Australia Pacific LNG Project

Volume 2: Gas Fields

Chapter 9: Water Quality and Aquatic Ecology

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9.1 Introduction

9.1.1 Purpose

This chapter assesses the aquatic habitat, flora and fauna, water quality and fluvial geomorphology associated with the proposed development of the coal seam gas (CSG) fields (the gas fields) and associated infrastructure as part of the Australia Pacific LNG Project (the Project). This assessment includes a description of existing values within the gas fields' study area, identification of the potential impacts on these values from proposed construction and operation activities, as well as strategies to mitigate and monitor these impacts.

The study area is principally within the Condamine-Balonne and Dawson River catchments, with a portion of the southern gas fields (Gilbert Gully) within the Border Rivers catchment as shown in Figure 9.1.

Key issues considered in this chapter are:

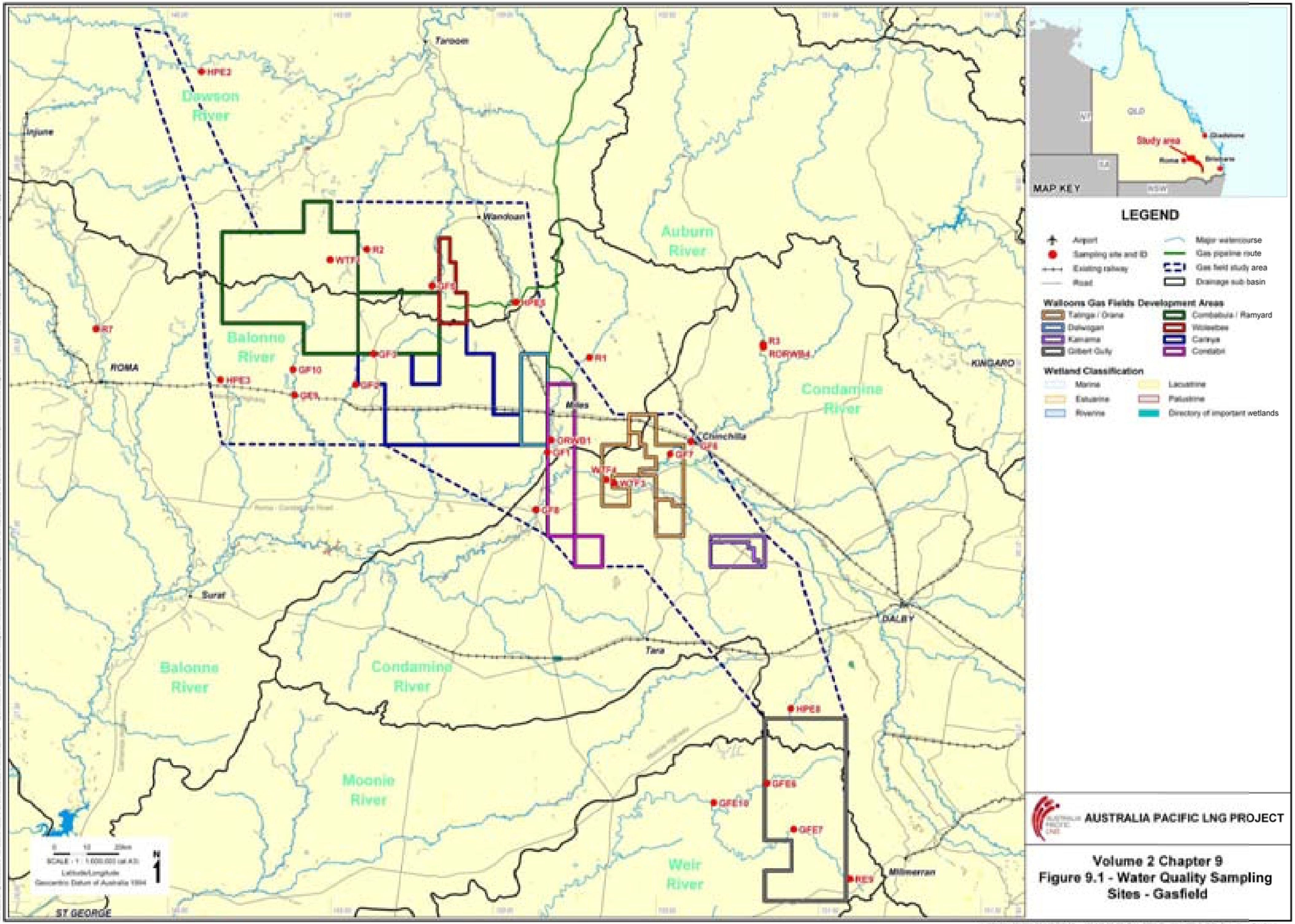
- Water quality
- Freshwater fish
- Aquatic macroinvertebrates
- Aquatic habitats and macrophytes
- Fluvial geomorphology.

All phases of the proposed gas fields' development, including site preparation, construction, operation, decommissioning and rehabilitation, have the potential to affect aquatic environments and their living natural resources. Australia Pacific LNG's sustainability principles, will guide the development of management measures to avoid and minimise potentially adverse impacts on the aquatic environment. Of Australia Pacific LNG's 12 sustainability principles, those that will guide management of aquatic environments and their associated communities and processes include:

- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas.
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

Hydrobiology's technical assessment (2009) forms the basis of this chapter and is presented in Volume 5 Attachment 17.

Ecological issues associated with mammals, reptiles, amphibians and riparian/terrestrial vegetation within the study area are addressed in Volume 2 Chapter 8.



Volume 2 Chapter 9
Figure 9.1 - Water Quality Sampling Sites - Gasfield

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9.1.2 Scope of work

Information presented in this chapter is based on field investigations supplemented by literature reviews and searches of relevant databases. Dry season ecological, geomorphic and water quality sampling surveys have been completed and will be supplemented by a wet season survey program, planned for early 2010.

In accordance with the environmental impact statement (EIS) terms of reference for the Project, the objectives of the field surveys and related investigations and analysis were to:

- Describe the existing water quality within areas potentially affected by the proposed gas fields in terms of values identified in Environmental Protection (Water) Policy 2009 and the Queensland Water Quality Guidelines (Department of Environment and Resource Management (DERM) 2009)
- Characterise the aquatic flora and fauna (fish, macroinvertebrates and macrophytes) and key habitats occurring within areas potentially affected by the proposed gas fields, including groundwater dependent ecosystems and any exotic/weed species
- Identify rare, threatened or otherwise noteworthy aquatic flora and fauna species, communities and habitats occurring within areas potentially affected by the proposed gas fields, including matters of national environmental significance (under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* – the EPBC Act)
- Describe the existing geomorphic condition (including physical integrity, fluvial processes and morphology) of watercourses occurring within areas potentially affected by the proposed gas fields
- Identify and assess potential impacts on aquatic ecology, water quality and fluvial geomorphology during the construction, operation and decommissioning phases
- Identify measures to avoid and/or mitigate adverse impacts to aquatic ecology, water quality and fluvial geomorphology, where possible
- Identify strategies to manage any residual impacts following mitigation
- Identify appropriate monitoring programs to assess the effectiveness of proposed management strategies during construction, operation and decommissioning of the proposed gas fields.

