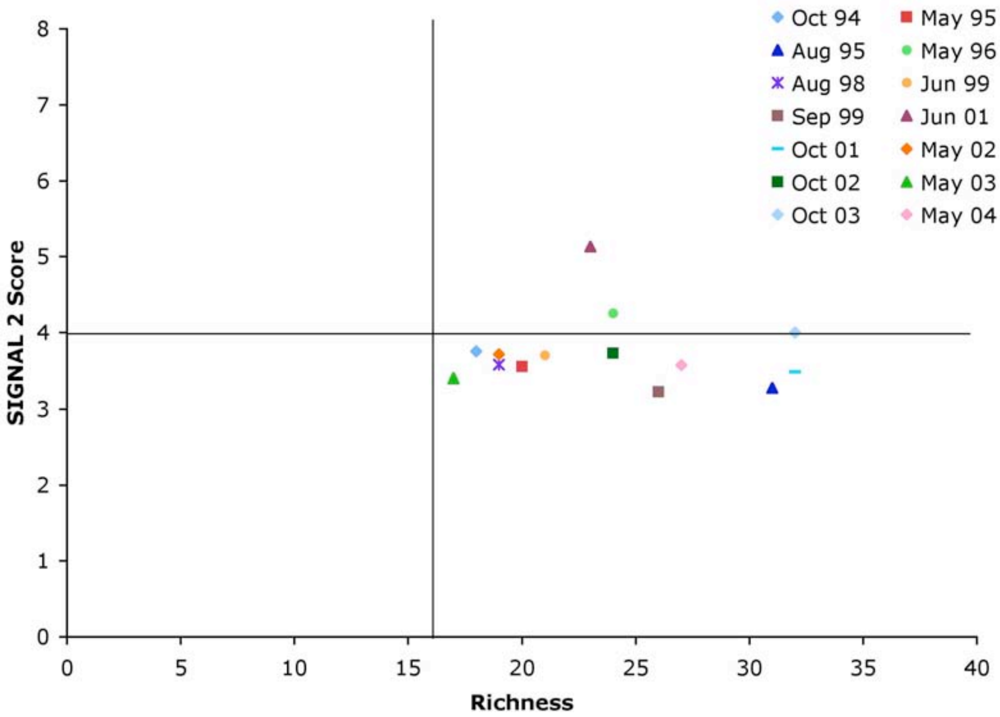


Figure 4.55 SIGNAL 2 / family bi-plot for edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

Macro-crustaceans

Macro-crustaceans 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 orange-fingered yabbies were caught. Australian paratya shrimp were also caught by frc environmental (2007).

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 of poor water quality (Chessman 2003), therefore allowing them to survive in ephemeral streams that are impacted by surrounding land-uses. Yabbies were the most common macro-crustacean in the survey of the Dawson River catchment (frc environmental 2007).

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. Freshwater prawns and shrimps were relatively common in the survey of the Dawson River, but would be expected to die out as pools dry up.

4.4.6 Summary

Aquatic macro-invertebrate community structure within the MLA and gas supply pipeline study areas was generally indicative of poor to moderate habitat and/or water quality, reflecting the results of water quality and aquatic habitat assessments in the study areas (see Sections 4.1 & 4.2). Differences in macro-invertebrate community structure appeared to be related to site-specific differences in habitat availability and diversity. Crayfish and prawns/shrimp were common in the study area.

In general, the macro-invertebrate communities of the downstream Dawson River were more diverse and contained more taxa sensitive to pollution and disturbance than those similar communities within the study area. Sites on the Dawson River at Taroom are likely to have permanent water, and therefore offer more stable habitat for macro-invertebrates. In contrast, the communities of the study area are influenced by harsh physical conditions, such as the drying of pools.

4.5 Fish Communities

4.5.1 MLA Study Area

In total, 254 fish from eight species were captured across the ten sites surveyed. Abundance was generally < 40 fish at any one site, however ninety-three were caught at site 5 on Mud Creek (Figure 4.56 & Table 4.5).

Species richness ranged from one species at One-Arm Man Creek (site 2) and eight to five species at Juandah Creek downstream of the MLAs (site 10) (Figure 4.57). Species richness and abundance at each survey site was likely related to site-specific factors such as the size of the pool surveyed, the presence and abundance of physical habitat such as large woody debris and fish passage within the waterway. For example, there was a high richness and abundance of fish at site 5 on Mud Creek, which was characterised by good riparian cover, good in-stream habitat cover such as large woody debris, and relatively good water quality (Figure 4.58). In contrast, species richness and abundance was low at One-Arm Man Creek and Mount Organ Creek (sites 2 and 8), which were characterised by low riparian cover, relatively low dissolved oxygen levels and a lack of in-stream habitat.

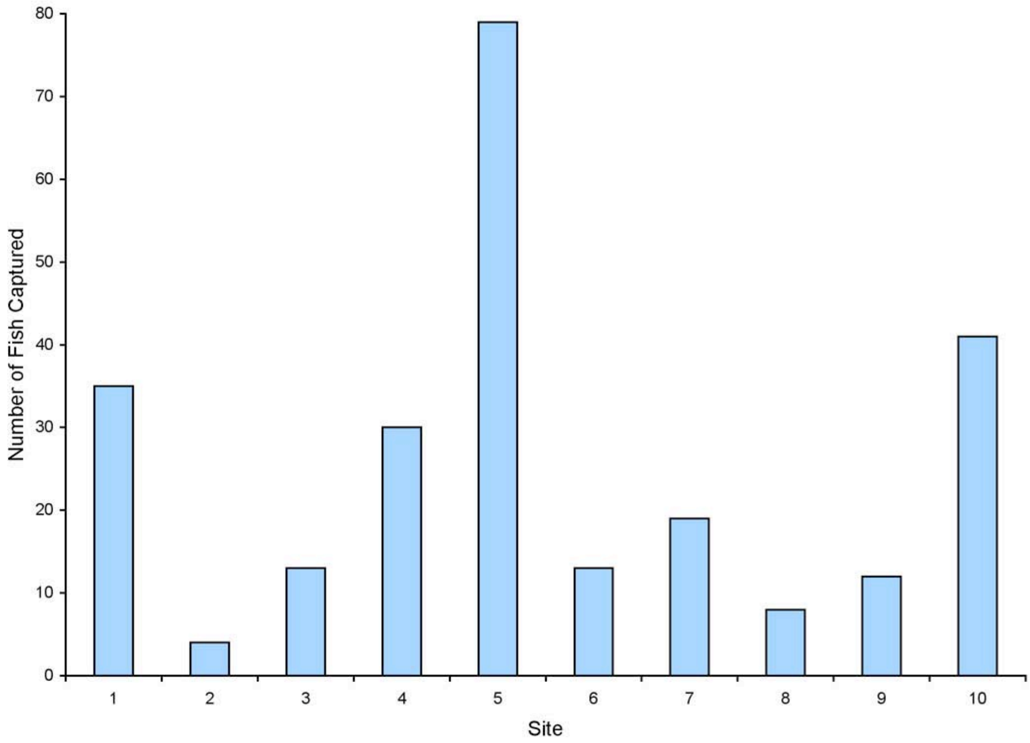


Figure 4.56 Fish abundance at each site in the MLA study area (all survey methods combined).

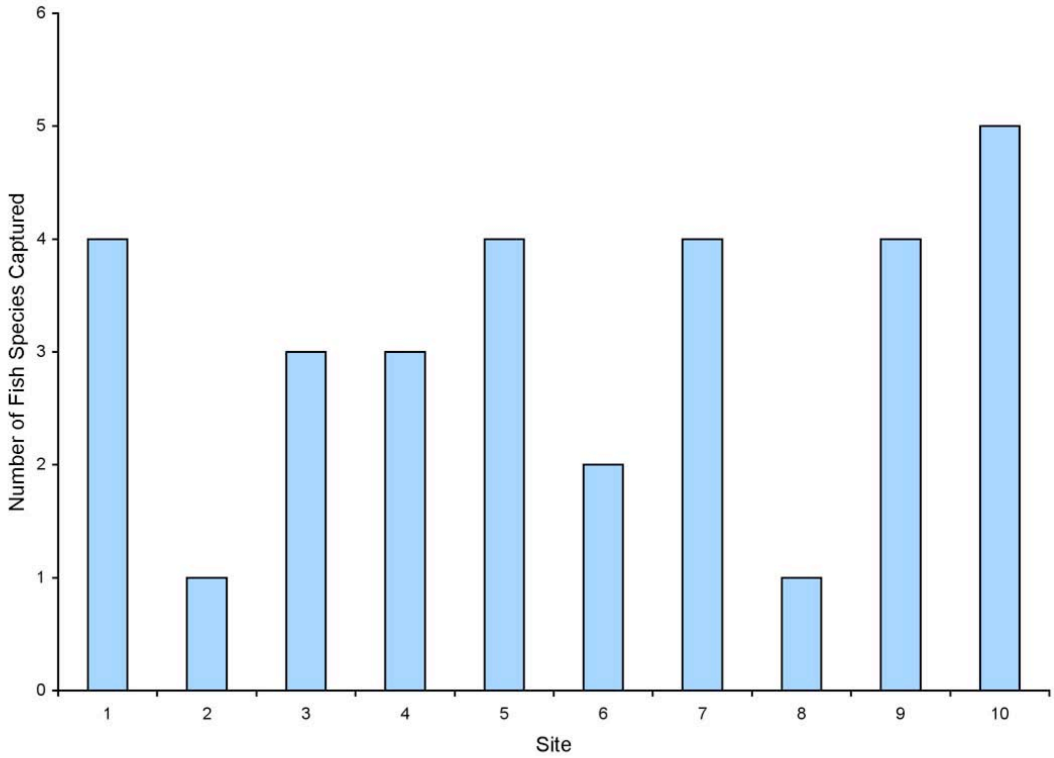


Figure 4.57 Species richness of fish captured at each site in the MLA study area (all survey methods combined).

Figure 4.58

Good riparian cover and large woody debris at site 5 on Mud Creek.

Table 4.5 Abundance of fish species at each site in the MLA study area (all survey methods combined).

Family	Latin Name	Common name	1	2	3	4	5	6	7	8	9	10
Ambassis	*Ambassis agassizii*	Agassiz's glassfish	11		2		50					
Clupeidae	*Nematalosa erebi*	bony bream										15
Eleotridae	*Hypseleotris* sp.	carp gudgeon	4			2	16	7	6			
Eleotridae	*Oxyeleotris lineolata*	sleepy cod										1
Melanotaeniidae	*Melanotaenia splendida*	eastern rainbowfish	1		1		6		3		2	
Percichthyidae	*Macquaria ambigua*	golden perch									3	4
Plotosidae	*Neosilurus hyrtlii*	Hyrtl's tandan				2			1		3	20
Terapontidae	*Leiopotherapon unicolor*	spangled perch	19	4	10	26	7	6	8	8	4	1
		unidentified juvenile							1			

Leiopotherapon unicolor (spangled perch) was the most widely distributed and abundant species, and was captured from every site surveyed (Figure 4.59). *Hypseleotris* sp. (carp gudgeon) was also relatively widely distributed and abundant. *Melanotaenia splendida* (eastern rainbowfish) were common but not very abundant throughout the study area (Figure 4.60). Less common species included *Ambassis agassizii* (Agassiz's glassfish) (Figure 4.61), *Nematalosa erebi* (bony bream), *Oxyeleotris lineolata* (sleepy cod, Figure 4.62), *Macquaria ambigua* (golden perch) and *Neosilurus hystlii* (Hyrtl's tandan). Bony bream, sleepy cod and golden perch were only caught in Juandah Creek downstream of the MLAs.

Figure 4.59

A juvenile spangled perch from Mud Creek (site 5).

Figure 4.60

An intermediate eastern rainbowfish from Juandah Creek (site 7).

Figure 4.61

An adult Agassiz's glassfish at site 3.

Figure 4.62

An adult sleepy cod at site 10.

Life History Stages

All life history stages (juvenile, intermediate and adult) were captured for all species except sleepy cod (one adult was captured at site 10 only). Across the study area, intermediates were the most abundant life stages for most species (bony bream, eastern rainbowfish, golden perch, Hyrtl's tandan and spangled perch); juveniles were the most abundant Agassiz's glassfish life stage; and adults were the most abundant carp gudgeon life stage. The largest species (on average) was bony bream and the smallest species (on average) was Agassiz's glassfish.

Indicators of Stream Health

No introduced species were captured during the survey. No listed threatened species were captured during the survey. Captured spangled perch had lesions at several sites, including sites 1, 6 & 7 (Figure 4.63). This may be due to the fungal disease Epizootic Ulcerative Syndrome (EUS or red spot disease), which affects a range of native fish species in Queensland, as well as the Northern Territory, new South Wales and Western Australia (Humphrey & Pearce 2004), though no testing was done to confirm this as it was beyond the scope of the current study. The factors that cause this disease are unclear (Humphrey & Pearce 2004). All other fishes appeared healthy.

Figure 4.63

At site 6, several spangled perch had lesions.

4.5.2 Gas Supply Pipeline Study Area

In total, 28 fish from four species were captured across the three sites surveyed. Abundance was low, with less than 13 fish caught at each site (Table 4.6).

Two species were captured at each site (Table 4.6). Species richness and abundance at each survey site was depauperate and was likely related to seasonal factors. While appropriate fish habitats was present at each of the sites surveyed, such as woody debris and tree roots, there were only small, drying pools at each of the sites. Fish would not have been able to disperse to these pools since water was flowing in the catchment (before March 2008), and only those species able to remain in the harsh conditions of the drying pools would remain.

Table 4.6 Abundance of fish species at each site surveyed along the gas supply pipeline route (all survey methods combined).

Family	Latin Name	Common name	4a	4b	7
Ambassis	*Ambassis agassizii*	Agassiz's glassfish	1	1	–
Cyprinidae	*Carassius auratus*	goldfish	–	–	10
Eleotridae	*Hypseleotris* sp.	carp gudgeon	–	10	3
Terapontidae	*Leiopotherapon unicolor*	spangled perch	3	–	–

Hypseleotris sp. (carp gudgeon) was the most abundant species throughout the gas supply pipeline study area, and it was captured from two of the three sites surveyed. *Leiopotherapon unicolor* (spangled perch) only caught in the Roche Creek anabranch. *Ambassis agassizii* (Agassiz's glassfish) were rare and captured at only two sites. *Carassius auratus* (goldfish) were only captured in Juandah Creek (site 7), however they were abundant here, particularly given the small size of the pool sampled.

Figure 4.64

An intermediate goldfish from Juandah Creek (site 7).

Life History Stages

Each life history stage (juvenile, intermediate and adult) was captured for carp gudgeons. Across the study area, intermediates were most abundant life stages for most goldfish; and juveniles were the most abundant carp gudgeon and spangled perch life stage. The largest species (on average) was the goldfish and the smallest species (on average) was the carp gudgeon.

Indicators of Stream Health

Goldfish are an introduced species and are listed as non-indigenous under the under the Fisheries Regulation 2008. Goldfish are native to eastern Asia, and they are able to withstand high summer temperatures and low DO levels (Allen et al. 2002). They feed on a varied diet that includes detritus, plant matter and aquatic macro-invertebrates (Allen et al. 2002).

No listed threatened species were captured during the survey.

4.5.3 A Regional and Ecological Perspective

The fish communities of Juandah Creek or other creeks within the MLAs have not been previously sampled. Berghuis & Long (1999) sampled two sites along the upper Dawson River during surveys of the Fitzroy Basin undertaken between 1994 and 1996 (**Error! Reference source not found.**), and caught 775 fish comprising ten species. More recently, a dry season survey of four sites in the upper Dawson River catchment captured 267 fishes, comprising eight species (frc environmental 2007), and a wet season survey of eight sites captured a total of 481 fish across 20 species. The number and species of fish caught during these studies are listed in Table 4.7.

The most abundant fish species captured in the upper Dawson River catchment during these studies were bony bream and eastern rainbowfish (Berghuis & Long 1999). Conversely, spangled perch and glassfish were the most abundant species captured within the study are during the present survey. Bony bream were only caught at the most downstream site in Juandah Creek.

Berghuis & Long (1999) did not report any exotic species in the Dawson Catchment, although they were recorded in the Fitzroy Basin. *Poecilia reticulata* (guppy) was caught from an urban creek near Rockhampton. *Carassius auratus* (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 (present study, Ecowise 2008), and *Gambusia holbrooki* (mosquitofish) have been captured in the Dawson River in November 2007 (frc environmental 2007). Mosquitofish are declared noxious species in Queensland under the Fisheries Regulation 2008.

Table 4.7 Number and species of fish caught in the upper Dawson River catchment during previous studies.

Family *Species*	**Common Name**	**Study**		
		Berguis & Long (1999)	**frc environmental (2007a)**	**Ecowise 2008**
Ambassidae				
Ambassis agassizii	Agassiz's glassfish	52	0	3
Antherinidae				
Craterocephalus stercusmuscarum	fly-specked hardyhead	88	0	2
Clupeidae				
Nematolosa erebi	bony bream	214	196	211
Cyprinidae				
Carassius auratus	goldfish	0	0	5
Eleotridae				
Hypseleotris sp. A	Midgley's gudgeon	89	8	2
Hypseleotris klunzingeri	western carp gudgeon	23	0	20
Mogurnda adsepersa	purple-spotted gudgeon	0	0	8
Oxyeleotris lineolata	sleepy cod	0	4	8
Philypnodon grandiceps	flathead gudgeon	0	0	3
Melanotaeniidae				
Melanotaenia s. splendida	eastern rainbowfish	224	3	26
Osteoglossidae				
Scheropages leichardti	Southern saratoga	0	0	4

Family *Species*	Common Name	Study		
		Berguis & Long (1999)	frc environmental (2007a)	Ecowise 2008
Percichthyidae				
Macquria ambigua oriens	golden perch	16	0	20
Plotosidae				
Neosilurus hyrtlii	Hyrtl's tandan	0	8	22
Porochilus rendahli	Rendahl's catfish	0	0	1
Tandanus tandanus	eel-tailed catfish	6	1	9
Poecillidae				
Gambusia holbrooki	mosquitofish	0	16	32
Pseudomugilidae				
Pseudomugil signifer	pacific blue eye	56	0	0
Terapontidae				
Leiopotherapon unicolor	spangled perch	7	31	76
Scortum hillii	leathery grunter	0	0	13

Fish Movement

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. The water quality of Australian rivers is 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, Table 4.8). Adult golden and spangled perch move upstream to spawn, and juveniles move downstream for dispersal. This movement is typically 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 currently holding these species are connected).

Table 4.8 Timing of critical movements of fish known to inhabit the region (Cotterell 1998).

Family / ***Species***	**Common Name**	**Action**	**Month**											
			J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Anguillidae														
Anguilla reinhardti	Long-finned eel	Migrating												
Clupeidae														
Nematolosa erebi	Bony bream	Migrating												
Eleotridae														
Hypseleotris compressa	Empire gudgeon	Migrating												
Mogurnda adspersa	Purple-spotted gudgeon	Unknown												
Plotosidae														
Neosilurus hyrtlii	Hyrtl's tandan	Migrating and spawning												
Belonidae														
Strongylura krefftii	Long tom	Migrating and possible spawning												
Apogonidae														
Glossamia aprion	Mouth almighty	Unknown	-	-	-	-	-	-	-	-	-	-	-	-
Melanotaeniidae														
Melanotaeniidae	Rainbowfish	Unknown	-	-	-	-	-	-	-	-	-	-	-	-

Family *Species*	Common Name	Action	Month											
			J	F	M	A	M	J	J	A	S	O	N	D
Osteoglossidae														
Scleropages leichardti	Southern saratoga	Unknown	-	-	-	-	-	-	-	-	-	-	-	-
Terapontidae														
Leiopotherapon unicolor	Spangled perch / grunter	Spawn – all habitats												

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 in-stream habitat to provide shelter or suitable spawning habitat. A variety of physical aquatic habitat such as woody debris and substrate diversity also support diverse macro-invertebrate communities, which are prey to many of the fish found in the study area.

Spangled Perch

Spangled perch are Australia's most widespread native fish, being abundant within most habitats (Allen et al 2002). They can tolerate wide ranges of temperature (5 – 44 °C), salinity (0 –34 ppt) and pH (4 – 10.2). 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). As an adaptation to living in quick-drying waterholes, spangled perch eggs hatch in 2 days and the larvae develop in 24 days (Ivanstoff & Crowley 1996, Allen et al 2002). Spangled perch are likely to persist in the creeks within the study areas throughout the year; they were sampled in both March and August 2008.

Agassiz's Glassfish

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 2003). 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). The diet of this species consists largely of small crustaceans and insect adults and larvae, including mosquitos (McDowall

1996). This species deposits and fertilises demersal eggs on aquatic vegetation (Merrick & Schmida 1984). The Agassiz's glassfish was relatively common across the study areas. However, these creeks are unlikely to provide a regionally important breeding habitat due to the lack of aquatic vegetation (although terrestrial grasses on the edge of the creeks may provide some suitable substrate for the deposition of eggs).

Carp Gudgeons

Carp gudgeons (*Hypseleotris* spp.) are common in coastal drainage basins of eastern Australia, from the northern section of the Murray-Darling Basin to Tully in north Queensland. This species is commonly confused with *Hypseleotris galii* (firetail gudgeon), especially as a juvenile; ecologically, the two species are probably very similar (Pusey et al 2004). Firetail gudgeons are usually found in open water, around aquatic plants in streams, ponds, swamps and drains (Allen et al 2002). 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 2003). These species are quite tolerant to changes in water quality, and under ideal conditions can rapidly increase in numbers (Merrick & Schmida 1984). This species was relatively abundant during the surveys of the MLA and gas supply pipeline study areas.

Hyrtl's Tandan

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). The present study captured the majority of specimens at the largest waterway surveyed (Juandah Creek, downstream of the MLAs), and it is likely that they would inhabit large pools in this creek throughout the year.

Bony Bream

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 conditions 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 – 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 at the largest waterway surveyed during surveys of the MLA and gas supply pipeline study areas (at Juandah Creek, downstream of the MLAs); they were not found in small ephemeral pools that characterise the waterways of the MLAs or the gas supply pipeline route.

Eastern Rainbowfish

The eastern rainbowfish is the common rainbowfish of many parts of north-eastern and central Australia, and is usually abundant wherever it occurs (Allen et al 2002). This species spawns all year round, although spawning peaks immediately before and during flood periods (Merrick & Schmida 1984). Surveys of the MLA study area captured eastern rainbowfish at the majority of sites; however, the creeks of the MLAs are unlikely to provide suitable breeding habitat because spawning tends to occur in slow-flowing, weedy areas (Merrick & Schmida 1984). Eastern rainbowfish were not found in the creeks along the gas supply pipeline route.

Golden Perch

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 (Midgely 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 recorded in Junadah Creek, downstream of the MLAs (site 10) during the post-wet season survey; although they are unlikely to be common in the smaller, isolated pools that characterise the waterways of the MLAs or the gas supply pipeline route.

Sleepy Cod

Sleepy cod are common and widespread in northern Australia between 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). Spawning usually occurs 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). The present study captured the majority of specimens at the largest waterway surveyed (Juandah Creek, downstream of the MLAs), and it is likely that this species would persist in this pool throughout the year.

Most of the species that were captured from the study area can tolerate a large range of water quality conditions (Table 4.9). The common fish species in the study area (spangled perch, glassfish, Midgley's carp gudgeons and eastern rainbowfish) are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table 4.9).

Table 4.9 Reported water quality tolerances of fish species captured 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
Clupeidae	*Nematolosa erebi*[C]	bony bream	15 – 31	4.0 – 12.0	6.7 – 8.5	50 – 780	0.3 – 20 but up to 600 (frc pers obs)
Eleotridae	*Hypseleotris* spp.[A]	carp gudgeons	8.4 - 31.2	0.3-19.5	4.4-8.9	51-4123	0.1-331.4
	Oxyeleotris lineolata[B]	sleepy cod	20.6 - 32	4.6-11	7-9.2	81-650	1 - 22 but up to 600 (frc pers obs)
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 (frc pers obs)
Plotosidae	*Neosilurus hyrtlii*[C]	Hyrtl's tandan	21 - 33	2.6-11.0	6.7-8.5	56-790	0.25 - 16, but up to 600 (frc pers obs)
Terapontidae	*Leiopotherapon unicolor*	spangled perch	5 – 41	≥ 0.4	4 – 8.6	0.2 – 35.5 ppt salinity	1.5 – 260
	Macquaria ambigua oriens[D]	golden perch	24 – 31	3.6 – 10.0	7.2 – 8.8	NA	4 – 40 cm secchi depth

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

4.6 Turtle Communities

4.6.1 MLA and Gas Pipeline Study Areas

Across the MLA study area, turtle traps were set at six of the ten sites (sites 1, 3, 6, 7, 8 and 10). Turtle traps could not be set at the other sites within the MLAs and along the gas supply pipeline route, due to insufficient water depths. Only one species of turtle was captured or observed throughout the study areas, and this was at one site only. Seven *Emydura macquarii krefftii*[3] (Krefft's river turtle) were captured in Juandah Creek, downstream of the MLAs (MLA site 10): two adults, one intermediate (Figure 4.65) and four juveniles (Figure 4.66). Juveniles were the most abundant life history stage, although no obvious turtle nesting banks were observed at this site, or across the study areas.

Figure 4.65

An intermediate Krefft's river turtle at site 10.

Figure 4.66

A juvenile Krefft's river turtle at site 10.

[3] 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).

4.6.2 A Regional and Ecological Perspective

Only Krefft's river turtle were captured from the MLA study area. Similarly, only Krefft's river turtles were caught from two sites during a recent survey of the upper Dawson River catchment (frc environmental 2007). During the frc environmental (2007) survey, adult turtles were more abundant than intermediate or juveniles. Krefft's river turtle inhabits rivers, creeks and lagoons through eastern Queensland from just north of Brisbane to Princess Charlotte Bay (Wilson & Swan 2008). Turtles from the *Emydura* genus are omnivorous, feeding on macrophytes, invertebrates, small vertebrates and carrion (Wilson & Swan 2008). They are often observed basking on protruding rocks or logs (Wilson & Swan 2008).

Other freshwater turtle species may occur in the Dawson Catchment, such as the eastern snake-necked turtle (*Chelodina longicollis*), and the saw-shelled turtle (*Elseya latisternum*) (Cogger 1996); with the eastern snake-necked turtle having been recorded from within 20 km of the MLAs (EPA 2007b). However, these turtles are only likely to inhabit larger waterways (Cogger 1996) and are unlikely to be abundant in the ephemeral creeks of the MLAs or along the gas supply pipeline.

Fitzroy River turtles (*Rheodytes leukops*) were first described in 1980 (Legler & Cann 1980). This species is only found in the Fitzroy River and its tributaries, in central Queensland. This species is listed as 'vulnerable' under the Queensland *Nature Conservation Act 1992* (NCA); the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and the International *IUCN Red List of Threatened Species 2007* (IUCN 2007).

Fitzroy River turtles were not captured during either field survey. The 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 found in shallow, fast-flowing riffle zone habitats characterised by well-oxygenated water (Cann 1998, Tucker et al. 2001). Female Fitzroy River turtles nest on sandy banks with a deep layer of sand and a low vegetative cover. Nests are typically laid in deep chambers (up to 170 mm) situated from 1 – 4 m above the water level, and have been observed up to 15 m back from the waters edge (Cogger et al. 1993, Cann 1998).

No fast-flowing habitats or turtle nesting banks were observed during surveys of the MLA and gas supply pipeline study areas. Due to a lack of suitable habitat, the Fitzroy River turtle is unlikely to occur within the study areas. However, this species may be present downstream of the Project location, in the upper Dawson River, as it has previously been recorded in the river (EPA 2007b).

4.7 Other Aquatic Vertebrates

4.7.1 MLA and Gas Supply Pipeline Study Areas

Our survey did not target other aquatic vertebrates. A semi-aquatic keelback snake (*Tropidonophis mairii*) was caught in the set net at Juandah Creek, downstream of the MLAs (MLA site 10) (Figure 4.67). An unidentified snake was also observed crossing the creek at Spring Creek (MLA site 6).

Figure 4.67

A semi-aquatic keelback snake at site 10.

No conservationally significant aquatic amphibians or reptiles have been recorded from, or are likely to occur in, the study area (DEW 2007a; EPA 2007b).

Keelback snakes are Australia's only semi-aquatic snake (EPA 2006). Keelback snakes are a small, non-venomous species of snake that reach a length of 1 m, but are generally about 50 cm long (EPA 2006). They are found in northern Australia from the Northern River region of New South Wales to the Kimberleys on the west coast (EPA 2006, Wilson & Swan 2008). They prefer well-watered habitats such as near creeks and swamps and are usually found in or near water (Wilson & Swan 2008). Keelbacks feed on frogs, tadpoles, lizards and fish, and are one of the few native animals able to prey on the poisonous *Bufo marinus* (cane toad) (Wilson & Swan 2008). They hide under plants, woody debris or in empty burrows when they are stationary (EPA 2006).

4.8 Summary of Aquatic Biological Values

The biological values of aquatic ecosystems within the study areas are relatively low and consistent with those of the wider catchment. Environmental values are dictated primarily by the ephemeral and intermittent nature of the region's waterways; although agricultural development within the region has significantly influenced water quality and the physical characteristics of aquatic habitat (Telfer 1995). Degraded creeks in the catchment are characterised by riparian vegetation loss, erosion, invasion of weed species, poor water quality and sedimentation (Telfer 1995); all features of the creeks within the MLAs and along the gas supply pipeline route (refer Attachment A).

Water quality is generally poor and is characterised by high turbidity and variable dissolved oxygen levels, which are typical of the region. Biodiversity is relatively low, with only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabiting the study areas. Nevertheless, the creeks within the MLAs and along the gas supply pipeline route do provide 'upstream' dispersal habitat for the fish species that were recorded in the study area (and possibly breeding habitat for some species). Therefore, macro-invertebrate and fish communities found within the MLAs are likely to contribute to the success of downstream populations through movement/migration.

No rare or threatened species of aquatic flora or fauna have been recorded from, or are likely to occur in, the waterways of the study areas.

5 Description of Proposed Development

5.1 General Description

The coal resources of the Project will be developed by open-cut mining and associated infrastructure, including a proposed gas supply pipeline from the existing Peat-Scotia Gas Line. Construction and mining activities have the potential to impact on aquatic ecology, through activities including:

- the operation of mining equipment and vehicles, and other plant and equipment
- vegetation clearing and earth moving
- discharge of wastewater
- management of stormwater runoff
- creation of dams
- construction of creek crossings
- stream diversions, and
- the loss of catchment area.

5.2 Operation and Maintenance of Vehicles and Other Equipment

5.2.1 Fuel Spills

Various vehicles and equipment will be used in the construction and operation phases of the Project. Vehicles and plant will be diesel operated, and may use substances such as hydraulic fluid and lubricating fluids, which each pose a potential threat to aquatic ecology if spilt.

Vehicle maintenance facilities, including fuel storage facilities, will be located within the mine infrastructure area (MIA), which is located adjacent to Woleebee Creek, above the Q100 flood inundation line. Waste oils and oil sludges from vehicles and plant will be collected into waste storage tanks, and removed from the site by a registered recycling contractor. Diesel and oils will be stored in accordance with AS1940 (2004) either in self-bunded tanks or within bunded areas, with a dirty water sump and drain directing dirty water from these areas to an environmental dam.

Three relocatable, self-bunded diesel fuel tanks will be used for in-field fuel facilities.

5.2.2 Maintenance of Vehicles and Equipment

Washdown facilities for both heavy and light vehicles will be provided in the MIA. Vehicle washdown water, which may contain traces of fuels and lubricants, will be collected in environmental dams. Batteries will be stored in a central bunded facility and collected and disposed of by a registered contractor. Tyres will be disposed of by burial in the mine overburden.

5.3 Vegetation Clearing and Earth Moving

5.3.1 MLAs

Vegetation clearing and earth moving will be required in association with construction of mine infrastructure, including:

- accommodation facilities
- the mine infrastructure area (MIA), which includes the Coal Handling and Processing Plant (CHPP) (approximately 23.4 ha)
- a gas fired power station near the northern boundary of the MLAs, adjacent to the Q100 flood inundation area of Woleebee Creek
- waste disposal facilities
- an explosives magazine
- a possible airstrip
- haul roads (30 m wide)
- mine access roads (including a 7.2 m wide site access road, a 6 m wide light vehicle access road and a 10 m wide heavy vehicle access road which will not cross any waterways)
- realignment of local government roads
- construction of pits
- construction of the Main, Mud Creek, and Summer Hill ROM coal dumps
- conveyors to link the three ROM coal dumps to the CPP
- a rail spur linking the CHPP to the proposed Surat Basin Rail main line, and
- construction of creek diversions.

5.3.2 Gas Supply Pipeline

The gas supply pipeline will be approximately 25 km in length. The pipeline will generally be located underground with 0.7 m depth cover (or greater subject to risk assessment) and constructed through a trench and backfill method, with vegetation clearing required along the pipeline corridor. It is expected that the actual pipeline and access track will likely only have a construction footprint of 10 to 20 m width, however, a pipeline corridor width of 50 m has been adopted for this impact assessment.

5.4 Wastewater and Stormwater

5.4.1 Stormwater

An overburden runoff management system will be constructed to capture stormwater runoff from areas disturbed by mining activities. This system will evolve with the mine development. By Year 30, it will comprise thirty-two sediment dams mostly located on or adjacent to small (first order) tributaries. Where they are located adjacent to the larger waterways of Woleebee, Frank and Juandah creeks (including diversions of these creeks), their outlets will be located above the 1% AEP flood inundation line.

Seven environmental dams will be constructed during the project life to capture water pumped from the mine pits and runoff the dump areas, the MIA and CHPP. These environmental dams are located on or adjacent to small (first order) tributaries. Where they are located adjacent to the larger waterways of Woleebee, Frank and Juandah creeks (including diversions of these creeks), their spillways will be located above the 1% AEP flood inundation line.

5.4.2 Industrial Wastewater

Three tailings dams will be constructed to capture wastewater from the CHPP over the 30 years of the mine lease, which will be recycled in a closed-loop system. Industrial wastewater from the MIA will be treated, if required, on the mine lease and discharged to the tailings dam.

5.4.3 Domestic Wastewater

Domestic effluent from the accommodation facilities, and administration and office buildings will be piped to the Wandoan Wastewater Treatment Plant (WWTP) for treatment, however the reuse of grey water on-site will be investigated as part of the detailed design.

5.5 Water Supply

Potable water requirements will be obtained by extending the potable water system from the township of Wandoan. This will require an upgrade of the water treatment facility in Wandoan, and a pipeline to the accommodation facilities and MIA, although water will be carted to site during the first six months of construction. The potable water requirements of the mine will not exceed the current Great Artesian Basin (GAB) allocation for the Wandoan Town Water Supply.

Industrial water ('raw' water) and fire water will be sourced from underground bores in the Township of Wandoan or in the MLAs during the construction phase. Water sources for the operation phase of the Project are currently being investigated, and include the potential use of coal seam gas water (supplied by a pipeline, refer to Volumes 2 & 3 of the EIS), or water from the raising of Glebe Weir (supplied by a pipeline, currently being investigated by SunWater). Raw water will be stored in a raw water dam near the MIA, which is located adjacent to the Q100 flood level of Woleebee Creek.

5.6 Loss of Catchment Area and Construction of Creek Diversions

By Year 30 of the project, the growth of the mine will result in runoff from approximately 8,500 ha of catchment area being captured in the site water management system for reuse. Combined with changes to the catchment runoff characteristics, this will reduce flows to some creeks that currently drain the MLAs. Based on water balance modelling, the reduction in mean annual runoff from the MLAs is expected to be a maximum in Year 30 of between 9% and 38% (or between 2% and 7% of Juandah Creek streamflow at Windamere).