9.1.3 Legislative framework

Environment Protection and Biodiversity Conservation Act

The EPBC Act provides for the protection of matters of national environmental significance. The Act requires that a proposal must be referred to the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) if it has the potential to have a significant impact on such matters.

An EPBC referral for the gas fields' element of the Australia Pacific LNG Project was lodged with DEWHA on 6 July 2009 (Referral Number: 2009/4974) for a determination as to whether this element of the proposal constitutes a controlled action requiring formal assessment under the EPBC Act. On 3

August 2009, the gas fields' element of the Project was declared a 'controlled action' as a consequence of potential impacts on Wetlands of international importance (Sections 16 and 17B), Listed threatened species and ecological communities (Sections 18 and 18A) and Listed migratory species (Sections 20 and 20A)

Without suitable impact mitigation, the gas fields' element of the Project has the potential to affect the following aquatic matters of national environmental significance:

- *Maccullochella peelii peelii* (Murray cod)
- The Narran Lakes Wetland Complex
- Great Artesian Basin (GAB) spring communities – specifically, *Eriocaulon carsonii* (salt pipewort or button grass) and *Myriophyllum artesium* (artesian milfoil).

Environment Protection Act

The Queensland *Environment Protection Act 1994* provides for sustainable resource development while protecting ecological processes. The Act regulates 'environmentally relevant activities'. An environmental authority is required to carry out an environmentally relevant activity, which is a petroleum activity.

The Environmental Protection (Water) Policy 2009 addresses relevant objectives of the *Environmental Protection Act 1994* for Queensland waters through the establishment of 'environmental values' and 'water quality objectives'. With no specific environmental values or water quality objectives currently established for any catchments within the study area, the Queensland Water Quality Guidelines (2009) are relevant.

The *Environmental Protection Regulation 2008* supports the EIS process and specifies environmentally relevant activities prescribed under the Act. It outlines matters the administering authority must consider when making environmental management decisions and also details prescribed water contaminants.

Water Act

The Queensland *Water Act 2000* provides for the sustainable planning and management of water and other resources by establishing a system for the planning, allocation and use of water. Approval is required under Section 266 of the Act for the following activities, unless these are carried out under a licence, petroleum lease or ATP under the *Petroleum and Gas (Production and Safety) Act 2004*:

- Any works in a watercourse that cause vegetation loss or damage
- Excavation or placement of fill in a watercourse, such as for road or pipeline crossings.

The Queensland water resource planning process, under the *Water Act 2000*, provides the framework for the sustainable allocation of water for human consumptive needs and environmental values.

The Water Resources (Condamine – Balonne) Plan 2004 identifies the 'environmental flow objectives' for the Condamine River. The Plan requires water abstractors to be licensed in accordance with the Resource Operations Plan to protect surface water flows and provide compensation flows to the Narran Lakes Nature Reserve Ramsar Site. Similar water resources plans have been developed for and apply to the Border Rivers and Fitzroy River catchments.

The Water Resource (Great Artesian Basin) Plan 2006 provides for sustainable management of groundwater in the GAB. It requires licensing of water abstractors to satisfy criteria for protection of the flow of water to springs and baseflow to watercourses stated in the Resource Operations Plan.

A water licence or permit is required from DERM under the *Water Act 2000* to take, interfere with or use water for an activity that is not authorised by the petroleum tenure, or for activities outside the area of the petroleum tenure. For use of associated water, other than for petroleum activities, a development approval for re-use of regulated waste may be required, unless covered by a general or specific approval under the Waste Regulation. Australia Pacific LNG will have general approval for the beneficial use of a resource if it complies with the standards in the Operational Policy for the Management of Water Produced in Association with Petroleum Activities (Associated Water) (DERM 13 December 2007) or can apply to DERM for specific approval for the beneficial use.

Fisheries Act

The *Fisheries Act 1994* (Fisheries Act) promotes ecological sustainability through accountability in terms of the use, conservation and enhancement of the community's fish resources and fish habitats. All waters of the State are protected against degradation by direct and indirect impact under Section 125 of the Fisheries Act.

Construction of waterway barrier works, such as road crossings, pipeline crossings and culverts that limit fish stock access and movement, require a development approval under the *Sustainable Planning Act 2009* assessed against the relevant provisions of the Fisheries Act.

Nature Conservation Act

The *Nature Conservation Act 1992* provides for the conservation and management of Queensland's native animals and plants. The Nature Conservation (Wildlife) Regulation 2006 classifies and details the management intent for plants and animals that are presumed extinct, or considered endangered, vulnerable, rare, near threatened or of least concern. Taking or interfering with protected flora and fauna listed under the Act requires a permit. This includes moving or relocating a protected species.

9.2 Methodology

A desktop review of relevant literature and existing data, along with field reconnaissance surveys, were undertaken to identify water bodies within the study area likely to contain important ecological values and to locate suitable sampling points.

Sampling sites were selected based on habitat features, accessibility and availability of water. Representative examples of stream types, habitats and ecological features were selected to enable the range of potential aquatic impacts to be assessed. Reference sites were also chosen, where possible. Additional sampling sites were included in late August in response to refinements to the high pressure gas pipeline network.

Waterbodies were sampled from late June through to early October 2009. Each site, where site access was granted, was surveyed once for aquatic ecology, once for fluvial geomorphology and twice for water quality. Although the field investigations are based on a single dry season survey (ecology and geomorphology) and two sampling events (water quality), a further round of wet season sampling is proposed (rainfall dependent). Results of the field surveys have been supplemented with background information for the study area. Additional results will be reported as field data becomes available.

Details of the sampling program and methods are provided in Volume 5 Attachment 17.

9.2.1 Water quality

Field measurements and surface grab samples were taken to assess water quality. Data were described in terms of existing environmental values and water quality objectives established under the Environment Protection (Water) Policy 1997, Australia and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) guidelines for the protection of aquatic ecosystems (ANZECC/ARMCANZ 2000) and the Queensland Water Quality Guidelines (DERM 2009).

Comparisons were also made to other relevant published and unpublished information.

9.2.2 Fish and macrocrustaceans

Fish sampling was achieved by electrofishing, in accordance with the Australian Code of Electrofishing Practice (New South Wales Fisheries Management 1997), and deployment of baited traps. Both types of fishing were conducted in accordance with requisite permitting conditions.

Fish and macrocrustaceans were identified to species level, and counted, in the field. Fish were classified as native, exotic, threatened, endemic or rare. Available information on species was reviewed to assess sensitivities to flow and water quality.

9.2.3 Macroinvertebrates

Macroinvertebrates were collected from edge/backwater and bed habitats (where available) in accordance with AusRivAS (Environment Australia 2001) and DERM Stream and Estuarine Assessment Program protocols. Macroinvertebrates were generally identified to family level. Chironomids (non-biting midges) were identified to sub-family level, in accordance with standard AusRivAS protocols (Environment Australia 2001).

Stream invertebrate grade number – average level – 2 (SIGNAL2) scores were calculated according to Chessman (2003). To enable a comprehensive assessment of macroinvertebrate community structure and function as well as potential flow/sediment related responses, macroinvertebrate communities were also described in terms of the following:

- Flow and substrate sediment preference groups (using indices developed for the ‘Stream and Estuarine Assessment Program’)
- Total species richness
- Plecoptera-Ephemeroptera-Trichoptera (PET) richness
- Functional feeding group proportions.

9.2.4 Fluvial geomorphology

An adapted version of the Murray Darling Basin Commission (MDBC) rapid assessment method (MDBC 2003) was used to rate reach-based habitat/geomorphic condition. This technique provided a comprehensive habitat assessment and enabled comparisons with other 'State of the River's and Australian river Assessment System (AusRivAS) assessed sites within the three catchments of interest. The use of this technique included assessment of:

- Physical channel condition (e.g. channel size, shape, stability, type, occurrence, degree of erosion, stream order, bed and bank material)
- Riparian condition
- Influential factors (e.g. artificial features, factors affecting bank stability, land use).

An additional investigative geomorphic field assessment was conducted near proposed water discharge points.

9.2.5 Aquatic habitat

Aquatic habitat was assessed using information provided on the AusRivAS habitat sampling field sheet and the geomorphic assessment proforma. Aquatic habitat was described in terms of channel diversity and in-stream features, surrounding land use, presence and composition of aquatic macrophytes, riparian zone condition and connectivity, shading and presence of in-stream debris. Macrophytes were described in terms of relative diversity, aquatic habitat condition, presence of exotic species and presence of any endangered, rare or otherwise noteworthy species.

9.3 Existing environment

The Project area is principally within the Condamine-Balonne and Dawson River catchments, with a portion of the southern gas fields, Gilbert Gully, within the Border Rivers catchment. Waterways across this region typically contain little or no flow for much of the year except for the wetter, summer months (December to March).

Sites throughout the study area were either dry or had receded to a series of unconnected pools at the time of sampling. The only exception to this was site HPE2 on the upper Dawson River, which was presumed to be spring fed.

9.3.1 Water quality

Regional overview

The dominant land uses in the Condamine-Balonne catchment are cattle and sheep grazing and to a lesser extent irrigated cropping, rural residential and urban development. Extensive land clearing in combination with land use practices, highly variable and intense rainfall and dispersive soils has contributed to the elevated sediment and nutrient levels within the waterways (Condamine-Balonne Water Committee (CBWC) et al. 2002). Clayton et al. (2008) stated that due to historical clearing of streamside vegetation and introduction of weed species such as willow, riparian condition, wetland condition and water quality were identified as major issues in the catchment. Point sources such as feedlots, piggeries, sewage outflows and landfills have also delivered concentrated loads of nutrients, sediments, and other contaminants to waterways, resulting in localised differences in water quality, habitat quality and biodiversity.

The Fitzroy catchment has extensive mineral deposits and highly fertile soils and therefore supports a large number of mines (particularly coal) and high level of agricultural production. The catchment has also been heavily impacted by stock, loss of riparian vegetation, diffuse pollution and numerous weirs and dams which have modified flow regimes and contributed to reduced water quality (Department of Natural Resources 1998). Water quality in the Fitzroy catchment is characterised by low to moderate conductivity levels, high turbidity and, suspended solids and increased nutrients (Fitzroy Basin Association 2008). Monitoring by DERM has also found elevated metals at various sites within the Fitzroy Basin.

The Border Rivers catchment is characterised by waters of low conductivity, moderate turbidity and moderate concentrations of Chlorophyll a. Total phosphorus and nitrogen oxide varies throughout the catchment, with low concentrations reported in the upper McIntyre River near Stanthorpe, to moderate concentrations in the Weir and Moonie Rivers (Department of Natural Resources 1999).

Field survey results

Water quality at the 15 sites monitored in the Condamine-Balonne catchments was moderate to poor with turbidity, ammonia, total nitrogen and total phosphorus levels generally exceeding the Queensland Water Quality Guidelines. Dissolved oxygen concentrations were generally lower than the Guidelines' range of 90 to 110 % saturation at all sites during the surveys, with conductivity within guideline levels for all sites. Water acidity (pH) also varied across the sites.

The two waterways monitored in the Dawson River catchment (which drains to the Fitzroy River) exhibited similar water quality with elevated turbidity, ammonia, total nitrogen and total phosphorus compared with the relevant guidelines for Central Coast upland rivers prescribed in the Guidelines (DERM 2009). Conductivity in these waterways was less than the prescribed trigger level, whilst pH and dissolved oxygen were within or close to the relevant levels.

Aluminium and copper concentrations were often greater than the ANZECC/ARMCANZ (2000) 95%[1] protection level for biota. This could be a result of the combination of regional geology and anthropogenic sources. All other metals monitored were within ANZECC/ARMCANZ guidelines. Hydrocarbons and pesticides were not present in detectable concentrations at any of the sites sampled.

Water quality generally reflected the impact of land use in the Condamine-Balonne and Dawson River catchments (vegetation clearance and grazing of livestock in areas with naturally dispersive soils). Water quality was consistent with other investigations, showing the typical seasonal variability of water quality in sub-tropical intermittent waterways (e.g. Fitzroy Basin Association 2008; Lee et al. 1999; CBWC 2002).

Water quality was not determined for the Border Rivers catchment owing to a lack of surface water during the period of this assessment.

9.3.2 Fish and macrocrustaceans

Regional overview

Notable species of fish occur in the catchments draining the study area including Murray cod, purple-spotted gudgeon, silver perch, Agassiz's olive perchlet, saratoga, leathery grunter and Darling River

[1] Trigger values developed from a probability distribution of aquatic toxicity end-points. The 95% protection/trigger levels are intended to protect 95% of species in the defined habitat type.

hardyhead. Of these, only Murray cod is listed under the EPBC Act with Darling River hardyhead and silver perch listed on the IUCN [2] Redlist of Threatened Species. Saratoga is endemic to the upper reaches of the Fitzroy River system (Allen et al. 2002).

In all, 28 native and three exotic fish species (common carp, goldfish and gambusia) have been recorded from these catchments as reported in Table 9.1 below.