Digging of pits will also result in the loss of some minor waterways, with higher order creeks being diverted. Again, this has the potential to negatively impact on riparian and aquatic habitat diversity and biodiversity both on-site and downstream.

The diversion of creeks around the pits will ensure that the waters of the creeks avoid disturbed areas, and maintain downstream flows as much as possible. The diversions will, however, result in the replacement of the existing natural ephemeral watercourses with artificial channels. At this stage, six creek diversions are proposed:

- a 2,500 m diversion of Spring Creek, commencing construction in Year 9
- a 970 m diversion of an unnamed tributary of Spring Creek, commencing construction in Year 9
- a 9,100 m diversion of Woleebee Creek, which will also carry water from Wandoan Creek and Blackant Creek, commencing construction in Year 10
- a 5,400 m diversion of an un-named tributary to Woleebee Creek (at the east of the proposed Mud Creek pit on MLA 50229) commencing construction in Year 14
- a 2,900 m diversion of Frank Creek, commencing construction in Year 15, proposed in two stages
- a diversion of Mud Creek, commencing construction in Year 17, and
- a diversion of Mt Organ Creek, commencing construction in Year 18.

5.7 Creek Crossings

5.7.1 Road, Conveyor and Rail Crossings

Road, conveyor and rail crossings of creeks are proposed within the MLAs. Specifically, the proposed conveyor lines cross:

- Mud Creek
- Woleebee Creek (downstream of the proposed diversion) and
- Up to six minor tributaries (first order streams).

The proposed haul roads and access roads cross:

- Frank Creek (upstream of the proposed diversion)
- Frank Creek (in the vicinity of the downstream end of the proposed diversion)
- Woleebee Creek (prior to the diversion being constructed)
- Mud Creek (downstream of the proposed diversion)
- Spring Creek (downstream of the proposed diversion), and
- Up to 15 minor tributaries (first order streams).

The proposed rail spur crosses:

- Frank Creek (in the vicinity of the downstream end of the proposed diversion) and
- Up to three minor tributaries of Frank Creek (first order streams).

5.7.2 Gas Supply Pipeline

The proposed gas supply pipeline route crosses:

- The headwaters of Stakeyard Creek, and a minor tributary (first order stream) of this creek
- Roche Creek, and four minor tributaries (first order streams) of this creek, and
- Juandah Creek and two minor tributaries (first order streams) of this creek.

6 Potential Impacts

6.1 Operation and Maintenance of Vehicles and Other Equipment

6.1.1 Fuel Spills

Fuels and oils required for the operation of construction and mining machinery only present a risk to aquatic ecology if spills enter watercourses. Both diesel and petrol are toxic to aquatic flora and fauna at relatively low concentrations.

Spilt diesel 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.

The risk to aquatic ecology from a fuel spill within the MIA is likely to be very low, due to high level of control demanded by AS 1940(2004) (Storage and handling of combustible liquids), and the drainage of refuelling and maintenance areas into environmental dams. Spilt fuel is most likely to enter the creeks via an accidental spill on the roads near creek crossings; or when there are construction activities adjacent to creeks. Roads cross the major creeks in the area, including Frank Creek, Woleebee Creek, Mud Creek and Spring Creek, along with their tributaries. A significant fuel spill to any of these creeks (in the order of tens or hundreds of litres) 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.

Implementation of best practicable practice fuel management will effectively address this risk (refer Section 7.1). Additionally, the risk to aquatic flora and fauna in the MLAs is reduced as the creeks are dry or isolated pools for much of the year, and therefore many spills could be effectively cleaned up before they can disperse throughout the waterways.

6.1.2 Maintenance of Vehicles And Equipment

Litter and waste associated with vehicle maintenance also has the potential entangle larger fauna, and contribute to the degradation of water quality. However, due to the controls in place, such as bunded storage areas and water drainage to environmental dams, the risk to aquatic ecology from spilt litter and waste from the MIA is likely to be very low.

6.2 Vegetation Clearing and Earth Moving

There is a high potential for soil erosion and sedimentation following vegetation clearing and earth moving, due to the erosive nature of the soils on site, as discussed in Chapter 9 Geology, Mineral Resources, Overburden & Soils and the associated technical report.

6.2.1 Construction Activities and Timing

Construction Years -2 and -1, and Operational Years 1 to 5

Within the construction phase and first five years of operations, construction of access roads, haul roads, the rail spur and the conveyor will pose the greatest threat to aquatic ecology, as these features cross the major waterways of the MLAs (Frank Creek and Woleebee Creek), and will require vegetation clearing and earth movement in the riparian zones. Construction of levee banks along Frank Creek will also be in close proximity of the creek. These activities could lead to impacts on aquatic ecology via increased turbidity and nutrient levels in these waterways, as well as alteration of aquatic habitats (the potential for an impact from each of these factors is discussed in further detail below in Sections 6.2.2 to 6.2.4).

Where an appropriate erosion and sediment control plan is followed (refer to Section 7.2), vegetation clearing and earth moving associated with construction of the accommodation facilities, power station, MIA, pits and dumps during this period is unlikely to pose a significant threat to aquatic ecology, as these features are situated away from the main creeks, and protection measures such as levee banks (where the pit is at the Q100 flood level) and sediment or environmental dams will be constructed.

Years 5 to 10

During this period, development of the Frank Creek, Austinvale, Woleebee, Mud Creek and Summer Hill pits will continue, and the Spring Creek diversion will be constructed. Appropriate numbers of sediment, environmental and tailings dams will be constructed to capture runoff from these areas. Where an appropriate erosion and sediment control plan is followed during clearing (refer to Section 7.2), vegetation clearing and earth moving during this period is unlikely to pose a significant threat to aquatic ecology. Impacts of the proposed diversions are discussed specifically in Section 6.6.

Years 10 to 20

Major activities during this period include expansion of the pits (including construction of further levee banks along Frank Creek), use of the Austinvale pit as a rejects disposal area, and construction of the Frank, Woleebee, Mud / Mt Organ and Unnamed Creek diversions. Where an appropriate erosion and sediment control plan is followed during clearing (refer to Section 7.2), vegetation clearing and earth moving associated with expansion of the pits is unlikely to pose a significant threat to aquatic ecology.

However, construction of levee banks adjacent to Frank Creek, and earthworks in association with the creek diversions (particularly the Woleebee Creek diversion, which will require earth moving in Blackant and Wandoan Creeks before the diversion is opened), could lead to impacts on aquatic ecology via increased turbidity and nutrient levels in these waterways, as well as alteration of aquatic habitats (the potential for an impact from each of these factors is discussed in further detail below in Sections 6.2.2 to 6.2.4).

Impacts of the proposed diversions are discussed specifically in Section 6.6.

Years 20 to 30

Major activities during this period include further expansion of the pits. Where an appropriate erosion and sediment control plan is followed during clearing (refer to Section 7.2), vegetation clearing and earth moving associated with expansion of the pits is unlikely to pose a significant threat to aquatic ecology.

6.2.2 Increased Turbidity

Vegetation clearing and/or sediment disturbance can increase sediment runoff into creeks and elevate turbidity, within creeks of the MLAs and along the gas supply pipeline route, and also within downstream waterways. Increased turbidity may impact on fishes and macro-invertebrates 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).

However, at the time of survey, waterways within the study area were generally highly turbid, and substrates were generally dominated by silt. No submerged macrophytes were found in the study areas during our surveys, and few have been found in the catchment (Telfer 1995). Faunal communities of the study area are adapted to living in turbid water. Given these background conditions, small increases in turbidity would be unlikely to have a significant impact on aquatic ecology; however significant increases in turbidity could have an impact upon some species. Refer to Section 7.3 for a discussion of appropriate Water Quality Objectives.

6.2.3 Input of Nutrients or Contaminants

Aquatic biota could also be impacted by nutrients or contaminants washed into the waterways with the sediment, e.g. nutrients from fertilisers. Nutrient inputs can lead to algal or macrophyte blooms, which produce high levels of dissolved oxygen (DO) in the water when photosynthesising during the day. However, at night when the algae can't photosynthesise, they consume oxygen due to respiration. This can cause DO to be reduced to very low levels, which are harmful to fish and biota, during the night.

Nutrient-laden runoff is likely to be low compared to agricultural practices, as fertilisers will only be used in association with rehabilitation and revegetation of disturbed areas. 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. Nevertheless, best practicable practice erosion and sediment control, and stormwater runoff management plans should be implemented to minimise the likelihood of Project-related nutrient-laden runoff (refer Section 7.2).

6.2.4 Alteration of Aquatic Habitat

The deposition of fine sediments has the potential to decrease stream bed roughness and completely fill in existing pools. Within the minor (first order) tributaries throughout the MLAs, this would be unlikely to have a significant impact, as these streams appear to only carry flood flows, and they do not generally hold water. However, in larger watercourses (second order and higher) such as Spring Creek, Mud Creek, Wandoan Creek, Woleebee Creek and Frank Creek, sediment deposition would lead to a decline in habitat diversity and a reduction in the number of pools available as 'refuge' habitat in the dry season. These impacts would lead to a decline in the abundance and diversity of both invertebrate and fish communities in the creeks.

6.3 Wastewater and Stormwater

A Water Management System (WMS) will be developed for the Project, which will be designed to achieve a 'no planned' mine water discharge from the mine site.

6.3.1 Stormwater

Overflow of the sediment dams, or dam failure, has the potential to allow sediments, nutrients and contaminants to enter the creeks of the MLAs and downstream waters. However, the WMS will be designed to divert clean water around disturbed areas and dirty water into sediment dams. Sediment will be allowed to settle out from the water column in these dams before the water is discharged to the environment through a low level pipe outlet if the water is of acceptable quality.

Release of water of an acceptable quality (acceptable water quality to protect native fish fauna in the MLAs is presented in Table 7.1) would not be expected to have a negative impact on aquatic ecology. The impact of small flows in the wet season would not have a discernable impact given the magnitude and frequency of natural flows. Release in the dry season may result in the creation of additional on-stream pools providing 'refuge habitat', and may also trigger fish movement and possibly spawning in the creeks. This may result in an overall increase in fish abundance and diversity throughout the MLAs. Timing of discharge to coincide with natural flows may help to mitigate the impacts of a loss of catchment area and streams, due to the construction of pits (refer to Section 7.3).

Sediment dams will be designed to remove coarse sediment in accordance with the Technical Guidelines recommendations for discharge of uncontaminated water to non-environmentally sensitive receiving waters. Low-level outlets will be sized to ensure retention times are sufficient to ensure the turbidity of overflowing water will not significantly influence the character of receiving waters (which would be naturally highly turbid during a flow event). The dams will discharge via the spillway only following significant rainfall that exceeds the design storage capacity (dams will retain runoff from a 10 year ARI time of concentration storm).

6.3.2 Industrial Wastewater

Environmental dams will be sized to ensure the risk of discharge is small. Water balance modelling indicates the preliminary capacities would results in no discharges under historical climate extremes. As the contributing catchments to these dams are small, the size of any discharge would be small compared with flows in the receiving waters. Minor spills from environmental dams AU-E1, W-E2, MC-E2, SH-E3 and WS-E1 would not be expected to have a large impact on aquatic ecology, as these dams are situated away from major creeks, and as the volume of the overflow would be reduced by infiltration before the water reached any major creek lines. However, the tailings dams and environmental dams AU-E2 and AU-E4 (and the raw water dam) are in close proximity to Woleebee Creek. A spill from these dams would be expected to have localised impact on the aquatic flora and fauna of this creek, and potentially some nearby reaches of Juandah Creek downstream. However, the flora and fauna of downstream waters including the Dawson River are unlikely to be impacted given the associated dilution and dispersion.

The overall level of risk to aquatic ecology from the overflow of these dams is low, as these dams will be designed in accordance with DNRW and EPA guidelines. Water used in coal preparation will be recycled in a closed-loop system and will not be discharged into the natural environment. Water from the environmental dams is not intended to be discharged to natural waterways, and will be used for dust suppression and in the CHPP.

6.3.3 Domestic Wastewater

Unplanned discharges and spills of domestic effluent prior to treatment at the Wandoan WWTP have the potential to introduce nutrient-rich discharge into the natural receiving environment. Sewage has the potential to be accidentally discharged to either Woleebee, Frank or Juandah Creeks at the two proposed pump stations.

Nutrient inputs due to accidental sewage discharge can lead to algal or macrophyte blooms, which produce high levels of dissolved oxygen (DO) in the water when photosynthesising during the day. However, at night when the algae can't photosynthesise, they consume oxygen due to respiration. This can cause DO to be reduced to very low levels, which are harmful to fish and biota, during the night. However, within the study area, the highly turbid water of the creeks is likely to prevent significant algae blooms for much of the year. The impacts of nutrient enrichment and any algal blooms due to a sewage spill would also be likely to be short-lived and not widespread. Impacted floral and faunal communities are expected to rapidly recover.

The Wandoan WWTP will be upgraded as a part of the Project, with some treated sewage used to irrigate adjacent areas. No impacts of increased sewage processing at the Wandoan WWTP to aquatic ecology are expected.

6.4 Water Supply

6.4.1 From GAB Water

Potable water requirements will be met by extending the potable water system from the township of Wandoan. The potable water requirements of the mine will not exceed the current Great Artesian Basin (GAB) allocation for the Wandoan Town Water Supply. There will be a short-term impact to aquatic ecology where water supply pipelines are installed across creeks. Where construction of the potable water pipeline from Wandoan follows the recommendations for pipeline constructions and creek crossing presented in relation to the gas supply pipeline in Section 7.7.4, no long-term impacts to surface waters are expected from the use of GAB water for potable purposes. Assessment of impacts to groundwater (and associated stygofauna) is beyond the scope of this study.

6.4.2 From the Glebe Weir on the Dawson River

No exotic species were recorded from within the MLAs. However, water supply from the Dawson River, and the creation of pools of permanent water on the site (in the form of dams), may significantly increase the opportunity for exotic species to become established within the study area. *Gambusia holbrooki* (mosquitofish) and *Carassius auratus* (common goldfish) have been captured in the Dawson River (frc environmental 2007, Ecowise 2008), and goldfish were captured in Juandah Creek (upstream of the MLAs) during the present survey of the gas supply pipeline study area. Exotic *Poecilia reticulata* (guppy) have also been recorded in the Fitzroy Basin (Berghuis & Long 1999). Exotic species can negatively impact on native aquatic ecosystems by out-competing native species for limited resources such as food and habitat.

6.4.3 From Coal Seam Methane By-Product Water

Overall, the CSM by-product water is expected to be high in total dissolved solids (TDS) compared with the TDS concentration in the natural waterways. If water supplied from the southern CSM pipeline enters the creeks crossed by the pipelines or within the MLAs, it may impact on aquatic ecology.

However, coal seam methane by-product water may be sourced from the Condamine Power Station, in the Condamine catchment. The declared noxious fish carp (*Cyprinus carpio*) is known from this catchment, and therefore the use of this water theoretically poses a significant threat for carp to be transferred to the waterways of the MLAs, and thus the Fitzroy Basin, where they do not currently occur. It is highly unlikely that carp would be present in the stored by-product water, however Volume 2 of the EIS provides a description of the risk of transfer of carp, and recommended mitigation measures.

6.4.4 Discharge from the Raw Water Dam

The raw water dam would only be expected to overflow during periods of significant rainfall. Accidental discharge from the raw water dam would flow to Woleebee Creek. Water quality in the raw water dam is expected to be similar to that of the study area if water is sourced from the Dawson River, but high in TDS if sourced from CSM by-product water. However, if this water were discharged during a rainfall event, the TDS concentrations would be expected to dilute quickly. Therefore, discharge from the raw water dam would not be expected to have a discernable impact on aquatic ecology.

6.5 Loss of Catchment Area

The direction of around 8,500 ha of upper catchment area to the site water management system is unlikely to have a regionally significant impact, as there are over 868,000 ha of similar catchment area within the Southern Tributaries Sub-catchment of the Dawson River alone. Locally, a reduction in flows to the creeks has the potential to impact on flushing in the creeks, and cues for faunal migration and reproduction. This could have an impact on the abundance and diversity of macrophytes, and macro-invertebrate and fish populations within the creeks of the MLAs. However, this would not be expected to have an impact on the aquatic communities of Juandah Creek or waterways further downstream, such as the Dawson River.

6.6 Creek Diversions

The creek diversions will result in the loss of at least 20 km of natural ephemeral watercourse, including reaches of Spring, Mt Organ, Mud, Woleebee and Frank Creeks and an un-named tributary of Juandah Creek. Levee banks will be constructed between creek diversions and the mining areas where required, to maintain separation of clean (natural) waters and 'dirty' (mine) waters during flood events. Creek diversions will be constructed in accordance with the DNRW Central West Regional Office guideline document *Watercourse Diversions – Central Queensland Mining Industry*. Creek diversions will be constructed three years prior to opening them to flows, to allow sufficient time for vegetation to establish in the new channels as this will contribute to erosion control.

As there are 2,258 km of essentially similar natural waterways within the Southern Tributaries Sub-catchment of the Dawson River (Telfer 1995), the proposed diversions are unlikely to have a regionally significant impact on the abundance of aquatic flora and fauna, on the diversity of aquatic communities, or on aquatic ecosystems functioning.

The aquatic flora and fauna that inhabit each of the creeks to be diverted are generally tolerant of a range of habitat and water quality. If the diversion channels are well engineered to maintain fish passage and replicate the aquatic habitat found in the natural creeks (refer to Section 7.6), the loss of natural ephemeral watercourse is highly unlikely to result in the loss (even locally) of any species of aquatic flora or fauna.

The construction of the diversion channels will require clearing and disturbance, which provides the potential for increased soil erosion and sedimentation (the impacts of which have been discussed in Sections 6.2.2 to 6.2.4). Therefore, there is a high potential for adverse effects resulting from soil erosion and sedimentation from these areas of disturbance, leading to high turbidity in the diversion channels and natural creeks downstream. Refer to Section 7.2 for appropriate mitigation measures.