Table 9.1 Presence of fish species previously recorded in the Condamine-Balonne, Border and Dawson catchments

Species	Common name	Condamine-Balonne[1]	Border[2]	Dawson[3]
Nematalosa erebi	Bony bream	✓	✓	✓
Hypseleotris spp.	Carp gudgeon	✓	✓	✓
Philypnodon grandiceps	Flathead gudgeon	✓	-	✓
Hypseleotris klunzingeri	Western carp gudgeon	✓	-	-
Hypseleotris sp. A	Midgley's gudgeon	✓	-	-
Mogurnda adspersa	Purple-spotted gudgeon	✓	-	-
Hypseleotris galii	Firetail gudgeon	✓	-	-
Melanotaenia splendida	Eastern rainbowfish	-	-	✓
Melanotaenia duboulayi	Crimson-spotted rainbowfish	✓	-	-
Melanotaenia fluviatilis	Murray River rainbowfish	✓	✓	-
Maccullochella peeli peeli	Murray cod	✓	✓	-
Macquaria ambiqua	Golden perch / yellowbelly	✓	✓	✓
Galaxias olidus	Mountain galaxias	✓	-	-
Tandanus tandanus	Freshwater catfish	✓	✓	✓
Neosilurus hyrtlii	Hyrtl's tandan	✓	-	-
Pseudomugil signifer	Pacific blue-eye	-	-	✓
Retropina semoni	Australian smelt	✓	✓	-
Leiopotherapon unicolor	Spangled perch	✓	✓	✓
Craterocephalus amiculus	Darling River hardyhead	✓	✓	-
Neoarius graeffei	Lesser salmon catfish	-	-	✓
Ambassis agassizii	Agassiz's olive perchlet	✓	✓	✓

[2] The International Union for the Conservation of Nature and Natural Resources (IUCN) is the world's main authority on the conservation status of species. The IUCN Red List is an inventory of the global conservation status of plant and animal species.

Species	Common name	Condamine-Balonne[1]	Border[2]	Dawson[3]
Bidyanus bidyanus	Silver perch	✓	-	-
Amniataba percoides	Barred grunter	-	-	✓
Scortum hilii	Leathery grunter	-	-	✓
Scleropages leichardti	Saratoga / spotted barramundi	-	-	✓
Hypseleotris compressa	Empire gudgeon	-	-	✓
Glossamia aprion	Mouth almighty	-	-	✓
Oxyeleotris lineolata	Sleepy cod	-	-	✓
Cyprinus carpio	Common carp	✓	✓	-
Carassius auratus	Goldfish	✓	✓	-
Gambusia holbrooki	Gambusia	✓	✓	-

[1] FRC 2009; Hydrobiology 2006; Ecology Management (EM) 2005 and 2008; Hagedoorn and Smallwood 2007
[2] Raw data provided by Dr Stephen Balcombe (Griffith University)
[3] Berghuis and Long 1999

Habitat requirements and sensitivity of some of the significant fish species known to occur in the Condamine-Balonne, Dawson and Border river catchments are provided in Table 9.2. Most species found in these catchments, including less significant species, appear to prefer slow water habitats and tolerate turbid conditions characteristic of the study area waterways during dry season conditions.

Field survey results

Fish surveys at the 16 sites in the Condamine-Balonne and Dawson River catchments yielded 1,898 fish belonging to 15 species (12 native and three exotic). Native fish were more abundant than exotic species at the 16 sites sampled except Dogwood Creek (R1) as shown in Table 9.3. *Hypseleotris* spp. (gudgeon) was the most common species encountered.

A total of 95 macrocrustaceans, belonging to three species, was recorded throughout the Condamine-Balonne and Dawson catchments, with red claw, a translocated species, encountered at three of the sites.

No rare, endangered or otherwise noteworthy fish or macrocrustaceans were recorded from the sites.

Table 9.2 Significant fish species known to be found in the Condamine-Balonne, Dawson and Border river catchments

Species	Common Name	Distribution and abundance	Habitat and food	Sensitivity/significance
Maccullochella peeli peeli	Murray cod	Formerly abundant throughout most of Murray-Darling Basin, but now uncommon. Migrates (up to 120km) upstream to spawn. Spawns in spring and early summer when temperatures exceed 15°C	Prefers deep holes and habitats with instream cover (eg. large woody debris, undercut banks or overhanging vegetation). Diet consists of fish, crayfish and frogs.	Listed as vulnerable under the EPBC Act 1999. Habitat destruction through sedimentation, altered flow regimes, overfishing and thermal pollution have contributed to declining numbers. Culturally very important to local indigenous groups as a food source and in mythology. Favoured by recreational fishers and regularly stocked in many localities within the Murray-Darling catchment.
Bidyanus bidyanus	Silver perch	Originally present throughout Murray-Darling Basin, now restricted to upper reaches. Not expected to occur upstream of Dalby-Chinchilla	Prefers areas of rapid flow in rivers, lakes and reservoirs. Diet consists of insects, molluscs, phytoplankton and annelid worms.	Numbers have declined significantly. Listed as vulnerable on the IUCN Red List. Potential threats include river regulation (migration barriers). Tolerates a wide temperature range. Irregularly stocked in many localities within the Murray-Darling catchment.
Mogurnda adspersa	Purple-spotted gudgeon	Known to be present in coastal streams from northern NSW to north Qld. Common in coastal Qld, but its distribution within the Murray-Darling Basin is restricted to a few rivers on the NSW/QLD border, including the Condamine. Spawn in summer when temperatures exceed 20°C.	Benthic species, usually associated with rocks or riffles in slow moving or still waters of creeks, wetlands, rivers and billabongs. Diet consists of small fish, worms, aquatic insects and tadpoles. Requires hard substrate for breeding.	Numbers have declined significantly in recent years. Potential threats include altered flow regimes and predation by exotic species. Listed as least concern (IUCN and NCR) in Queensland due to secure populations in coastal areas. Listed under State legislation of New South Wales (endangered), Victoria (extinct) and South Australia (extinct) and recent submission to the Commonwealth Government have recommended protection of these species within the Murray- Darling Basin through formal listing of these species under the EPBC Act 1999.

Species	Common Name	Distribution and abundance	Habitat and food	Sensitivity/significance
		Females spawn several times during a spawning season. Males guard the nest and developing fry and breed less frequently.		
Ambassis agassizii	Agassiz's glassfish (Olive perchlet)	Known to be present in coastal streams from northern NSW to north Queensland. Only known from a few localities in the Darling River Basin (upstream of Bourke), but locally abundant in Condamine-Balonne and Border Rivers.	Prefers vegetated edges of lakes, creeks, swamps, wetlands and rivers. Often associated with snags and aquatic vegetations. Diet consists of microcrustaceans, aquatic and terrestrial insects (including mosquitos), small arachnids and small fish.	Numbers have declined significantly in recent years. Potential threats include altered flow regimes, cold water pollution and predation by exotic species. Listed under State legislation of New South Wales (endangered), Victoria (extinct) and South Australia (extinct) and recent submission to the Commonwealth Government have recommended protection of this species within the Murray-Darling Basin through formal listing of these species under the EPBC Act 1999.
Scleropages leichardti	Saratoga, spotted barramundi	Endemic to upper reaches of Fitzroy (Dawson) River System, where it is relatively uncommon.	Prefers billabongs or pools in slow flowing, turbid streams. Diet consists of frogs, fish, invertebrates and crustaceans.	Not listed as threatened, but endemic and uncommon in Fitzroy Basin. Favoured by recreational fishers and populations maintained in several impoundments in Queensland by stocking.
Scortum hilii	Leathery grunter	Endemic to upper reaches of Fitzroy (Dawson) River System, where it is reported to be uncommon.	Prefers freshwater streams and still pools in clear or turbid water. Specialised feeder. Diet consists of mostly mussels and algae.	Not listed as threatened, but endemic and uncommon in Fitzroy Basin.

Species	Common Name	Distribution and abundance	Habitat and food	Sensitivity/significance
Craterocephalus amniculus	Darling River hardyhead	Relatively common but confined to upper reaches of Darling River near NSW-Queensland border. Spawns mid to late summer	Prefers slow flowing, shallow, clear water in small creeks and streams with good vegetation. Diet consists of macroinvertebrates and microcrustaceans.	Listed as Vulnerable on the IUCN Redlist. Potential threats include water abstraction, altered flow regimes, habitat destruction and predation and or competition from exotic species.

References: Allen et al. (2002); Faulks et al. (2008); Lintermans (2009).

Table 9.3 Fish and macrocrustacean diversity and abundance recorded during dry season surveys

Fish species	Common name	Condamine / Balonne														Dawson	
		R7	GF10	GF9	GF3	GF2	R1	GF1	GF8	WTF4	WTF3	GF7	GF6	RORWB4	R3	HPE2	GF5
Nematalosa erebi	Bony bream	21	12		2	1		1	47	26	2	1		34			
Carassius auratus	Gold fish	12	47		2	1	26		1			5					
Cyrinus carpio	Common carp				1							3					
Hypseleotris spp.	Gudgeon	4	44		4	18	11		31	15	5	11		1187	3	2	
Philypnodon granidceps	Flathead gudgeon									2							
Melanoteania fluviatilis	Murray River rainbowfish		1						2								
Macquaria ambiqua	Golden perch / yellowbelly						5		6	1	1	2				1	
Tandanus tandanus	Freshwater catfish															1	
Gambusia holbrooki	Eastern mosquitofish		6			3	10		36	28	5	1	6	29	9		
Pseudomugil signifer	Pacific blue-eye															1	
Retropinna semoni	Australian smelt					3	2		27	6	3		76	22			
Leiopotherapon unicolor	Spangled perch	2	6		1	1	1		3	9							
Crustacean species	Common name																
Macrobrachium sp.	Prawns															65	
Cherax quadricarinatus	Red claw	11			4												10
Cherax sp.	Crayfish									3			2				

Note: Shaded rows indicate exotic or translocated species

9.3.3 Macroinvertebrates

Macroinvertebrate samples were collected at 16 sites during the dry season in the Condamine-Balonne (14 sites) and Dawson catchments (two sites). Suitable edge habitat was only available at some sites; nine in the Condamine-Balonne catchment and two in the Dawson catchment. All sites located in the Border Rivers Catchment were dry at the time of sampling.

Taxa richness ranged between 13 and 35 species at each site sampled, with four sites registering three or more PET taxa. PET taxa are considered to be those macroinvertebrate orders most sensitive to pollution. PET scores of more than four at a given site are generally indicative of good water quality and aquatic habitat. Applying these criteria, no sites surveyed during the dry season contained macroinvertebrate communities that would typically reflect good water quality and habitat conditions. Table 9.4 shows the taxa richness, abundance and PET scores for each site.

Table 9.4 Summary data for macroinvertebrates collected from edge samples during dry season monitoring

Site	Abundance	Richness	Number of PET taxa
R7	52	16	1
GF9	207	24	1
GF3	58	15	3
GF2	299	35	3
GF1	74	15	0
GF8	97	23	4
WTF4	139	30	4
WTF3	85	13	2
GF7	141	24	2
GF5	327	28	3

The 'stream invertebrate grade number – average level – 2' (SIGNAL2) is a scoring system designed to reflect water quality and ecosystem health. Macroinvertebrates collected from the study area during dry season sampling were indicative of assemblages subject to high salinity or nutrient levels, or urban, industrial or agricultural pollution and/or downstream effects of dams. Given the water quality results recorded (Section 9.3.1) and observations of aquatic habitat (Section 9.3.5), it is possible that the SIGNAL2 values reflect elevated turbidity and nutrient levels typical of intermittent flow regimes.

Macroinvertebrate functional feeding groups provide another means of assessing broad-scale aquatic ecosystem health. Specialist feeders (such as shredders and scrapers) are generally more sensitive to environmental disturbance whilst generalist feeders (such as predators, gatherers, filter feeders and scavengers) are less sensitive to such changes (Rawer-Jost et al. 2000). Of those sites monitored during the dry season, three sites (WTF3, WTF4 and GF8) on the Condamine River had the highest proportions of shredders and one site (GF1) on Dogwood Creek had a high proportion of scrapers. Overall, however, all sites were dominated by less sensitive taxa (refer to Figure 9.2).

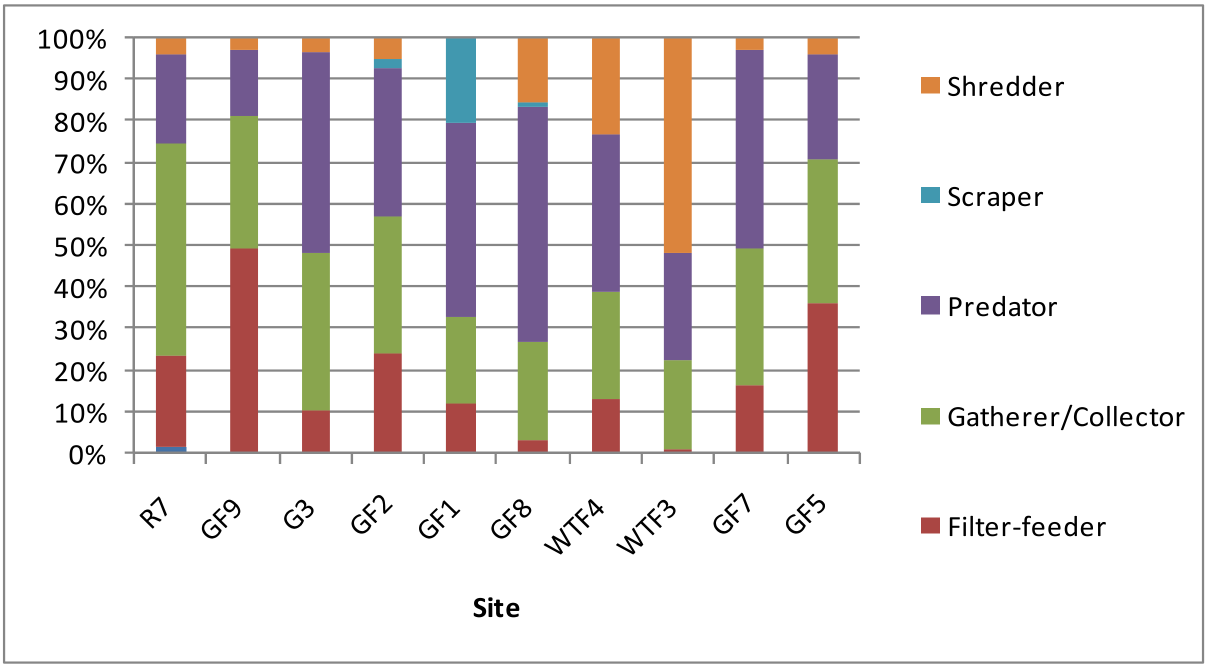


Figure 9.2 Relative proportion of functional feeding groups

The available information from the dry season monitoring, indicates reasonably diverse assemblages of generalist feeders, and therefore more tolerant species, across the study area. These findings are consistent with results from previous macroinvertebrate assessments.