Diversion of flows from the existing channels to the completed diversion channels may leave fish and other fauna such as turtles stranded. These fauna will perish unless they are relocated. Refer to Section 7.5 for relocation techniques.

6.7 Creek Crossings

6.7.1 Construction of Creek Crossings

Construction of new permanent and temporary crossings may disturb sediments, leading to increases in localised turbidity and sediment deposition. When construction is carried out during the dry season, these impacts will be minimal or absent, although a highly localised loss of aestivating crustaceans may be expected within the construction footprint. The impacts of disturbance to habitat will be highly localised and are considered acceptable in both a local and regional context, given the existing disturbed nature of the creeks.

When construction of creek crossings is carried out in the wet season, there will be a temporary impact to fish passage during construction activities. Impacts to water quality will not be significant in a local or regional context if appropriate erosion and sediment control measures are in place (refer to Section 7.7.1).

6.7.2 Obstruction of Fish Passage

Stream crossings can create waterway barriers that prevent or impede movements of aquatic fauna such as fishes and turtles. Within the MLAs, there are some examples of existing successful, culvert-based road crossings. Multiple large section box culverts carry all but flood-flows, and enable the effective passage of aquatic fauna (Figure 6.1). However, there are also examples of poorly-designed pipe culverts and undersized box culverts that would obstruct fish passage at certain times of the year (refer to Section 4.1). That is, fish passage is already restricted in the MLAs. Poorly-designed fish crossings associated with the Project have the potential to further impact on fish movement within the study area. Adoption of best practice design with respect to fish passage will avoid this potential impact, as discussed further in Section 7.7.3.

Figure 6.1

The box culvert on Frank Creek at the crossing of Jackson Wandoan Rd is large and would allow the effective passage of aquatic fauna.

6.7.3 Pipeline Crossings

Pipeline crossings of creeks will disturb bed and bank stability, potentially leading to increased localised erosion, and subsequently increased turbidity and sediment deposition downstream (the impacts of which have been discussed in Sections 6.2.2 to 6.2.4). After construction, the newly formed bed and banks may continually erode, given the high flows that occur in the region in the wet season. This may result in an increase in channel width and a loss in channel definition, which could in turn lead to a decrease in downstream flow. The impacts of decreased bed and bank stability will be localised, and will require remediation (refer to Section 7.7) in order to minimise potential local impacts on aquatic flora and fauna.

6.8 Biting Insects

Mosquito eggs are laid in mud or on vegetation associated with shallow pooled water, and hatch when water levels rise (e.g. with the incidence of rainfall). The larvae and pupae of most species take at least 6 days to develop. Within the study areas, creeks, 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 and operational activities that result in pooled water will potentially provide an increase in mosquito and biting midge breeding habitat in the study area. During the operation phase, dams have the potential to provide additional breeding habitat for these organisms.

An increase in the population of mosquitoes and biting midge has the potential to impact on human health. Opportunities exist to minimise both the breeding of mosquitoes and biting midge on site through appropriate education, control, engineering, and building design (refer to Section 7.8).

6.9 Matters of National Environmental Significance

The Project will not impact on boggomoss springs, as there are no springs within, or in the immediate vicinity of, the MLAs or gas supply pipeline routes (DEWHA 2008a). The Great Barrier Reef World Heritage Area and the Shoalwater and Corio Bays Ramsar site are unlikely to be impacted by the Project, as they are over 300 km to the north-east of the MLAs, and water quality that far downstream of the MLAs and gas supply pipeline will not be impacted by the Project.

The Fitzroy River turtle (*Rheodytes leukops*) has a relatively small home range (mean 417 m) and is generally found in association with riffle zones or deeper sections of pool habitats adjacent to riffle zones, as riffles become seasonally ephemeral (Tucker et al. 2001). Fitzroy River turtles were not captured during this survey, and have not been recorded in waterways within 280 km of the Project area. No riffles or deeper sections were observed during the survey and it is highly unlikely that the Fitzroy River turtle inhabits the ephemeral creeks of the MLAs or the gas supply pipeline route. The Project is unlikely to have a significant impact on this species.

The boggomoss snail (*Adclarkia dawsonensis*) is found associated with boggomoss habitat located approximately 100 km downstream of the MLAs on the Dawson River. Boggomoss communities are unlikely to be impacted by the Project MLA areas and gas supply pipeline, which will not be impacted by this Project.

In summary, the Project is not likely to impact on Matters of National Environmental Significance (MNES) with respect to aquatic ecology.

7 Avoidance, Minimisation and Mitigation of Impacts

7.1 Operation and Maintenance 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 within the MIA is undertaken within bunded areas designed and constructed in accordance with *Australian Standard AS1940(2004) – The storage and handling of flammable and combustible liquids*.
- 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 Mine's Environmental Officer.
- 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).

7.2 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 EM Plan) to minimise the quantity of sediment run off into waterways during construction and operation of the mine. Such a plan should consider the:

- staging of earth moving and vegetation clearing
- use of erosion control technologies as appropriate (such as matting), and
- rehabilitation of native vegetation after clearing, including the establishment of ground cover

7.2.1 Timing

Vegetation clearing and earthworks will be done in stages over the life of the mine. During each stage of construction, sediment and environmental dams, and levee banks, will be constructed to protect natural waterways from sediment-laden runoff. The risk of overflow to nearby waterways will be further reduced where:

- Timing of clearing and earthworks close to (nominally within 100 m of, depending on local topography and site conditions) a major waterway (Frank, Woleebee, Wandoan, Blackant, Mud, Mount Organ and Spring Creeks) is done in the dry season if possible.

7.2.2 Turbidity and Sedimentation

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, ditches or similar formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks.
- Monitoring creek water (of creeks downstream of current clearing / exposed soil) quality during periods of rainfall (refer to Section 7.10.1 for a description of monitoring).

7.2.3 Rehabilitation of Native Vegetation

After construction of crossings and other infrastructure in waterways, 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 margins (for example following construction of creek crossings, refer to Section 7.7). The width of the replanted riparian vegetation should match the existing riparian vegetation; however, 5 m would be the minimum width required to provide a functioning riparian zone. Planted trees in the riparian zone should provide canopy cover and have root systems that can stabilise the banks and disturbed area.

7.3 Wastewater and Stormwater

To conserve the aquatic floral and faunal communities of adjacent and downstream waters, the quality of waters released from the sediment dams should be similar to that of the receiving waters. As a guide, Table 7.1 presents preliminary water quality objectives 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 4.9).

Table 7.1 Preliminary water quality objectives for the discharge water quality required to maintain the natural fish communities of the region.

Parameter	Range Required to Sustain the Fish Communities Sampled During this Study
Temperature (° C)	< 34
Dissolved Oxygen (mg/L)	1.5 – 10.0
pH	6.0 – 8.5
Conductivity (µS/cm)	19.5 – 650
Turbidity (NTU)	< 200*

* Most species found in this study have been recorded from waterways with high turbidity (typically <200 NTU, but up to 600 NTU; frc environmental pers obs.)

When possible, the discharge of water from the sediment dams to the natural environment should be managed to coincide with natural flow events, minimising disruption of cues for reproduction and/or migration of aquatic fauna.

7.4 Water Supply

7.4.1 Transfer of Exotic Fish Species

The use of water from the Glebe Weir during the Project could increase the opportunity for mosquitofish and goldfish to become more widely distributed through the region. The significance of this impact is being considered as a part of the Glebe Weir Raising and Pipeline impact assessment, as presented in Volume 4 of the EIS. The requirement for screens on the pipeline intake to prevent the transfer of exotic fish should be subject to negotiations with DPI&F. Similarly the use of CSG water from the Condamine region could theoretically increase the opportunity for carp to become established in the Fitzroy

Basin, and the significance of this impact is being considered as part of this supply option (presented in Volume 2 of the EIS).

The Proponent should ensure that the dams on the site are free from noxious species on a regular basis (refer to Section 7.10 for a description of monitoring).

7.5 Loss of Catchment Area

The loss of catchment area could reduce the magnitude of freshwater flows to the receiving environment. This may be mitigated through:

- Not discharging treated stormwater to the natural receiving environment during dry periods, to minimise potential local impacts to the timing, duration and magnitude of flows in the creeks, which can each be important cues for reproduction and/or migration of aquatic fauna.
- Long-term remediation of the Project area.

7.6 Creek Diversions

To effectively mitigate the loss of on site aquatic and riparian habitat, diversions should be designed and constructed to provide bed and bank habitat of a similar character to that of natural watercourses within the region. Key considerations include:

- The diversion low flow channel should provide a stable, sinuous channel, of dimensions similar to the existing natural channel, and that will maintain a similar flow to the existing natural channel. Bends and varying depth contours in particular are important in maintaining habitat diversity and refuge areas for fish and other fauna during periods of high flow. Other important physical features of the creek to replicate include sediment type, in-stream habitat availability (e.g. tree roots, logs, boulders etc.) and riparian vegetation. This may include the placement of boulders or logs and branches from vegetation clearing into the channel.
- Diversions should only be opened to flows once geotechnical stability and vegetation requirements have been satisfactorily established. Until this time, the existing channels should continue to function normally.
- Designing the diversions to have water velocities of ≤0.3 m/s when possible facilitate passage of all native fish species (Cotterell 1998). During flood flows,

the design of the channel should minimise the time that the channel has water velocities of >1 m/s as far as practical, as this will likely impede all fish passage (Cotterell 1998).

- Where possible, diversion channels should only be initially opened to flows in the dry season (May – September). This will minimise any impacts to fish movement and reproduction that may be occurring in the sections of creeks to be diverted.

Prior to construction of the creek diversions, approvals will be required from the EPA under the *Environmental Protection Act 1994*, the DNRW under the *Water Act 2000* and the DPI&F under the *Fisheries Act 1994*. Preliminary recommendations for the design and construction of each creek crossing are presented below; however these are based on preliminary information only from the survey of one or two sites on each creek.

7.6.1 Woleebee Creek Diversion

The diversion of Woleebee Creek is substantial, proposed to be approximately 9 km in length. Construction of this diversion is proposed in three stages, starting in Year 10 and finishing in Year 12. However, sufficient time should be allowed for the planted vegetation within the entire diversion channel to establish prior to commissioning (estimated to be at least two years). That is, if construction finishes in Year 12, the channel should not be opened to flows until at least Year 14. Mine scheduling indicates, as outlined in Chapter 6 (Project Operations), that pits adjacent to Woleebee Creek Diversion will commence being mined in Year 16.

Construction of the diversion channel in its entirety prior to commissioning will cut-off flow from Wandoan and Blackant Creeks to the natural channel of Woleebee Creek. Without mitigation, this is likely to be unacceptable from both a hydraulic and ecological perspective. Therefore, it is recommended that the channels of these creeks remain open, and the diversion channel be built either side of the banks. These banks should only be redesigned to direct flows into the new diversion channel immediately prior to opening it to flows. Reinforcing the banks of Blackant and Wandoan Creeks with hard structures such as crib walls or rip-rap if required in these locations would be acceptable.

Habitat features of Woleebee Creek that should be replicated in the design of diversion include overhanging vegetation (including both Eucalypt and pine trees), log-jams, boulders, vegetated islands, isolated pools and bends to provide habitat diversity. Substrate diversity, including areas of sand, gravel and cobble, is also a feature of this creek.

The upper banks should be revegetated with large Eucalypt species to stabilise banks, and sedges and rushes should be planted along the lower banks to provide habitat during periods of flow. Where it is determined during detailed design that more substantial erosion control is required, the use of seeded soil wrap (to enable the establishment of a ground cover) or crib walls is preferred over the use of rip-rap.

7.6.2 Other Diversions

Habitat features of Frank Creek, Mud Creek, Mount Organ Creek and Spring Creek that should be replicated in the design of diversions include isolated pools and bends to provide habitat diversity. The provision of gravel or cobble will also enhance habitat diversity, and may provide potential riffle habitat during periods of flow. Large woody debris such as branches and logs should be anchored into the stream bed (either by burial or by using large boulders) to provide physical habitat for fauna.

The upper banks should be revegetated with large Eucalypt species to stabilise banks, and sedges and rushes should be planted along the lower banks to provide habitat during periods of flow. Where it is determined during detailed design that more substantial erosion control is required, the use of seeded soil wrap (to enable the establishment of a ground cover) or crib walls is preferred over the use of rip-rap.

7.6.3 Stranding of Fish and Other Aquatic Fauna

Pools remaining in the channel to be diverted during the dry season are likely to act as refuge habitat for aquatic fauna. These fauna would contribute to the re-population of local and regional waterways during the wet season. Opening the diversion channel in the dry season (May – September) will minimise the number of fish that are likely to become stranded in the any refuge pools in section of creek to be diverted.

If pools remain in the section of creek to be diverted, fish and other aquatic fauna will become stranded once the section is isolated, and flow is diverted to the new section of creek. Once flow is diverted from the existing channel, stranded fish should be captured and translocated to either the diverted creek or upstream of the diverted creek, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004), which recommend that:

- fish should be captured from the creek to be diverted using gear appropriate to the waterways and species present (at the site, 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 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.

7.7 Creek Crossings

7.7.1 Construction of Permanent Creek Crossings

Impacts associated with the construction of permanent road and rail 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).
- The implementation of stormwater and erosion control measures.

Wet Season

- The workspace is isolated, irrespective of if there is an isolated pool or flowing water. The isolation should be designed such that:
  - It is completed within one work-day, to minimise the impact on aquatic fauna
  - 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 (e.g. steel plates, flumes, sand bags or aquadam)
- be made impermeable by using polyethylene liner and sand bags
- if flowing water is present, 100% downstream flow is maintained by using appropriately sized pumps
- pump intakes must have a screen, with openings no larger that 2.54 mm, to ensure that no fish are entrapped
- fish must be salvaged from the isolated workspace and translocated (see section 7.6), and
- the upstream dam is slowly removed, to allow water to flush the sediment from the workspace area
- sediment-laden water should be pumped into sumps or onto vegetation
- operation of the clean-water pump to sustain partial flow below the downstream dams must be continued until the downstream dam is removed.

7.7.2 Construction of Temporary Creek Crossings

Impacts associated with the construction of temporary road crossings will be minimised if they:

- Are constructed during the dry season.
- Follow the guidelines presented in Section 7.7.1 above.
- Bed and bank habitat should be rehabilitated after removal of the temporary crossing, as described below.

Rehabilitation of Instream Aquatic Habitat

After removal of a temporary crossing, impacts may be mitigated by:

- Rehabilitation of the bed and bank structure such that original dimensions and shape are achieved. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Banks are revegetated as outlined in section 7.2.3.
- Salvaging existing bed material prior to construction and placing it back into the creek 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 (as usually, new coarse substrate is covered in a fine dust, which will become suspended in the water).

- Aquatic habitat structures are replaced 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.

7.7.3 Obstruction of Fish Passage

The limited flow of water within the creeks of the region, emphasise the need to provide for effective fish passage (Cotterell 1998). Ford crossings can be used for crossings of small gullies and first order streams, without having major impacts on fish movement throughout the study areas.

Where practical, for crossings of the larger streams in the MLAs (Frank, Woleebee, Wandoan, Blackant, Mount Organ, Mud and Spring Creeks), bridges are preferred to culverts. For example, construction of the rail bridge crossing of Frank Creek will not have a significant impact on fish passage within Frank Creek (based on the preliminary design). It is recognised that bridges are unlikely to be practical for all stream crossings.

Where culverts are used, their design and installation will potentially significantly influence fish passage. It is recommended that Queensland's Department of Primary Industries and Fisheries (DPI&F) be consulted during stream crossing design, siting and maintenance. The Department's guidelines for the design of culverts state that culverts should be designed such that they are (Cotterell 1998):

- located at least 100 m from any other waterway barrier on the creek (e.g. road crossing, dam etc.) in order to minimise the cumulative effects of fish barriers
- as short (along the length of the stream) and wide (across the stream channel) 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),
- open-bottomed if possible, to retain the natural morphological features of the stream. If this is not possible, culverts should be countersunk below the stream bed and natural materials such as rocks secured to the base of the culvert to increase roughness and reduce water velocity (water velocities of ≤0.3 m/s are

likely to facilitate passage of all native fish species; velocities of >1 m/s will likely impede all fish passage)

- constructed without a ‘drop off’ at the culvert outlet, as this impedes fish migration upstream
- constructed with minimum disturbance to the outer banks on stream bends, as these are usually the most unstable and prone to erosion, and
- surrounded by riparian vegetation (that is planted after construction if necessary) to stabilise banks, provide food and habitat for fauna and prevent predation of aquatic fauna by birds.

Culverts should be installed at the driest time of year (preferably in the dry creek bed, avoiding pools), to minimise erosion and to reduce the impacts of construction on fish migrations (which, within the study area, are likely to be triggered by rain and the onset of corresponding flows). During the wet season, isolation methods should be in accordance with those outlined in Section 7.7.1.

Culverts should be maintained so that there is regular removal of debris or plant growth, which can impede fish passage (Cotterell 1998).

7.7.4 Gas Supply Pipeline

The guidelines presented in Section 7.7.1 apply to the temporary disturbance of the creeks associated with the installation of the gas supply pipeline. Table 7.2 presents a summary of specific recommendations for the pipeline crossing of each waterway. Fish salvage methods are described in Section 7.6.3, and water quality monitoring is described in Section 7.10.1.

Table 7.2 Summary of creek crossing recommendations for the gas supply pipeline.

Site	Recommended Pipeline Crossing		Recommended Road Crossing for Equipment		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum Width of Re-planted Riparian Vegetation
	Dry Conditions	Wet Conditions	Dry Conditions	Wet Conditions				
1	Open Cut	Isolate and open cut[1]	Ford	Ford	No	No	Small drainage in the headwaters, not of fisheries concern. No specific aquatic rehabilitation required.	–
2	Open Cut	Isolate with steel plates and open cut[1]	Temporary ford	Temporary box culvert[1]	Yes in wet conditions.	Yes in wet conditions.	Avoid clearing trees if possible. Revegetate banks when works are complete. Place any fallen trees into channel to provide habitat.	20 m
3	Open Cut	Isolate with steel plates and open cut	Create temporary ford	Use isolated area to create a ford or install temporary culvert	Yes in wet conditions.	Yes in wet conditions.	Replace bed and bank vegetation. Replace bed habitat when complete.	Left bank 25 m, right bank 10 m.