9.3.4 Fluvial geomorphology

A detailed climatic and hydrological description of the study area and a broad-scale assessment revealed the following:

- Summer-dominated flows occur within the catchments.
- Flow varies greatly between years
- Waterways within the study area are characterised by extended periods of no to low flow
- Waterways within the study area are generally intermittent although remnant pools can persist through the dry season, particularly in the waterway mainstems.

The detailed climatic and hydrological description of the study area is provided in Volume 2 Chapter 4 and Volume 2 Chapter 11, respectively.

The Condamine River in the study area is generally considered to exhibit mobile and meandering characteristics as described by Whittington et al. (2001). Geomorphic change in the form of in-channel ingressions (increased sediment supply and reduced bed variability) may be occurring in response to water extractions and land-use practices. Most reaches surveyed had limited channel diversity owing to sediment accumulation on the channel bed. The reaches that flowed through or adjacent to the study area were generally highly disturbed. These disturbed conditions were less pronounced in the southern Condamine tributaries within the Gilbert Gully region.

The Dawson catchment watercourses within the study area exhibited similar geomorphic characteristics that can be related to adjacent land clearance, water extraction and agricultural land use. Increased erosion from waterway banks, related increased sediment loads and resultant channel ingressions and decreased geomorphic variability have been described by Telfer (1995). National Land and Water Resource Audit (2001) states that the sediment loads of the Dawson and its southern tributaries may be 10 to 50 times greater than those experienced under natural conditions.

All reaches surveyed in the Border Rivers catchment were highly disturbed with major in-filling evident at most sites.

9.3.5 Aquatic habitat, macrophytes and wetlands

Aquatic habitat

Most of the 27 sites assessed throughout the Condamine, Balonne, Dawson and Border rivers had poor or very poor quality aquatic habitat.

Five sites located in the Condamine-Balonne catchment and one site on the Upper Dawson River had a good aquatic habitat rating. These good ratings were the result of good channel and habitat diversity, minimal surrounding land use impact and good riparian connectivity and shading. The reference site located on Dogwood Creek (R1) was the only site to record an aquatic habitat rating of high.

Macrophytes

Very few macrophytes were recorded during the surveys – none were notable, rare or priority species. Macrophytes were observed at the following sites:

- Yuleba Creek – Condamine-Balonne catchment (GF9): *Phragmites australis* (common reed), covering approximately 1% of the creek margins
- Tchanning Creek – Condamine-Balonne catchment (GF2): *Cyperacea* spp. (sedges) and the exotic weed *Urochloa mutica* (para grass), covering approximately 1% of the creek margins
- Charleys Creek and Rocky Creek – Condamine-Balonne catchment (GF6 and GF6a): *Ludwigia* spp., covering about 20% of the instream habitat and creek margins Wooleebee Creek – Dawson catchment (GF5): *Cyperacea* spp. (sedges), covering about 1% of the creek margins.

It is possible that the low diversity and abundance of aquatic macrophytes observed during the dry season survey may be at least partly a consequence of the timing of the observations, although they are generally consistent with other studies indicating limited abundance of macrophytes within the Fitzroy catchment (Noble et al. 1997; Telfer 1995).

Wetlands

Several wetlands of national importance occur within the Condamine-Balonne river catchment, of which only two – Lake Broadwater (located 25km south-west of Dalby) and the Balonne River Floodplain complex, including the Ramsar listed Narran Lakes in the lower Balonne – are relevant to the study area.

Numerous GAB spring wetlands are also located within and adjacent to the gas fields.

Narran Lakes

Narran Lakes Nature Reserve is located approximately 500km downstream of the proposed gas fields and has an area of about 5,500ha. Narran Lakes form part of a large terminal wetland of the Narran River (at the end of the Condamine River) in NSW and is listed as a wetland of international importance under the Ramsar Convention. The lakes are internationally significant for waterbird breeding and as habitat for species including a number listed under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA).

Narran Lakes Nature Reserve is also listed as a wetland of national importance as a major breeding site for waterbirds, and contains a variety of flora associations considered to be threatened in New South Wales. Adequate inundation of the lakes reserve is of fundamental importance for maintenance of waterbird breeding.

Lake Broadwater

Lake Broadwater is situated at the border of the Condamine Valley and its water is supplemented by flows from Wilkie Creek and Broadwater Gully in the south-west and the Condamine River from the south via the Long Swamp – a series of swampy flood flow channels that fill during Condamine River floods.

Lake Broadwater is listed on the Directory of Important Wetlands as being a good example of a semi permanent freshwater lake in an area where these are rare (DEWHA 2008). The lake also supports seasonally diverse and abundant flora and fauna, including species protected under JAMBA and CAMBA. Lake Broadwater is located outside of the gas fields tenements, but a small component of the proposed Gilbert Gully gas field is located within the catchment and is connected to the lake via the floodplain.

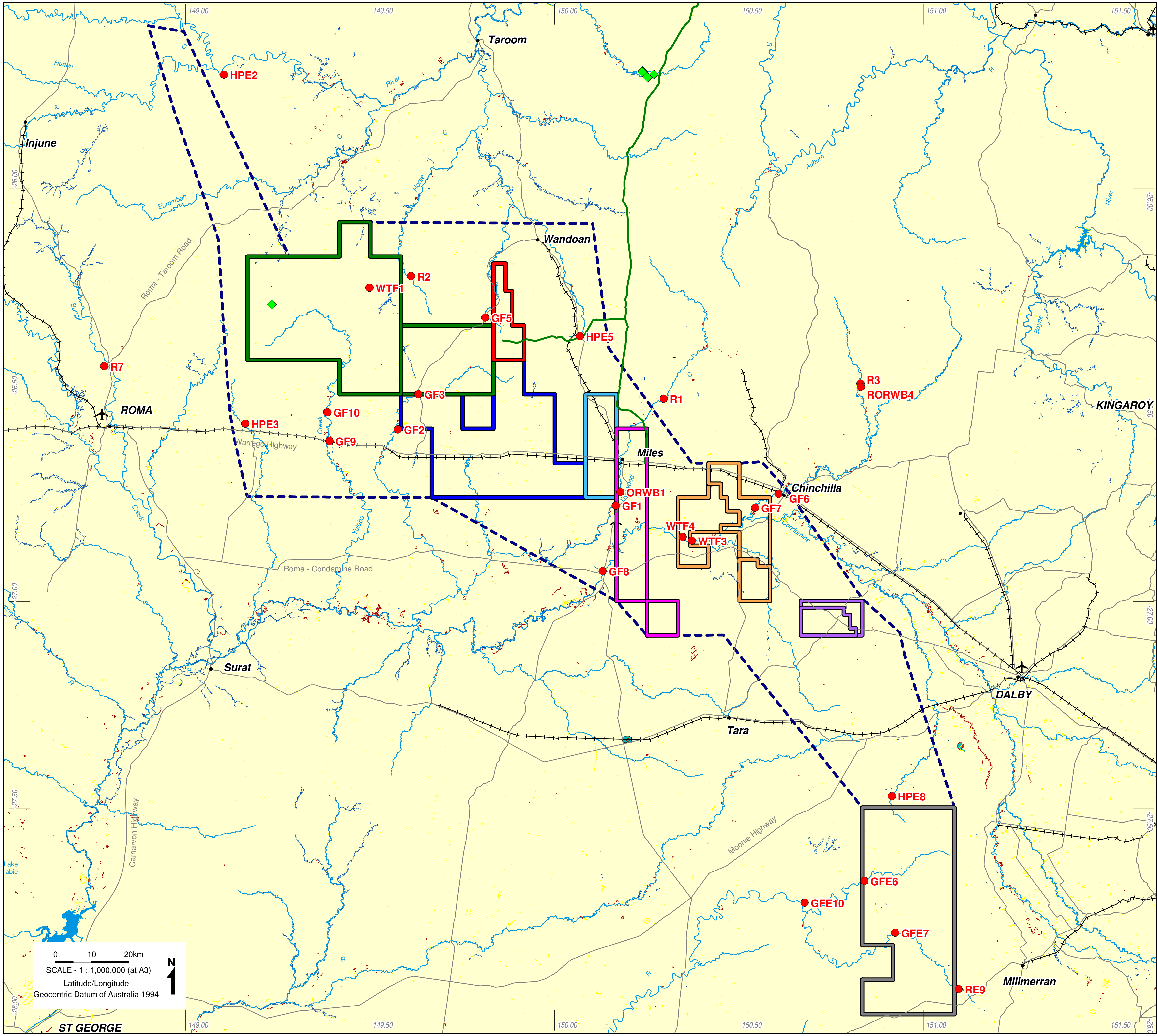
Great Artesian Basin spring wetlands

Great Artesian Basin spring wetlands occur on the outer edge of the GAB in Queensland, New South Wales and South Australia. The communities of native species dependent on the natural discharge of groundwater from the GAB are listed as an endangered community under the EPBC Act 1999. A number of these species are also listed under the Queensland *Nature Conservation Act 1992* or the IUCN Redlist. Of these, two species of plant (artesian milfoil and salt pipewort) are known to occur within the Springsure Supergroup (DEWHA 2001).

The study area is located within one of twelve Supergroup complexes – specifically the Springsure Supergroup, Brigalow Belt Complex (EPA 2005; Fensham et al. 2004).

Salt pipewort requires flowing mound springs with alkaline soil. The species is highly opportunistic with regular colonisation and extinction events occurring within spring complexes. Local extinctions have been linked to competition with other plants (DEWHA 2001). Salt pipewort has been impacted by reduced flow, trampling by feral animals and excavation (EPA 2005).

Artesian milfoil has also only been found in wetlands fed by flowing artesian water (Fensham et al. 2004). Although neither of these species was found during the field surveys, for the purposes of the impact assessment it was assumed that these communities are present where there are actively flowing mound springs. The location of known springs in relation to the gas fields' development footprint is provided in Figure 9.3.



LEGEND

- Airport
- Sampling site and ID
- Mapped spring complex
- Existing railway
- Road
- Major watercourse
- Gas pipeline route
- Gas field study area

Walloons Gas Fields Development Areas

- Talinga / Orana
- Dalwogan
- Kainama
- Gilbert Gully
- Combabula / Ramyard
- Woleebee
- Carinya
- Condabri

Wetland Classification

- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine
- Directory of important wetlands

Source Information

Queensland Wetland Data Version 1.2 - Wetlands
Environmental Protection Agency 2008
Queensland Wetland Data Version 1.2 - Springs
Queensland Herbarium, Environmental Protection Agency 2008
Wetlands - Directory of Important
Department of Environment and Resource Management 2009
Gas pipeline route
Supplied by Origin Energy on 03/11/2009

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Figure 9.3 - Location of known artesian spring communities

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9.4 Potential impacts

The potential impacts to water quality, aquatic ecology and fluvial geomorphology were assessed for each of the impact mechanisms associated with construction and operational activities. Risks to the aquatic environment were estimated using an assessment of the consequences (including vulnerability) and likelihood of an impact occurring (see Volume 1 Chapter 4). The residual risk after mitigation measures have been implemented was categorised as either low, medium, high, severe, or extreme (refer to Section 9.6.1). The extent of potential impacts was also assessed on local and regional scales.

The potential impacts and risks are detailed in Volume 5 Attachment 17.

9.4.1 Construction

Waterways could be impacted during the construction phase through the installation of gas wells, temporary accommodation facilities, water storages, water treatment facilities, roads, pipelines, gas processing facilities and associated infrastructure.

Increased delivery of sediments and nutrients to watercourses

The main impact mechanism likely to affect the aquatic environment during this phase is sediment mobilisation. The most likely causes of sediment mobilisation will be earthworks adjacent to watercourses and the construction of open-cut pipeline trenches and road crossings within watercourses. Sediment impacts are expected to be potentially more severe in habitats characterised by lower turbidity, such as spring-fed streams as fauna and flora in these habitats are generally adapted to clear-water conditions. Watercourse crossing construction could temporarily increase sediment mobilisation through a combination of heavy equipment use and trampling effects in the vicinity of banks and the removal of riparian vegetation in the creation of right of way corridors or access tracks. Sediment from side-cast materials from pipeline trenches that are positioned near waterways could also be mobilised if heavy rainfall occurs during construction. Increased delivery of sediments and nutrients to watercourses can result in:

- Degraded water quality through increased turbidity, suspended solids and nutrients
- Decreased light penetration, leading to reduced primary production
- Scouring of fine-scale habitat structure, such as egg-laying surfaces
- Smothering or in-filling of fine-scale benthic habitat (such as interstitial spaces) and food resources
- Introductions of noxious riparian or aquatic weeds associated with vehicles and machinery
- Introductions or translocation of aquatic fauna (fish and macroinvertebrates) associated with vehicles, machinery and uncontrolled fishing practices (for example, use of exotic species as live bait)
- Modification of in-stream habitat resulting in reduced habitat diversity and habitat fragmentation
- Scouring downstream and deposition upstream of road crossings
- Raised bed levels (altered channel capacity) and increased flood levels resulting from increased sedimentation within the channel
- Bank instabilities resulting from raised bed levels and altered flow hydraulics.

Excavation and vegetation clearing within and adjacent to watercourses will be required for construction of road and pipeline crossings. Sediment control measures, in accordance with regulatory requirements, will be strictly adhered to throughout the construction phase to ensure any impacts will be mitigated.