Site	Recommended Pipeline Crossing		Recommended Road Crossing for Equipment		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum Width of Re-planted Riparian Vegetation
	Dry Conditions	Wet Conditions	Dry Conditions	Wet Conditions				
4a	Open Cut	Isolate with steel plates and open cut	Create temporary ford	Install temporary box culvert	Yes in wet conditions.	Yes in wet conditions.	Avoid clearing trees if possible. Revegetate banks when works are complete, stabilise with seeded soil wrap if required. Place any fallen trees into channel to provide habitat.	10 m
4b	Open Cut	Isolate with steel plates and open cut	Create temporary ford	Install temporary box culvert	Yes in wet conditions.	Yes in wet conditions.	Avoid clearing trees if possible. Revegetate banks when works are complete, stabilise with seeded soil wrap if required. Place any fallen trees into channel to provide habitat.	5 m
6	Open Cut	Isolate with steel plates and open cut[1]	Create temporary ford	Temporary box culvert[1]	Yes in wet conditions.	Yes in wet conditions.	Avoid clearing trees if possible. Revegetate banks when works are complete. Place any fallen trees into channel to provide habitat.	15 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing for Equipment		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum Width of Re-planted Riparian Vegetation
	Dry Conditions	Wet Conditions	Dry Conditions	Wet Conditions				
7	Open Cut at location already disturbed by cattle access	Isolate with steel plates or coffer dam in high flow. Drill if water levels are high; this will also help to avoid clearing riparian trees.	Temporary ford	Temporary single – span bridge or culvert	Yes in wet conditions if isolated.	Yes in wet conditions if isolated or drill used.	Erosion control required. When complete, slope bank and stabilise with seeded sediment wrap, crib wall and / or planted vegetation. Do not remove large trees. Place any fallen trees into creek bed to provide habitat.	Left bank 5 m, right bank 10 m.

1 Small ephemeral stream, not expected to flow for very long after rain

7.8 Biting Insects

7.8.1 Minimisation of Breeding Habitat

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.
- Constructing dams and water storages intended to contain stormwater and wastewater with steep edges, to minimise the extent of shallow water, which can provide breeding habitat.

7.8.2 Design and Engineering

Mosquitoes are less likely to pose a health risk where:

- More open window area on the windward side of buildings, rather than the leeward, passively 'pressurises' a building, and reduces opportunities for biting insects to enter from the preferred leeward side.
- Fully screening buildings to prevent insect entry.
- Installing ceiling fans or air conditioning to increase airflow.

7.8.3 Control of Biting Insect Populations

Natural Control using Native Fish

Where the water quality is acceptable (refer to Table 7.1), native larvivorous fish can be stocked into sediment dams and the raw water dam on-site to contribute to mosquito control (water quality in the tailings dam and the environmental dams is unlikely to be of sufficient quality for stocking fish). Fish species that occur in the study areas that prey on mosquito and midge larvae are recommended for stocking, these species include Agassiz's glassfish (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*) and carp gudgeons (Hypseleotris sp.).

These fish can be obtained from some aquariums and from registered fish hatcheries (DPI 2004); native fish from commercial suppliers typically cost $200 – $400 per 100 fish (frc environmental 2002). Previous studies have suggested that fish stocking densities of around 1 fish per m^2 of potential breeding habitat (i.e. the approximately 2 m of shallow habitat around the margin of the lake that may support aquatic macrophytes) should be sufficient to control mosquito populations (frc environmental 2002).

In order for stocked fishes to effectively control mosquito breeding, the fish must be allowed to develop sufficiently abundant populations, and must be able to get to locations used by mosquitoes for breeding. In effect, this requires permanent and relatively stable water (quality), and sufficient depth of water to allow the fish access to potential breeding habitats.

Chemical Control of Mosquitoes

Mosquito control is based principally on the application of larvicides (which kill developing larvae). Two larvicides are commonly used: *Bacillus thuringiensis israelensis* (Bti), a bacterial larvicide; and a methoprene based hormone regulator. These larvicides are relatively target-specific, and are appropriate for use in the Project area.

Complaints by Mine employees or surrounding residents should primarily determine the requirement for application of larvicides in breeding habitats. If complaints are received, breeding habitats should be determined by conducting a survey of breeding habitat, by dipping for larvae along the margins waterways on the site. When a high abundance of mosquito larvae are found in a dip sample (>10 larvae per dip), treatment of the waterway with a commercial larvicide, such as Altosid 30 day briquettes, may be warranted.

Chemical Control of Midges

Biting midges are not affected by mosquito larvicides and cannot be treated by chemical means within breeding areas due to the toxicity of midge adulticides (such as Bifenthrin) to other organisms. Control of biting midges needs to include site specific studies of where midge populations are coming from before control measures such as barriers/fences (which may be treated with ‘Bistar’, a midge adulticide containing Bifenthrin) can be effectively implemented.

7.9 Threatened Species and Ecological Communities

The Project is highly unlikely to have an impact on any threatened aquatic species or ecological communities, as these species and communities are unlikely to occur in the waterways of the MLAs or along the gas supply pipeline.

7.10 Monitoring Requirements

7.10.1 Turbidity Monitoring

Monitoring of turbidity levels in the creeks is recommended:

- On a monthly basis in waterways throughout the MLAs, and in the creeks crossed by the gas supply pipeline immediately prior to pipeline installation, in order to determine background turbidity levels
- during periods of rainfall in creeks that are within 500 m of vegetation clearing earth moving activities, and
- daily when constructing permanent or temporary creek crossings.

It is recommended that turbidity levels should not exceed 10% above background during construction. If turbidity levels exceed 10% of background concentrations, it is recommended that construction cease and that stormwater and erosion and sediment control measures be revised prior to re-commencement of construction.

7.10.2 Aquatic Ecology Monitoring Program

A long-term aquatic ecological monitoring program will be required to monitor the impacts of the mine of the waterways within the MLAs, and downstream, and to inform the mine's environmental management plan and remedial actions. The proposed monitoring program should be designed to detect changes to the physical environmental and ecological communities within the waterways, thereby providing the opportunity to prevent further damage if impacts are detected. The results of this monitoring program should inform continual improvement of the EM Plan for the Project.

It is proposed monitoring occurs at approximately five sites within the MLAs, five sites downstream of the MLAs, and five comparison sites that will not be impacted by the Project. Each site should be approximately 100 m in length. Sites should be established on the diversion channels once they are commissioned. Two monitoring events should be completed each year, one in the early wet season, and one in the late wet season. At least two baseline survey events should be completed prior to the commencement of construction.

The monitoring program should include quantitative, replicated monitoring of water quality, aquatic habitat, macrophytes and aquatic fauna (focussing on macro-invertebrates and fish).

Water Quality and Aquatic Habitat

Water quality and aquatic habitat should be assessed in accordance with AusRivAS protocols. The percent cover of each macrophyte species present should also be assessed at each site. This information should be compared among creek sections (within the MLAs, downstream of the MLAs, and comparison sites) for each survey event using one-way Analysis of Variance (ANOVA). This information may also be used in multi-variate analyses of fish communities (see below).

Macro-invertebrates

At least five quantitative replicate macro-invertebrate samples should be collected from each habitat present at each site. Each replicate should be collected with a surber sampler or triangular-framed dip net from a 30 cm by 30 cm area of habitat. Samples should be sorted; and invertebrates counted and identified to the lowest practical taxonomic level (in most instances family) to comply with methods described in Chessman (2003).

Taxonomic richness, PET richness, Signal 2 scores and abundance should be calculated for each replicate sample collected. Differences in each of the macro-invertebrate indices will be analysed between sites and location (within the MLAs, downstream of the MLAs, and comparison sites) over time using a two-way nested ANOVA (with site nested in location).

To determine differences among macro-invertebrate assemblages at different sites, community data should also be analysed using multivariate techniques, including analysis of similarities (ANOSIM), non-metric multidimensional scaling (nMDS) and similarity percentages – species contributions (SIMPER) for each habitat type sampled.

Fish Communities

Fish communities should be surveyed using gear types appropriate to the conditions at each site. This may involve the use of one, or a combination of, the following gear types: backpack or boat electrofishing units; seine nets (~10 mm mesh size); gill nets (75 mm and 150 mm mesh); baited traps (of 2 mm and 20 mm mesh); and dip nets (of 2 mm mesh).

Electrofishing should be conducted strictly in accordance with *the Australian Code of Electrofishing Practice*. General Fisheries and Animal Ethics permits will be required to complete the monitoring.

At each site, the species captured and the abundance of each species by life history stage (juvenile, intermediate, adult) should be recorded, along with the apparent health of individuals. Specimens cannot be identified in the field should be euthanised and returned to the laboratory for identification.

The richness, total abundance, abundance of 'key' species, and abundance of each life history stage should be compared among creek sections (within the MLAs, downstream of the MLAs, and comparison sites) for each survey event using one-way ANOVA.

The relationships between fish communities among different creeks and with the habitats present at each site should be analysed using multivariate techniques (including ANOSIM, nMDS, SIMPER and BIOENV).

7.10.3 Monitoring of Dams for Exotic Species

The dams on-site (in particular the raw water dam) should be monitored for the establishment of exotic species. This can be done in conjunction with the aquatic ecology monitoring program outlined above. Fish should be surveyed using a combination of boat-based electrofishing, set traps and seine nets. If exotic species are discovered, an exotic species management plan should be developed and implemented.

8 Residual Impacts

8.1 Operation and Maintenance of Vehicles and Other Equipment

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), and appropriate spill kits are carried in the field, the risk from a fuel spill to aquatic ecology is considered to be very low. The risk to aquatic ecology from spilt litter and waste from the MIA is also likely to be very low.

8.2 Vegetation Clearing and Earth Moving

Where the suggested mitigation measures are adopted, an appropriate Construction Management Plan is followed, and turbidity is routinely monitored in the creeks to inform management, it is considered unlikely that construction-related increases in turbidity or nutrients in the waterways of the study area would have an ecologically significant impact.

8.3 Wastewater and Stormwater

8.3.1 Stormwater

Release of water of an acceptable quality from the sediment dams would not be expected to have a negative impact on aquatic ecology. The impact of small outflows in the wet season would not have a discernable impact when compared to the natural flows occurring. Release in the dry season may result in the creation of permanent pools that act as 'refuge habitat' in the creeks, and may also trigger fish movement and possibly spawning in the creeks.

8.3.2 Industrial Wastewater

Contaminants will be unlikely to impact on aquatic ecology where the Water Management System (WMS) is successful in ensuring that there is no mine water discharge from the site.

Accidental spills from environmental dams 5, 6 and 7 would not be expected to have a large impact on aquatic ecology, as these dams are situated away from major creeks, as volume of the overflow would be reduced by overland flow before the water reached any major creek lines. However, the tailings dams and environmental dams 1 to 4 are in close proximity to Woleebee Creek. A spill from these dams would be expected to have localised impact on the aquatic flora and fauna of this creek, and potentially some nearby reaches of Juandah Creek downstream. However, no impacts would be expected to waterways further downstream, such as the Dawson River, due to dilution and dispersion of the contaminants.

8.3.3 Potable Wastewater

Sewage has the potential to be accidentally discharged to either Woleebee, Frank or Juandah Creeks at the two proposed pump stations. The impacts of nutrient enrichment and any algal blooms due to a sewage spill would also be expected to be short-lived, and communities would be expected to recover from such an impact. Therefore, eutrophication of the waterways due to a sewage spill is considered to be a low risk to aquatic ecology.

8.4 Water Supply

8.4.1 From GAB Water

There will be a short-term and reversible impact to aquatic ecology where water supply pipelines are installed across creeks. Where construction of the potable water pipeline from Wandoan follows the recommended mitigation measures for pipeline constructions and creek crossings, no long-term impacts to surface waters are expected from the use of GAB water for potable purposes.

8.4.2 From the Glebe Weir on the Dawson River

Where screens are fitted to the intake pipe, and are regularly maintained and tested, the opportunity for exotic species to become established within the study area will not be significantly increased above the current situation (mosquitofish and goldfish are already established within the catchment).

8.4.3 From Coal Seam Methane By-Product Water

Overall, water supply from coal seam methane by-product water is unlikely to have a significant impact on the aquatic ecology of the natural waterways within the study area. Refer to Volume 2 of the EIS for a description of the risk of transfer of the declared noxious carp (*Cyprinus carpio*) from the Condamine catchment.

8.4.4 Discharge from the Raw Water Dam

The raw water dam would only be expected to overflow during periods of significant rainfall. Discharge from the raw water dam would not be expected to have a discernable impact on aquatic ecology.

8.5 Loss of Catchment Area

The diversion of runoff from approximately 8,500 ha of upper catchment area to the site water management system due to the creation of pits is unlikely to have a regionally significant impact. Locally, a reduction in flows to the creeks could negatively impact on the abundance and diversity of macrophyte, macro-invertebrate and fish populations within the creeks of the MLAs. However, this would not be expected to have an impact on aquatic communities of Juandah Creek or waterways further downstream, such as the Dawson River.

8.6 Creek Diversions

At least 20 km of natural watercourse will be lost, including reaches of Spring, Mt Organ, Mud, Woleebee and Frank Creeks and an un-named tributary of Juandah Creek. However, if the diversion channels are well engineered to maintain fish passage and replicate the aquatic habitat found in the natural creeks, this loss of natural ephemeral watercourse is highly unlikely to result in the local loss of any species of aquatic flora or fauna.

The proposed diversions are unlikely to have a regionally significant impact on the abundance of aquatic flora and fauna, on the diversity of aquatic communities, or on aquatic ecosystems functioning.

8.6.1 Construction of Creek Crossings

Construction of creek crossings will result in a temporary disturbance of aquatic and riparian habitat. However, if these habitats are appropriately rehabilitated, there will be no permanent local or regional impact.

When there is water present in the channel, there will be a temporary impact to fish passage during construction activities. There may also be impacts to water quality, however these will not be significant in a local or regional context if appropriate erosion and sediment control measures and monitoring are put in place.

8.7 Biting Insects

Construction and operational activities that result in pooled water will potentially provide an increase in mosquito and biting midge breeding habitat in the study area. During the operation phase, dams have the potential to provide additional breeding habitat for these organisms. An increase in the population of mosquitoes and biting midge due to an increase in breeding habitat has the potential to impact on human health. However, the impact of mosquitoes and biting midges on human health can be minimised through appropriate education, breeding control, engineering, and building design.

8.8 Conservationally Significant Habitats

The Project will not impact on conservationally significant aquatic habitats, including those that are listed under State or Commonwealth legislation.

8.9 Threatened Species and Ecological Communities

The Project is highly unlikely to have a significant impact on threatened species or communities that are listed under State or Commonwealth legislation.

9 Conclusions

The biological values of aquatic ecosystems within the study areas are relatively low and consistent with those of the wider catchment. Environmental values are dictated primarily by the ephemeral and intermittent nature of the region's waterways; although surrounding land uses, including vegetation clearing, cattle grazing and cropping, have negatively impacted the aquatic habitat of the study area and the wider catchment. Water quality is relatively poor, and reflects the predominantly agricultural nature of the region and the ephemeral nature of the creeks. However, the aquatic habitat of the study areas are considered to be in a moderate condition overall, with many of the sites surveyed supporting large trees in the riparian zone and characterised by a variety of aquatic micro-habitats.

Biodiversity in the study area is slightly lower than that found in the more permanent waters of the region (such as the Dawson River). Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area; that is, communities are typically have a low sensitivity to changes in water levels and water quality. However, macro-invertebrate and fish communities found within the MLAs are likely to contribute to the success of downstream populations through movement/migration. Flow is an important cue for migration and reproduction in many of the species recorded in the study areas. One species of freshwater turtle (the Krefft's river turtle) was found downstream of the MLAs in Juandah Creek; however turtles are unlikely to be abundant in the ephemeral creeks of the study areas at any given time. No rare or threatened aquatic floral or faunal species were found in the study areas, or are considered likely to occur, based on the habitats present.

The coal resources of the Project will be developed as an open-cut mine and related local infrastructure. Construction and mining activities, including: the operation of vehicles and other equipment; vegetation clearing and earth moving; creation of wastewater in association with the required infrastructure; management of stormwater runoff; creation of dams; construction of creek crossings; creation of stream diversions; and the loss of catchment area, each have the potential to impact on aquatic ecology.

The potential impacts of fuel handling, vegetation clearing, dam operation and stormwater discharge on the creeks within the study areas (and downstream waterways) can be minimised if current best practicable practice environmental management programs are followed.

The Project is highly unlikely to have an impact on boggomoss springs, the Great Barrier Reef World Heritage Area or the Shoalwater and Corio Bays Ramsar site. The Project is unlikely to impact on any threatened aquatic species or ecological communities (as listed under State or Commonwealth legislation), as these species and communities are unlikely to occur in the waterways of the MLAs or along the gas supply pipeline.

In summary, the Project is not likely to impact on Matters of National Environmental Significance (MNES) with respect to aquatic ecology.

Of the potential impacts of the Project on the creeks of the study areas, the diversion of creek channels, and the construction of creek crossings (which can affect fish movement) could result in the greatest impact to the aquatic environment. However, the significance of any potential impacts can be reduced if appropriate mitigation measures are followed. In particular, the channel morphology and aquatic habitats of the creeks to be diverted should be surveyed in detail, so that the diversion channels can be constructed so that they replicate the natural channels in terms of channel morphology, sediment type, instream physical habitat and riparian vegetation. Creek crossings should be constructed in accordance with the recommendations in the DPI&F Fish Habitat Guideline FHG 001, *Fish Passage in Streams, Fisheries guidelines for design of stream crossings* (Cotterell 1998).

Taking into account the low existing biological values of the aquatic environments of the study area, in general, the impact assessment demonstrates that there will be only a low magnitude of impact to the local aquatic environments of the MLAs and gas pipeline route, and negligible regional impacts. However, future water quality and aquatic ecology monitoring will be required to determine the impact of the Project on aquatic ecology, in order to inform adaptive management of the Project.

10 Summary of Impact Avoidance, Minimisation and Mitigation Strategies

Recommended strategies to avoid, minimise and mitigate potential impacts of the Project to aquatic flora and fauna, as previously detailed in this aquatic ecology assessment, are summarised below:

- Fuel storage areas should meet AS1940, to contain any fuel spills or the runoff of other contaminants. Appropriate spill containment kits should be available and used for the cleanup of spills.
- Portable refuelling stations, for refuelling of machinery in the field, should bunded to meet AS1940, and placed above the Q100 flood level of nearby waterways and dams.
- An erosion and sediment control management plan should be developed (as a part of the EM Plan) to prevent excess sediment from running off into the creeks during earth moving and vegetation clearing related to construction and operation of the mine.
- Clearing and earthworks within 100 m of a major waterway (Frank, Woleebee, Wandoan, Blackant, Mud, Mount Organ and Spring Creeks) should be done within the dry season.
- During and after construction, erosion control matting should be placed in ditches and drainage lines from all cleared areas, especially on slopes and levee banks. In the event of excessive runoff during construction, contour banks, ditches or similar should be formed across cleared slopes to direct the runoff towards surrounding vegetation and away from creeks. During periods of rainfall, creeks should be monitored to detect runoff.
- After construction, native vegetation should be replanted where possible, and along creek margins where riparian vegetation has been cleared, to a width that matches the existing riparian vegetation (but at least 5 m). Species planted should be the same as the plants naturally found in the riparian zone, and should provide canopy cover and have root systems that can stabilise the banks and disturbed area.
- Water should only be released from sediment dams during periods of rainfall and flow in the natural waterways. Water quality of the released water should be maintained at levels similar to those recorded naturally in the study area during periods of rainfall.
- When possible, the discharge of water from the sediment dams to the natural receiving environment should be managed to coincide with natural flow events.
- The proposed diversions should be designed and constructed to provide bed, bank and in-stream habitat of a similar character to that of natural watercourses within the region.

- Prior to diversion, the sections of creeks to be diverted should be surveyed in detail, and used as a basis for designing bends, pools, bars to detailed design of each diversion, the natural channel of each creek should be and other features to be incorporated into the diversion design.
- The success of rehabilitation and erosion and sediment control methods should be monitored, and the diversions should only be opened to flows once geotechnical stability and vegetation requirements have been satisfactorily established.
- Construction of the Woleebee Creek diversion is proposed in three stages, starting in Year 10 and finishing in Year 12. Sufficient time must be allowed for the habitats within the entire diversion channel to establish prior to commissioning (estimated to be at least two years). That is, if construction finishes in Year 12, the channel should not be opened to flows until at least Year 14.
- The channels of Blackant and Wandoan Creeks should remain open during the construction of the Woleebee Creek diversion, with the diversion channel being built either side of the banks. These banks should only be redesigned to direct flows into the new diversion channel immediately prior to opening it to flows. Reinforcing the banks of Blackant and Wandoan Creeks with hard structures such as crib walls or rip-rap if required in these locations would be acceptable.
- Once flow is diverted from the existing channel, stranded fish and turtles should be captured and translocated to either the diverted creek or upstream of the diverted creek, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004) and ethical handling procedures.
- Construction of road and rail crossings should be undertaken during the dry season. However, stormwater and erosion and sediment control measures should still be put in place during construction.
- In the detailed design phase of the Project, the exact location of the crossings should be sited so that the minimum number of riparian trees needs to be cleared. Trees that are cleared should be anchored into the stream bed (for example by partial burial of the use of boulders), to enhance in-stream habitat in the creek.
- After removal of a temporary crossing, the rehabilitated bed and bank structure must mimic the existing dimensions and shape.
- At the completion of construction, banks should be recontoured to the original shape and revegetated. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Existing bed material should be salvaged prior to construction of a temporary creek crossing or pipeline crossing, and placed back into the creek at completion of construction. If the existing bed material was unable to be salvaged, a comparable sediment size material should cover the bed and should be approximately 10 cm thick.

If the sediment is fine (mud and/or silt), it is preferred that the bed material be replaced with sand, to prevent future erosion. If the sediment is coarser (gravel, cobble, pebbles and/or boulder), the new material should be washed prior to placing in the creek.

- After construction of a temporary creek crossing or pipeline crossing, the aquatic habitat structures should be replaced in the creeks. Prior to construction, any instream structures (woody debris, large cobbles) should be salvaged bed and placed back in the creek bed after construction. Felled trees could also be placed into creeks to create woody debris habitat.
- Creek crossings should be constructed in accordance with the recommendations in the DPI&F Fish Habitat Guideline FHG 001, *Fish Passage in Streams, Fisheries guidelines for design of stream crossings* (Cotterell 1998).
- Culverts should be maintained so that there is regular removal of debris or plant growth, which can impede fish passage.
- Pipeline crossings of creeks should be done in the dry season when possible. At the completion of construction, banks should be recontoured to the original shape and revegetated. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Where pipeline crossings are done in the wet season, turbidity should be monitored and fish should be salvaged from isolated areas.
- Mosquito and biting midge breeding habitat should be minimised. All drainage lines should be regularly cleared to ensure that water continues to flow and no ponded areas are created. All dams and water storages created to contain stormwater and wastewater should have steep edges, to minimise the amount of shallow water, which can provide breeding habitat.
- Building design and full screening of windows should be used to prevent insect entry. Ceiling fans or air conditioning can be installed to increase airflow.
- Where the water quality is acceptable, native larvivorous fish should be stocked into sediment dams and the raw water dam on-site to contribute to mosquito control at densities of around 1 fish per m^2 of potential breeding habitat. Fish species that occur in the study areas that prey on mosquito and midge larvae are recommended for stocking, these species include Agassiz's glassfish (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*) and carp gudgeons (Hypseleotris sp.).
- Complaints by Mine employees or surrounding residents should primarily determine the requirement for application of mosquito larvicides in breeding habitats. If complaints are received, breeding habitats should be determined by conducting a survey of breeding habitat, by dipping for larvae along the margins waterways on the site. When a high abundance of mosquito larvae are found in a dip sample (>10

larvae per (cup-sized) dip), the waterway should be treated with a commercial larvicide.

- Monitoring of turbidity levels in the creeks should be completed:
  - on a monthly basis in waterways throughout the MLAs, and in the creeks crossed by the gas supply pipeline immediately prior to pipeline installation, in order to determine background turbidity levels
  - during periods of rainfall in creeks that are within 500 m of vegetation clearing earth moving activities, and
  - daily when constructing permanent or temporary creek crossings.
- It is recommended that turbidity levels should not exceed 10% above background during construction. If turbidity levels exceed 10% of background concentrations, construction should cease and the erosion control measures in place must be revised prior to re-commencement of construction.
- A long-term aquatic ecology monitoring program should be implemented, with at least two baseline survey events prior to construction.
- The dams on-site (in particular the raw water dam) should be monitored for the establishment of exotic species in these waterbodies. If exotic species are discovered, an exotic species management plan should be developed and implemented.

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Attachment A Description of the Sites Surveyed


Fallen logs and tree roots provided habitat


Large trees helped to stabilise the banks


Riparian vegetation provided canopy cover of the channel


Much of the stream bed was sandy and dry


Cattle have access to the creek

Channel Habitat

Morphology

Flow Regime:	Ephemeral
Channel Width (m):	7
Mean Depth (m):	0.3
Flow Level:	No flow
Bank Erosion:	Limited
Sediment deposits:	None
Stream Order:	2

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid / Opaque
Water colour:	Brown / Green

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	75	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	10
Dry:	90
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	
Gravel:	5
Sand:	85
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	65 – 90%

Comments: The riparian zone was in relatively good condition with many large eucalypt trees. The channel provided good in-stream habitat due to bends, braids, logs and branches. Habitat was in moderate condition overall, degraded by cattle access.

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Wandoan Coal Project

Survey Date:	07/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Frank Creek

Cond.

M

frc site number 1

UTM Zone 55K 793918 E 7101706 N WGS84

				
Sedges grew on the edge of the channel	A rail bridge crossing the creek	The channel was small and the water was shallow	There were no trees or shrubs adjacent to the channel	

Channel Habitat

Morphology		Water Quality	
Flow Regime:	Ephemeral	Water Odour:	None
Channel Width (m):	1.5	Water Foaming:	None
Mean Depth (m):	0.2	Water Oils:	None
Flow Level:	No flow (pools)	Turbidity:	Clear/ Slight
Bank Erosion:	Limited	Water colour:	Brown
Sediment deposits:	None		
Stream Order:	1		

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	80	20

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)		Substrate (%)		Substrate Cover	
Riffle:		Bedrock:		Periphyton:	10 – 35%
Run:		Boulder:		Moss:	
Pool (rocky):		Cobble:	2	Filametous algae:	
Pool (sandy):	50	Gravel:	3		
Dry:	50	Sand:	85	Macrophytes:	10 – 35%
Edge:		Silt/Clay:	10	Detritus:	10 – 35%
Overall Complexity:					

Comments: No trees in the riparian zone. No in-stream debris for habitat variability. Rail bridge and culvert crossing for road. Poor condition overall.

frc environmental deep thinking. science.	Wandoan Coal Project				Un-named Tributary of Juandah Creek	Cond.
	Survey Date:	08/08/07			frc site number 2	P
	Written By:	TS	Approved By:	LT	UTM Zone 55K 797288 E 7105662 N WGS84	
	Date Issued:	28/09/2007				

				
Box culvert under Jackson-Wandoan Road	Banks were covered by grass and trees	Steep banks were stabilised by trees	Slightly eroded banks on the outside of a bend	Fallen logs and branches provided habitat

Channel Habitat

Morphology

Flow Regime:	Ephemeral
Channel Width (m):	4.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Moderate/ Limited
Sediment deposits:	None
Stream Order:	3

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	95	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	5
Pebble:	5
Gravel:	10
Sand:	70
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	65 – 90%

Comments: Downstream of confluence with Halfway Creek. Some erosion, fencelines have trapped debris. Overall moderate habitat condition.

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Wandoan Coal Project

Survey Date: 8/08/07
Written By: TS Approved By: LT

Frank Creek

frc site number 3
UTM Zone 55K 792788 E 7107103 N WGS84

Cond.
M

				
A small log jam provided habitat	Banks were devoid of trees in places	Tree roots provided habitat	Erosion on the outside of a bend	The banks were small and stable in places

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	5.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Extensive/ Moderate
Sediment deposits:	None
Stream Order:	2

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	90	80	20

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

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

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	65 – 90%

Comments: Fallen terrestrial debris provided in-stream habitat. Habitat condition reduced by erosion and cattle access. Moderate condition overall.

frc environmental
deep thinking. science.

Wandoan Coal Project

Survey Date: 7/08/07
Written By: TS Approved By: LT

Halfway Creek

Cond. M

frc site number 4
UTM Zone 55K 791701 E 7105303 N WGS84


The stream was a small gully


There were few trees in the riparian zone


A stand of Acacias grew away from the right bank


There was some small-scale erosion


The creek flows under the road via a pipe

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	1.5
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Limited
Sediment deposits:	None
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	2
Pebble:	3
Gravel:	5
Sand:	80
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	10 – 35%

Comments: Small first order stream though pasture land. No structure for in-stream habitat and few trees in the paddock. Poor condition.

frc environmental
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Wandoan Coal Project

Survey Date: 8/08/07
Written By: TS Approved By: LT

Un-named tributary of Frank Creek

frc site number 5
UTM Zone 55K 790071 E 7108843 N WGS84

Cond.
P

				
The channel ran beside the road	Box culvert under Jackson-Wandoan Rd	There was natural riparian vegetation	The stream bed was sandy	Trees provided overhanging vegetation

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	2.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	None
Sediment deposits:	None
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	90	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	0
Pebble:	5
Gravel:	5
Sand:	85
Silt/Clay:	5

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	10 – 35%

Comments: Small first order stream with a sandy substrate. Culvert under the road would allow fish passage and the riparian vegetation was in-tact. Lack of in-stream physical habitat diversity reduced habitat condition. Moderate condition overall.

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Wandoan Coal Project

Survey Date:	8/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Un-named Tributary of Wandoan Creek

Cond. **M**

frc site number 6

UTM Zone 55K 789364 E 7106471 N WGS84


The bed was sandy


Erosion on the outside of a bend


Fallen logs and branched provided habitat


Trees were intermittent along the bank


Pipe culverts under Jackson-Wandoan Rd

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	3.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Moderate
Sediment deposits:	None
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	70	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	
Gravel:	10
Sand:	85
Silt/Clay:	5

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	35 – 65%

Comments: Sporadic trees and fallen branches provided habitat. Pipe culvert may restrict fish passage. Erosion and vegetation clearing reduced habitat condition. Overall poor habitat.

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Wandoan Coal Project

Survey Date:	8/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Un-named Tributary of Wandoan Creek

Cond.

P

frc site number 7

UTM Zone 55K 787983 E 7105722 N WGS84

Some large trees helped to stabilise banks

Pooled water was turbid

Bare eroded banks in places

Drying pools had algae on the substrate

Bridge crossing would allow fish movement

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	2.5
Mean Depth (m):	0.3
Flow Level:	Low
Bank Erosion:	Extensive
Sediment deposits:	None
Stream Order:	2

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	Slick
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	25
Pool (rocky):	
Pool (sandy):	
Dry:	75
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	5
Boulder:	5
Cobble:	10
Pebble:	5
Gravel:	10
Sand:	55
Silt/Clay:	10

Substrate Cover

Periphyton:	10 – 35%
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	35 – 65%

Comments: The banks were eroded and bare in places. However, there were a variety of substrate types and water depths. Overall moderate habitat condition.

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Wandoan Coal Project

Survey Date:	8/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

One-arm Man Creek

Cond.

M

frc site number 8

UTM Zone 55K 785971 E 7104359 N WGS84

Mat algae grew on moist sediment

A fallen log upstream of the road would provide habitat

Loose sediment was falling into the creek bed

The pooled water was shallow and turbid

Sediment appeared to have been pushed over the bank

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	
Mean Depth (m):	0.3
Flow Level:	No flow
Bank Erosion:	Extensive
Sediment deposits:	None
Stream Order:	3

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid/ Opaque
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	55	70	30

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	20
Dry:	80
Edge:	
Overall Complexity:	

Substrate (%)

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

Substrate Cover

Periphyton:	10 – 35%
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	10 – 35%

Comments: Material had been pushed onto and over the banks from the roadside. Relatively few trees in the riparian zone. Weeds grew in the dry channel.

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Wandoan Coal Project

Survey Date: 7/08/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Wandoan Creek

Cond.

P

frc site number 9

UTM Zone 55K 783878 E 7104993 N WGS84

The site held substantial water but there was no flow

Large trees helped to stabilise banks

Fallen logs and edge vegetation provided habitat

Riparian trees provided shading and fallen logs

The creek was dry near the bridge

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	5.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Limited
Sediment deposits:	None
Stream Order:	4

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid/ Opaque
Water colour:	Brown

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	90	70	30

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	100
Pool (rocky):	
Pool (sandy):	
Dry:	
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	
Gravel:	10
Sand:	80
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	

Comments: Good edge habitat compared with the other sites sampled. Logs, tree roots and branches provided in-stream habitat. Some disturbance from bridge and rubbish disposal. Moderate condition overall.

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Wandoan Coal Project

Survey Date: 8/08/07
Written By: TS   Approved By: LT
Date Issued: 28/09/2007

Juandah Creek

Cond. **M**

frc site number 10

UTM Zone 55K 792928 E 7113108 N WGS84

				
Pipes under the road would restrict fish passage	There was fine sediment accumulating in the pool	Water would flow over the road at times	The banks included sandstone and boulders	There were some trees on the banks

Channel Habitat

Morphology		Water Quality	
Flow Regime:		Water Odour:	None
Channel Width (m):	6.0	Water Foaming:	None
Mean Depth (m):	0.5	Water Oils:	None
Flow Level:	No flow	Turbidity:	Turbid/ Opaque
Bank Erosion:	Limited/ Moderate	Water colour:	Brown
Sediment deposits:	Sludge		
Stream Order:	4		

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)		Substrate (%)		Substrate Cover	
Riffle:		Bedrock:		Periphyton:	10 –35%
Run:		Boulder:	2	Moss:	
Pool (rocky):		Cobble:	5	Filametous algae:	
Pool (sandy):	50	Pebble:	3		
Dry:	50	Gravel:	5	Macrophytes:	10 –35%
Edge:		Sand:	75	Detritus:	35 – 65%
Overall Complexity:		Silt/Clay:	10		

Comments: Surrounding land use includes grazing. Some fallen logs and branches would provide in-stream habitat. Pipes under road would probably restrict fish passage in tomes of low – moderate flow. Moderate condition overall.

frc environmental deep thinking. science.	Wandoan Coal Project				Woleebee Creek	Cond.
	Survey Date:	7/08/07			frc site number 11	M
	Written By:	TS	Approved By:	LT	UTM Zone 55K 786688 E 7111284 N WGS84	
	Date Issued:	28/09/2007				


Some of the banks were sandstone


A large sandy run habitat


Tree roots and boulders would provide habitat


The road crossing was a dirt track


There was good vegetative cover on the banks

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	5.0
Mean Depth (m):	0.3
Flow Level:	No flow
Bank Erosion:	Moderate
Sediment deposits:	None
Stream Order:	4

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	70	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	10
Dry:	90
Edge:	
Overall Complexity:	

Substrate (%)

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

Substrate Cover

Periphyton:	10 – 35%
Moss:	
Filamentous algae:	
Macrophytes:	
Detritus:	35 – 65%

Comments: Tree roots and substrate diversity provide in-stream habitat. Dirt road crossing is not a barrier to flow or fish passage. Evidence of cattle access to the creek reduces overall condition. Moderate condition.

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deep thinking. science.

Wandoan Coal Project

Survey Date:	8/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Woleebee Creek

Health

M

frc site number 12

UTM Zone 55K 787623 E 7115657 N WGS84

				
Fallen logs and cobbles would provide habitat	Some trees provided shade and in-stream habitat	Sediments included cobbles	Cobbles may provide a riffle habitat when the creek flows	The channel was only small and shallow

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Limited
Sediment deposits:	
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	95	5

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	30
Pebble	5
Gravel:	5
Sand:	55
Silt/Clay:	5

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	10 – 35%

Comments: This site would offer in-stream habitat diversity during times of flow, and was different from the other sites sampled. Cattle access to the channel reduced the overall condition to moderate.

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Wandoan Coal Project

Survey Date:	7/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Un-named Tributary of Mud Creek

Cond.

M

frc site number 13

UTM Zone 55K 779889 E 7113389 N WGS84

			
A small pipe allows flow under the road	The creek was a small channel through cropping land	The creek ran through taller crops upstream of the road	There was no riparian vegetation

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Limited
Sediment deposits:	None
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	95	5

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

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

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	35 – 65%

Comments: Small channel through agricultural land. No riparian vegetation or in-stream habitat obvious. Poor condition.

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Wandoan Coal Project

Survey Date: 7/08/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Un-named Tributary of Mud Creek

frc site number 14

UTM Zone 55K 780685 E 7118377 N WGS84

Cond.

P

				
Floating algae in the water column	Good tree cover in the riparian zone	There was some aggradation of fine sediment	The water was turbid	The banks were steep and bare in places

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	3.0
Mean Depth (m):	0.6
Flow Level:	No flow
Bank Erosion:	Moderate
Sediment deposits:	Sludge/ Sand
Stream Order:	3

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid/ Opaque
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	90	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	80
Pool (rocky):	
Pool (sandy):	
Dry:	20
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	5
Pebble:	5
Gravel:	5
Sand:	75
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	10 –35%
Macrophytes:	10 –35%
Detritus:	35 –65%

Comments: Fallen logs and branches, cobbles and bends / depth contours provided in-stream habitat diversity. There was floating filamentous algae in the water column. Moderate condition overall.

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Wandoan Coal Project

Survey Date: 7/08/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Mud Creek

Health: M

frc site number 15

UTM Zone 55K 776976 E 7116943 N WGS84

Terrestrial debris in the channel.

Terrestrial debris caught on a fence through the channel

The bridge crossing of Crossmont Rd

There was a high cover of detritus on the stream bed

There were some bare, steep banks

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	5.0
Mean Depth (m):	
Flow Level:	No flow
Bank Erosion:	Moderate
Sediment deposits:	None
Stream Order:	3

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	80	95	5

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	5
Pebble:	10
Gravel:	10
Sand:	65
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	65 – 90%

Comments: Terrestrial debris was abundant. Trees in the riparian zone provided good canopy cover. Moderate erosion reduced the overall condition to moderate.

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Wandoan Coal Project

Survey Date: 07/08/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Mud Creek

Health: M

frc site number 16

UTM Zone 55K 780723 E 7120888 N WGS84

				
Aggradation of fine sediment	Pool downstream of the road	Terrestrial debris provided habitat	Some large trees helped to stabilise banks	Cattle have direct access to the creek

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	3.5
Mean Depth (m):	0.5
Flow Level:	Low
Bank Erosion:	Limited
Sediment deposits:	Sludge
Stream Order:	2

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid/ Opaque
Water colour:	Brown

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	10	100	
Riparian Vegetation	90	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	100
Pool (rocky):	
Pool (sandy):	
Dry:	
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	2
Pebble:	3
Gravel:	5
Sand:	80
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	10 – 35%
Detritus:	35 – 65%

Comments: The banks were steep, although trees helped to stabilise the banks. Cattle have direct access to the creek and there was a relatively low amount of in-stream habitat diversity. Moderate condition.

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Wandoan Coal Project

Survey Date:	07/08/07		
Written By:	TS	Approved By:	LT
Date Issued:	28/09/2007		

Spring Creek

Cond.

M

frc site number 17

UTM Zone 55K 772346 E 7120241 N WGS84

				
Fallen logs and branches would provide habitat	The banks were relatively stable	Exposed tree roots would provide habitat	Trees lined parts of the channel	

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	3.0
Mean Depth (m):	
Flow Level:	None
Bank Erosion:	Limited
Sediment deposits:	None
Stream Order:	1

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	90	80	20

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	
Dry:	100
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	
Gravel:	
Sand:	90
Silt/Clay:	10

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	65 – 90%

Comments: Small first-order stream that had some in-stream habitat diversity. Trees grew along only parts of the channel. Cattle and horses have access to the channel. Moderate condition for a small first order stream.

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Wandoan Coal Project

Survey Date: 7/08/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Un-named Tributary of Spring Creek

Cond. **M**

frc site number 18

UTM Zone 55K 771815 E 7118558 N WGS84


Erosion at the confluence of two tributaries


There were few trees in the riparian zone


Many of the banks were bare and eroded


Cattle have access to the channel

Channel Habitat

Morphology

Flow Regime:	
Channel Width (m):	2.5
Mean Depth (m):	0.1
Flow Level:	No flow
Bank Erosion:	Extensive
Sediment deposits:	None
Stream Order:	2

Water Quality

Water Odour:	None
Water Foaming:	None
Water Oils:	None
Turbidity:	Turbid/ Opaque
Water colour:	

Flora and Fauna

Vegetation

	Percent Cover	Percent Native	Percent exotic
Macrophytes	0		
Riparian Vegetation	70	90	10

Macroinvertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	–	–	na	na
PET Richness	–	–	na	na
Signal 2 Index	–	–	na	na

Habitat (%)

Riffle:	
Run:	
Pool (rocky):	
Pool (sandy):	7
Dry:	93
Edge:	
Overall Complexity:	

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	
Gravel:	
Sand:	80
Silt/Clay:	20

Substrate Cover

Periphyton:	
Moss:	
Filametous algae:	
Macrophytes:	
Detritus:	35 – 65%

Comments: Erosion was extensive at this site, and cattle had access to the creek. There was only one large tree in the riparian zone that would stabilise banks and provide in-stream habitat. Poor condition.

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Wandoan Coal Project

Survey Date: 7/8/07
Written By: TS Approved By: LT
Date Issued: 28/09/2007

Un-named Tributary of Spring Creek

frc site number 19
UTM Zone 55K 771794 E 7118787 N WGS84

Cond.
P


View downstream through the channel


View upstream through the channel


View of left bank


View of right bank


Grasses, sedges and trees grew on the banks

Channel Habitat

Morphology

Channel Width (m):	6
Mean Depth (m):	0.5
Water Level:	No flow
Bank Erosion:	Limited
Sediment Deposits:	Sand
Catchment Position:	Midland
Adjacent landuse:	Grazing
Stream order:	3

Water Quality

Temperature (°C):	27.6
pH:	6.7
Conductivity (uS/cm):	259
DO (% Sat):	59
Turbidity (NTU):	159
Water Odour:	Nil
Water Oils:	Slick

Habitat (%)

Riffle:	-
Run:	-
Pool:	80
Edge:	10
Dry:	20
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	5
Sand:	45
Silt/Clay:	50

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	3
Dominant Type:	Exotic
Canopy Cover (%):	5

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	8	6	-	NA
PET Richness	3.5	3.3	-	NA
Signal 2 Index	1	1	-	NA

Substrate Cover (%)

Periphyton:	10–35
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	None
Trailing Bank Vegetation:	None
Dominant type:	Grasses and sedges
Bank stability:	Moderately unstable

Comments: Within MLA50230 (southeastern); downstream reaches heavily vegetated; woody debris and detritus provided cover for fauna; riparian vegetation dominated by grasses and sedges but included several eucalypts; upstream pool dominated by filamentous algae and periphyton; upstream corrugated iron fence and triple culvert road crossing obstructed flow during recent flood event; banks ~0.75m high.

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Wandoan Coal Project

Frank Ck

Survey Date:	13-03-08	Date Issued:	April 2008
Written By:	K.M.	Approved By:	L.T.

frc site number 1 (reconnaissance site S3)
UTM Zone 55K 792,788 E 7,107,102 N WGS84

Habitat Score

M

View downstream through the channel

View upstream through the channel

View of left bank

View of right bank

A variety of substrates provided cover

Channel Habitat

Morphology

Channel Width (m):	4
Mean Depth (m):	0.4
Water Level:	No flow
Bank Erosion:	Extensive
Sediment Deposits:	Sand
Catchment Position:	Midland
Adjacent landuse:	Grazing
Stream order:	2

Water Quality

Temperature (°C):	25.0
pH:	7.1
Conductivity (uS/cm):	528
DO (% Sat):	78
Turbidity (NTU):	550
Water Odour:	Nil
Water Oils:	Nil

Habitat (%)

Riffle:	-
Run:	-
Pool:	15
Edge:	-
Dry:	85
Overall Complexity:	Low

Substrate (%)

Bedrock:	5
Boulder:	5
Cobble:	10
Pebble:	5
Gravel:	10
Sand:	55
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Native
Canopy Cover (%):	25

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	13	9	-	NA
PET Richness	2.5	2.3	-	NA
Signal 2 Index	1	1	-	NA

Substrate Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	10–35
Detritus:	35–65

Bank Cover

Streambank Cover (%):	50–79
Overhanging Vegetation:	Moderate
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses and sedges
Bank stability:	Unstable

Comments: Within MLA50231 (southwestern); woody debris and detritus provided cover; riparian vegetation dominated by grasses and sedges but included several eucalypts; series of isolated pools; variety of substrate available as cover for fauna; downstream barbed wire fence and bridge pylons obstructed flow during recent flood event; banks ~3 m high.

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Wandoan Coal Project

Survey Date:	13-03-08	Date Issued:	April 2008
Written By:	K.M.	Approved By:	L.T.

One Arm Man Ck

frc site number 2 (reconnaissance site S8)

UTM Zone 55K 785,971 E 7,104,359 N WGS84

Habitat Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank (downstream of road)	View of right bank	Culverts were 90% blocked with flood debris

Channel Habitat

Morphology

Channel Width (m):	6
Mean Depth (m):	0.5
Water Level:	No flow
Bank Erosion:	Moderate
Sediment Deposits:	None
Catchment Position:	Midland
Adjacent landuse:	Grazing
Stream Order:	4

Water Quality

Temperature (°C):	27.7
pH:	6.1
Conductivity (uS/cm):	280
DO (% Sat):	112
Turbidity (NTU):	510
Water Odour:	Nil
Water Oils:	Nil

Habitat (%)

Riffle:	-
Run:	-
Pool:	50
Edge:	20
Dry:	30
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	5
Cobble:	10
Pebble:	10
Gravel:	10
Sand:	55
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Native
Canopy Cover (%):	30

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	7	2	-	NA
PET Richness	2.7	3.6	-	NA
Signal 2 Index	1	0	-	NA

Substrate Cover (%)

Periphyton:	10–35
Moss:	None
Filamentous algae:	None
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	Moderate
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses and sedges
Bank stability:	Moderately unstable

Comments: Within MLA50231 (northern); large pool upstream of road crossing and series of isolated pools downstream of road crossing; the three small culverts in the road crossing substantially impeded flow during recent flood event and continue to do so; log piles, bent-over casuarinas, flipped slabs of bedrock and erosion indicate high velocity flood event; riparian vegetation included several native trees.

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Wandoan Coal Project

Survey Date:	12-03-08	Date Issued:	April 2008
Written By:	K.M.	Approved By:	L.T.

Woleebee Ck

frc site number 3 (reconnaissance site S11)
UTM Zone 55K 786,688 E 7,111,284 N WGS84

Habitat Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	A log jam indicated recent flood event

Channel Habitat

Morphology

Channel Width (m):	2
Mean Depth (m):	0.5
Water Level:	No flow
Bank Erosion:	Moderate
Sediment Deposits:	Sand
Catchment Position:	Midland
Adjacent landuse:	Grazing
Stream order:	4

Water Quality

Temperature (°C):	27.9
pH:	7.1
Conductivity (uS/cm):	399
DO (% Sat):	86
Turbidity (NTU):	2,500
Water Odour:	Nil
Water Oils:	Slick

Habitat (%)

Riffle:	-
Run:	-
Pool:	50
Edge:	2
Dry:	48
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	10
Cobble:	10
Pebble:	5
Gravel:	20
Sand:	45
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Exotic
Canopy Cover (%):	10

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	14	4	-	NA
PET Richness	2.7	2.0	-	NA
Signal 2 Index	1	0	-	NA

Substrate Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	None

Bank Cover

Streambank Cover (%):	50–79
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	None
Dominant type:	Grasses and sedges
Bank stability:	Moderately stable

Comments: Within MLA50229 (western); cattle have accessed creek bed; mostly cleared riparian zone; very turbid water; log jam indicated flood event; large boulders provided cover for fauna and bed stability; heavy erosion along left bank; dirt road crossing prevents flow during periods of low water.

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Wandoan Coal Project

Survey Date: 12-03-08
Written By: K.M. Approved By: L.T.
Date Issued: April 2008

Woleebee Ck

frc site number 4 (reconnaissance site S12)
UTM Zone 55K 787,623 E 7,115,657 N WGS84

Habitat Score

M

				
View downstream through the channel	View upstream (from the left bank)	View of left bank	View of right bank	Prickly pear in the riparian zone

Channel Habitat

Morphology

Channel Width (m):	4
Mean Depth (m):	0.3
Water Level:	No flow
Bank Erosion:	Extensive
Sediment Deposits:	Sand
Catchment Position:	Upland
Adjacent landuse:	Grazing
Stream Order:	3

Water Quality

Temperature (°C):	25.3
pH:	7.36
Conductivity (uS/cm):	388
DO (% Sat):	108.8
Turbidity (NTU):	83.2
Water Odour:	Nil
Water Oils:	Slick

Habitat (%)

Riffle:	-
Run:	-
Pool:	70
Edge:	10
Dry:	30
Overall Complexity:	Low

Substrate (%)

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

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	5
Dominant Type:	Mixed
Canopy Cover (%):	50

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	10	-	NA
PET Richness	3.0	2.8	-	NA
Signal 2 Index	0	0	-	NA

Substrate Cover (%)

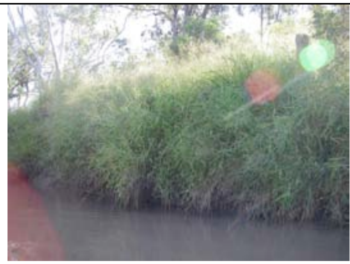
Periphyton:	None
Moss:	None
Filamentous algae:	<10
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	50 – 75
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses and sedges
Bank stability:	Moderately unstable

Comments: Within MLA 50229 (northern). Moved downstream of reconnaissance site due to access issues and location of waterhole. Cattle have access to creek, and paddock fence crossing may trap debris and restrict water flow and faunal passage at times. Large woody debris and detritus provide habitat and food.

frc environmental deep thinking. science.	Wandoan Coal Project	Mud Ck	Habitat Score
	Survey Date: 13-03-08 Date Issued: April 2008	frc site number 5 (reconnaissance site S15)	M
	Written By: T.S. Approved By: L.T.	UTM Zone 55K 776,976 E 7,116,943 N WGS84	

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	The road crossing did not have culverts

Channel Habitat

Morphology

Channel Width (m):	3.5
Mean Depth (m):	1.0
Water Level:	No flow
Bank Erosion:	Limited
Sediment Deposits:	None
Catchment Position:	Midland
Adjacent landuse:	Light Grazing

Water Quality

Temperature (°C):	29.1
pH:	6.3
Conductivity (uS/cm):	129
DO (% Sat):	99.4
Turbidity (NTU):	304
Water Odour:	Nil
Water Oils:	Nil
Stream Order:	2

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Edge:	30
Dry:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	2
Pebble:	3
Gravel:	5
Sand:	80
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	7 - 10
Dominant Type:	Exotic
Canopy Cover (%):	15

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	5	-	NA
PET Richness	2.7	2.8	-	NA
Signal 2 Index	1	0	-	NA

Substrate Cover (%)

Periphyton:	<10
Moss:	<10
Filamentous algae:	<10
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses
Bank stability:	Moderately stable

Comments: Within MLA 50229 (western). Grasses heavily dominate the riparian zone. Little large woody debris in-stream to provide habitat. No culvert at the road crossing so water pooled upstream of the road.

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Wandoan Coal Project

Survey Date:	13-03-08	Date Issued:	April 2008
Written By:	T.S.	Approved By:	L.T.

Spring Ck

frc site number 6 (reconnaissance site S17)

UTM Zone 55K 772,324 E 7,120,292 N WGS84

Habitat Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	Detritus provided habitat

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	5	Temperature (°C):	20.8
Mean Depth (m):	1.0	pH:	6.5
Water Level:	No flow	Conductivity (uS/cm):	264
Bank Erosion:	Moderate	DO (% Sat):	20.3
Sediment Deposits:	Gravel / Silt	Turbidity (NTU):	20.5
		Water Odour:	Nil
Catchment Position:	Midland	Water Oils:	Slick
Adjacent Land-use:	Grazing	Stream Order:	4

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	90	Cobble:	-
Edge:	30	Pebble:	-
Dry:	10	Gravel:	10
Overall Complexity:	Low	Sand:	80
		Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Native
Canopy Cover (%):	30

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	18	2	-	NA
PET Richness	2.9	3	-	NA
Signal 2 Index	2	0	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	<10	Streambank Cover (%):	50 – 80
Moss:	<10	Overhanging Vegetation:	Extensive
Filamentous algae:	10–35	Trailing Bank Vegetation:	Moderate
Macrophytes:	10–35	Dominant type:	Grasses
Detritus:	10–35	Bank stability:	Moderately unstable

Comments: Moderate bioassessment score; just upstream of MLA50230 (southeastern). Woody debris, tree roots and detritus provides cover; steep banks are heavily vegetated by grass but riparian vegetation includes eucalypts and melaleucas. Isolated pools contain some deb risd from bridge construction and some rubbish.

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Wandoan Coal Project

Survey Date: 13-03-08
Written By: T.S. Approved By: L.T.
Date Issued: April 2008

Juandah Ck

frc site number 7 (reconnaissance site S10)
UTM Zone 55K 792,928 E 7,113,108 N WGS84

Score
M


View downstream across road


View upstream through the channel


View of left bank


View of right bank


Rotting filamentous algae floated on the surface

Channel Habitat

Morphology

Channel Width (m):	4
Mean Depth (m):	0.8
Water Level:	Low
Bank Erosion:	Little
Sediment Deposits:	Silt
Catchment Position:	Upper
Adjacent landuse:	Grazing
Stream Order:	2

Water Quality

Temperature (°C):	22.7
pH:	6.6
Conductivity (uS/cm):	246
DO (% Sat):	55.0
Turbidity (NTU):	28
Water Odour:	Nil
Water Oils:	Nil

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Edge:	100
Dry:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	10
Silt/Clay:	90

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	<2
Dominant Type:	Exotic
Canopy Cover (%):	5

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	12	3	-	NA
PET Richness	3.5	3	-	NA
Signal 2 Index	3	0	-	NA

Substrate Cover (%)

Periphyton:	<10
Moss:	<10
Filamentous algae:	35-65
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Moderate
Dominant type:	Grasses and weeds
Bank stability:	Moderately stable

Comments: Moderate bioassessment score; upstream of MLA50229 (western). Riparian zone dominated by grasses and weeds; few trees and little canopy cover; isolated pool with no flow; filamentous algae abundant, with rotting algae floating on the surface; some detritus and trailing bank vegetation to provide in-stream habitat.

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Wandoan Coal Project

Survey Date: 13-03-08
Written By: T.S. Approved By: L.T.
Date Issued: April 2008

Mt Organ Ck

frc site number 8 (not surveyed during reconnaissance)

UTM Zone 55K 773,822 E 7,111,490 N WGS84

Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	Substrate included cobbles, pebbles and gravel.

Channel Habitat

Morphology

Channel Width (m):	4
Mean Depth (m):	0.3
Water Level:	No flow
Bank Erosion:	Moderate
Sediment Deposits:	Sand
Catchment Position:	Midland
Adjacent landuse:	Light Grazing

Water Quality

Temperature (°C):	33.6
pH:	6.9
Conductivity (uS/cm):	355
DO (% Sat):	140
Turbidity (NTU):	60
Water Odour:	Nil
Water Oils:	Nil
Stream order:	5

Habitat (%)

Riffle:	-
Run:	-
Pool:	40
Edge:	5
Dry:	60
Overall Complexity:	Low

Substrate (%)

Bedrock:	5
Boulder:	5
Cobble:	-
Pebble:	-
Gravel:	20
Sand:	50
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	5
Dominant Type:	Native
Canopy Cover (%):	1

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	13	15	-	NA
PET Richness	3.0	2.8	-	NA
Signal 2 Index	3	3	-	NA

Substrate Cover (%)

Periphyton:	<10
Moss:	<10
Filamentous algae:	<10
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Nil
Dominant type:	-
Bank stability:	Moderately unstable

Comments: Moderate bioassessment score; downstream of MLAs. Riparian vegetation includes melaleucas, casuarinas and eucalypts; banks were eroded on the outside of bends; large and small woody debris and rocks provided in-stream habitat. Sand was deposited upstream of the bridge.

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Wandoan Coal Project

Survey Date:	13-03-08		
Written By:	T.S.	Approved By:	L.T.
Date Issued:	April 2008		

Juandah Ck

frc site number 9 (not surveyed during reconnaissance)

UTM Zone 55K 789,131 E 7,117,414 N WGS84

Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	Flood debris was trapped on the bridge pylons

Channel Habitat

Morphology

Channel Width (m):	20
Mean Depth (m):	1.0
Water Level:	Low
Bank Erosion:	Moderate
Sediment Deposits:	Sludge
Catchment Position:	Lowland
Adjacent Land-use:	Light Grazing

Water Quality

Temperature (°C):	21.4
pH:	6.4
Conductivity (uS/cm):	200
DO (% Sat):	33.1
Turbidity (NTU):	120
Water Odour:	Nil
Water Oils:	Nil
Stream order:	5

Habitat (%)

Riffle:	-
Run:	-
Pool:	90
Edge:	20
Dry:	10
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	10
Pebble:	10
Gravel:	10
Sand:	30
Silt/Clay:	40

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	20
Dominant Type:	Native
Canopy Cover (%):	5

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	8	3	-	NA
PET Richness	3.9	4.0	-	NA
Signal 2 Index	0	0	-	NA

Substrate Cover (%)

Periphyton:	<10
Moss:	<10
Filamentous algae:	<10
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	50 – 80
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses and trees
Bank stability:	Moderately stable

Comments: Moderate bioassessment score; downstream of MLAs. Wooden bridge over creek has trapped debris during flood; dirt track crossing downstream of the bridge has small pipe culvert that restricts flow; large woody debris, bridge, trailing bank vegetation and detritus provide in-stream habitat; riparian zone includes grasses, melaleucas, coolabahs, eucalypts and acacias.

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Wandoan Coal Project

Survey Date: 13-03-08
Written By: T.S. Approved By: L.T.
Date Issued: April 2008

Juandah Ck

frc site number 10 (not surveyed during reconnaissance)

UTM Zone 55K 781,537 E 7,156,707 N WGS84

Score

M

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

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	3	Temperature (°C):	-
Mean Depth (m):	0	pH:	-
Water Level:	Dry	Conductivity (uS/cm):	-
Bank Erosion:	-	DO (% Sat):	-
Sediment Deposits:	None	Turbidity (NTU):	-
Catchment Position:	Lowland	Water Odour:	-
Adjacent Land-use:	-	Water Oils:	-
		Stream order:	-

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	-
Edge:	-	Pebble:	-
Dry:	100	Gravel:	-
Overall Complexity:	Low	Sand:	20
		Silt/Clay:	80

Flora and Fauna

Riparian Vegetation

Riparian Width (m): 20
Dominant Type: Native
Canopy Cover (%): 40

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	-	-	-	NA
PET Richness	-	-	-	NA
Signal 2 Index	-	-	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	None	Streambank Cover (%):	-
Moss:	None	Overhanging Vegetation:	Dominant
Filamentous algae:	None	Trailing Bank Vegetation:	None
Macrophytes:	None	Dominant type:	Trees <10m
Detritus:	10–35	Bank stability:	Moderate

Comments: -

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Wandoan Coal Project

Survey Date: 20-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Stakeyard Creek

frc site number Gas supply pipeline site 2

UTM Zone 55K 202926 E 7127009 N WGS84

Score

M

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

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	25	Temperature (°C):	-
Mean Depth (m):	0	pH:	-
Water Level:	Dry	Conductivity (uS/cm):	-
Bank Erosion:	-	DO (% Sat):	-
Sediment Deposits:	None	Turbidity (NTU):	-
Catchment Position:	Lowland	Water Odour:	-
Adjacent Land-use:	Crops, grazing	Water Oils:	-
		Stream order:	-

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	-
Edge:	-	Pebble:	-
Dry:	100	Gravel:	-
Overall Complexity:	Low	Sand:	30
		Silt/Clay:	70

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10 - 25
Dominant Type:	Native
Canopy Cover (%):	15

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	-	-	-	NA
PET Richness	-	-	-	NA
Signal 2 Index	-	-	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	None	Streambank Cover (%):	-
Moss:	None	Overhanging Vegetation:	Trace
Filamentous algae:	None	Trailing Bank Vegetation:	Trace
Macrophytes:	None	Dominant type:	Grass, trees
Detritus:	35-65	Bank stability:	Moderate

Comments: Small first-order stream. Impacted by adjacent cropping and grazing. Small farm dam on channel.

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Wandoan Coal Project

Survey Date: 20-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Unnamed tributary of Roche Creek

frc site number Gas supply pipeline site 3

UTM Zone 55K 800129 E 7123615 N WGS84

Score

M

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

Channel Habitat

Morphology

Channel Width (m):	8
Mean Depth (m):	0.15
Water Level:	Low
Bank Erosion:	-
Sediment Deposits:	Island, Span
Catchment Position:	Lowland
Adjacent Land-use:	Grazing

Water Quality

Temperature (°C):	12.7
pH:	6.7
Conductivity (uS/cm):	154.2
DO (% Sat):	61.4
Turbidity (NTU):	-
Water Odour:	-
Water Oils:	-
Stream order:	-

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Edge:	-
Dry:	-
Overall Complexity:	Low

Substrate (%)

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

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Native
Canopy Cover (%):	10

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	9	-	NA
PET Richness	1	0	-	NA
Signal 2 Index	3.1	2.1	-	NA

Substrate Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	10–35

Bank Cover

Streambank Cover (%):	-
Overhanging Vegetation:	None
Trailing Bank Vegetation:	None
Dominant type:	Grass, trees
Bank stability:	Moderate

Comments: The channel is split with 1 dry and 1 wet. Flood debris is present directly upstream from culvert. Lots of cattle in the surrounding area. There is a fence 90 metres from the culvert.

frc environmental
deep thinking. science.

Wandoan Coal Project

Survey Date: 27-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Roche Creek

Score

M

frc site number 4a

UTM Zone 55K 798409 E 7120029 N WGS84

View downstream through the channel

View upstream through the channel

View of left bank

View of right bank

Channel Habitat

Morphology

Channel Width (m):	6
Mean Depth (m):	0.10
Water Level:	Low
Bank Erosion:	-
Sediment Deposits:	Mid span
Catchment Position:	Lowland
Adjacent Land-use:	Grazing

Water Quality

Temperature (°C):	13.4
pH:	7
Conductivity (uS/cm):	9
DO (% Sat):	94
Turbidity (NTU):	-
Water Odour:	-
Water Oils:	-
Stream order:	-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Edge:	-
Dry:	100
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	20
Silt/Clay:	80

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	5
Dominant Type:	Native
Canopy Cover (%):	5

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	9	-	NA
PET Richness	1	1	-	NA
Signal 2 Index	3.3	2.2	-	NA

Substrate Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	10–35

Bank Cover

Streambank Cover (%):	-
Overhanging Vegetation:	None
Trailing Bank Vegetation:	None
Dominant type:	Grass, shrubs, trees
Bank stability:	Moderate

Comments: There is a fence upstream from the culvert and there is lots of cattle in the surrounding area. In flood conditions site 4b and 4b would connect. Kangaroo and birds were observed at the site.

frc environmental
deep thinking. science.

Wandoan Coal Project

Survey Date: 20-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Anabranch of Roche Creek

frc site number Gas supply pipeline site 4b

UTM Zone 55K 798292 E 7119397 N WGS84

Score

P

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

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	6	Temperature (°C):	-
Mean Depth (m):	0	pH:	-
Water Level:	Dry	Conductivity (uS/cm):	-
Bank Erosion:	-	DO (% Sat):	-
Sediment Deposits:	None	Turbidity (NTU):	-
Catchment Position:	Lowland	Water Odour:	-
Adjacent Land-use:	Flood plain	Water Oils:	-
		Stream order:	-

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	-	Cobble:	-
Edge:	-	Pebble:	-
Dry:	100	Gravel:	-
Overall Complexity:	Low	Sand:	40
		Silt/Clay:	60

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	15
Dominant Type:	Native
Canopy Cover (%):	5

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	-	-	-	NA
PET Richness	-	-	-	NA
Signal 2 Index	-	-	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	None	Streambank Cover (%):	-
Moss:	None	Overhanging Vegetation:	Detritus
Filamentous algae:	None	Trailing Bank Vegetation:	None
Macrophytes:	None	Dominant type:	Grass, shrubs, trees
Detritus:	<10		
		Bank stability:	High

Comments: Dry gully, connected by a small pipe under the road. Gently sloping banks to flood plain on the right. The upper bank of the flood plain is on the left.

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Wandoan Coal Project

Survey Date: 27-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Unnamed Tributary of Juandah Creek

frc site number Gas supply pipeline site 6

UTM Zone 55K 797467 E 7116939 N WGS84

Score

M

				
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank	Tree roots stabilise bank

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	7	Temperature (°C):	11.5
Mean Depth (m):	0.3	pH:	7.5
Water Level:	Low	Conductivity (uS/cm):	219
Bank Erosion:	-	DO (% Sat):	118.1
Sediment Deposits:	Side bars	Turbidity (NTU):	-
Catchment Position:	Lowland	Water Odour:	-
Adjacent Land-use:	Grazing	Water Oils:	-
		Stream order:	-

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	20	Cobble:	-
Edge:	-	Pebble:	-
Dry:	80	Gravel:	-
Overall Complexity:	Low	Sand:	15
		Silt/Clay:	85

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	5 – 10
Dominant Type:	Native
Canopy Cover (%):	-

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	-	7	-	NA
PET Richness	-	0	-	NA
Signal 2 Index	-	3.2	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	None	Streambank Cover (%):	-
Moss:	None	Overhanging Vegetation:	Sub-dominant
Filamentous algae:	None	Trailing Bank Vegetation:	Trace
Macrophytes:	None	Dominant type:	Grass, trees
Detritus:	35-65	Bank stability:	Moderate

Comments: Large creek with steep banks. Large eucalyptus trees stabilise the banks. Cattle have damaged the creek bed and banks.

frc environmental
deep thinking. science.

Wandoan Coal Project

Survey Date: 20-08-08
Written By: T.S. Approved By: L.T.
Date Issued: September 2008

Juandah Creek

frc site number Gas supply pipeline site 7
UTM Zone 55K 794977 E 7112624 N WGS84

Score
M

Attachment B Introduction to the Data Analyses Used

Habitat Bioassessment Scores

The standard Habitat Bioassessment Score datasheets (DNRM 2001) were used to numerically assess nine 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**

Macro-invertebrate Indices

Aquatic macro-invertebrates 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. Macro-invertebrates 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 macro-invertebrates 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 macro-invertebrate 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 macro-invertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macro-invertebrate 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 macro-invertebrate 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.

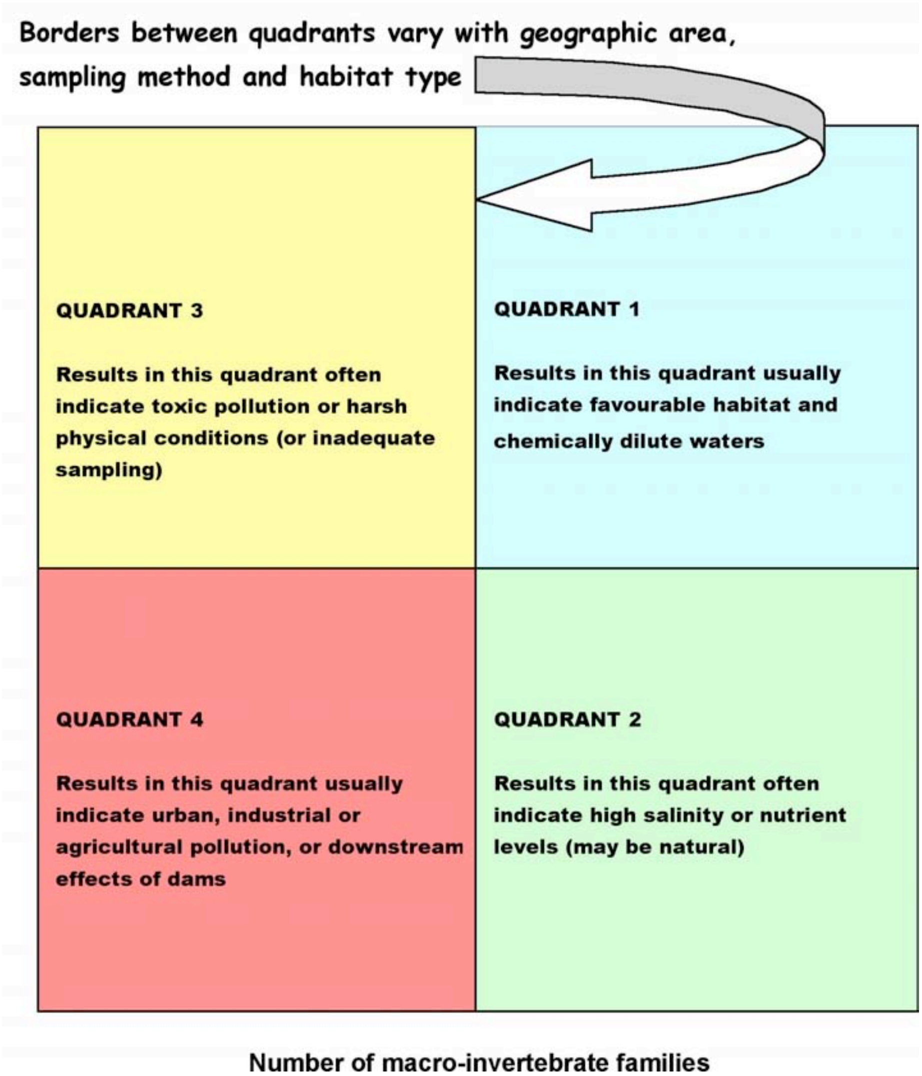


Figure B.1 The quadrant diagram for the family version of SIGNAL 2 (Chessman 2003).

Attachment 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

R Lomasick

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

Fisheries

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.

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:

- ☑ 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

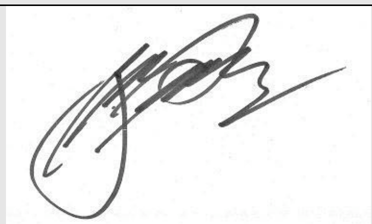
ANZCCART 2001, *Euthanasia of Animals Used for Scientific Purposes,* ed. J.S. Reilly, Australian and New Zealand Council for the Care of Animals in Research and Teaching, Adelaide.

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.

	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

ecoaccess
environmental licences & permits

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.

Environmental Protection Agency
www.epa.qld.gov.au ABN 87 221 158 786

Queensland Government
Environmental Protection Agency
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