Disturbance to notable fish species

Notable fish species occur within the Condamine-Balonne, Dawson and Border rivers catchments, although none were caught during surveys. The Murray cod, listed under the EPBC Act, is re-stocked for angling purposes.

These notable species typically inhabit waters with high turbidity and total suspended solids levels. Construction activities could further increase total suspended solids, turbidity and sediment delivery. Most streams in the study area are intermittent, and are dry or recede to a series of unconnected pools for a large part of the year. Therefore, appropriate timing of construction activities and implementation of erosion control measures should reduce the potential for sediment-related impacts.

There may also be some localised effects associated with temporary diversion of perennial watercourses during road and crossing construction. However, impacts are likely to be short term and rapid species re-colonisation/recovery is expected. Assuming that suitably designed road crossings are constructed (i.e. clear span bridges or large box culverts), impacts to fish passage should be minimal.

Disturbance to threatened artesian spring communities

The EPBC-listed salt pipewort and artesian milfoil are known to be associated with artesian springs within vicinity of the gas fields, and more specifically, the section of the proposed high pressure pipeline between Spring Gully and Fairview. Increased delivery of sediments and nutrients associated with road or pipeline crossings could reduce light availability and smother habitats. However, based on the proposed location of the high pressure pipeline network, and given that actively flowing discharge springs will be avoided, the likelihood of impacts occurring is low.

Temporary diversion of watercourses

The temporary diversion of watercourses during construction of road and pipeline crossings could enhance sediment transport and present a short-term barrier to fish passage. Most streams in the study area are intermittent and, assuming that construction is timed to avoid forecasted wet weather, the potential for impacts would be low. In permanently flowing streams, there could be some short-term impacts associated with sediment mobilisation. Sediments might accumulate upstream of the crossing and scouring could occur downstream of the crossing. However, with implementation of measures as incorporated into the environmental management plans, any impacts are likely to be localised and temporary.

Direct removal of flora

Riparian vegetation will need to be cleared at right of way watercourse crossings during construction, which could result in reduced habitat diversity and habitat fragmentation. Riparian vegetation was generally found in poor to moderate condition throughout the study area and direct species related impacts (e.g. physical removal) are likely to be minimal and localised. Very few aquatic macrophytes are likely to be present within watercourses, particularly during the dry season, and no notable macrophyte species are known to occur in the study area. Impacts associated with removal of aquatic macrophytes during construction are therefore likely to be low.

Chemical or wastewater contamination

Accidental chemical and wastewater spills associated with the gas fields are possible as a result of storage and handling of oils, diesel, petrol and grease, drilling fluids, sewage wastewater or other construction chemicals. Chemicals and untreated wastewater is toxic to biota. However, with effective environmental management procedures, the risk is considered low.

Increased bank erosion

Overland runoff and resultant gullying is already a common occurrence throughout the study area, particularly in cleared sections. Initiation or exacerbation of gullying (and resulting sediment-laden runoff and bank instabilities) due to inadequate drainage control, is a concern during construction, particularly in banks consisting of highly erodible soils (cracking/dispersive clays). Potential impacts include:

- Bank instabilities, including gully initiation or enhancement
- Increased sediment delivery to channel
- Reduction in channel capacity
- Smothering of riffle habitat
- Pool infilling
- Reduction in bed sediment particle size variability.

With effective design prior to construction and the implementation of appropriate erosion and sediment control measures from exposed areas, the risk of these types of impacts occurring is low.

Trenching and re-laying of bank and bed sediments

During construction, potential impacts could be direct, related to bank or bed destabilisation, or indirect, via sediment entrainment by flows that may occur during construction resulting in:

- Localised rilling and gullying down banks
- Direct fluvial scour of exposed surfaces
- Failure of un-vegetated banks.

These issues are particularly pertinent for incised stream types with high steep and construction on or adjacent to dispersive soils.

Implementation of effective design and mitigation measures will ensure that the risk of this impact occurring is low.

Enhanced breeding of mosquitoes

Factors that promote mosquito breeding include high rainfall, temperature and humidity (Queensland Health 2002). The highly variable climate associated with the study area is not likely to be conducive for mosquito breeding, particularly if construction activities are undertaken during the winter months when rainfall is low.

Macroinvertebrate sampling undertaken during the dry season collected few mosquito larvae (Family: Culcidae) throughout the study area (only from sites R7, GF2 and GF3). These results are indicative of low population densities within the gas fields. The potential to increase mosquito breeding habitat as a result of construction is deemed to be low.

The potential impacts and mitigation measures associated with the construction of the gas fields are summarised in Section 9.6.1.

9.4.2 Operation

The potential operational impacts associated with well dewatering, treated water discharges, wastewater management, gas processing facility operation and permanent camps are more complex than construction related impacts. Water management will be the main consideration during the operational phase.

Each potential impact has been assessed, based on the risk assessment process, to determine the likelihood of and consequence of a particular impact occurring, and to assess the residual risk after mitigation measures have been implemented. The residual risk was categorised as negligible, low, medium, high, or very high. A full description of the risk assessment method is provided in Volume 1 Chapter 4.

Alteration of flow regimes

There are currently seven alternative options for the location of the release of permeate discharge – two locations in the Condamine River (including the existing Talinga Water Treatment Facility), one each in Yuleba, Tchanning, Wooleebee and Dulacca creeks and one in an unnamed stream. Potential impacts from the release of permeate will vary in magnitude and severity, influenced by:

- The size of stream in which the water will be discharged, with larger streams generally more capable of conveying greater volumes of water and, as such, the relative impact of releasing flows decreases with increasing stream size. These relative differences have significant follow on implications for those flow parameters that define the likelihood for geomorphic and ecological change (e.g. velocity, stream power, shear stress)
- The type of stream in which the water will be discharged: incised streams with steep, high banks are more likely to be affected by increased discharge than those with more gradually sloped banks
- Boundary conditions of the stream at, and downstream of, the release point: bank and bed sediment type (particularly with regard to any dispersive qualities) and the presence and abundance of riparian and aquatic vegetation are important controls of channel stability
- The volume of water to be released each day
- The timing of release (i.e. wet season release versus continuous release).

The Water Resource (Condamine-Balonne) Plan (2004) states all performance indicators – low flow, summer flow, beneficial flooding flow, 1 in 2 year flood and 1 in 10 year flood –greater than 133% or less than 66% of the predevelopment flow be minimised. Integrated Quantity and Quality Model (IQQM) results indicate that if a constant discharge equal to 50 Ml/d released from the proposed upstream Condamine discharge location or 65Ml/d from the proposed downstream Condamine discharge location will meet the environmental flow objectives.

However, a constant discharge regime may substantially alter low flow regimes as demonstrated through analysis of the flow duration curves (Volume 5 Attachment 22 – Surface water). Preliminary flow exceedence curves indicated that discharges would need to cease for approximately 30% of the time on the Condamine River and up to 85% of the time on smaller tributaries to mimic natural flows and minimise alteration to low flow regimes. As a result, discharge volumes may need to be limited to ensure that the resulting flows are not increased above 133% of the pre-development (pre weir) flow patterns. Any additional discharge would need to be considered in the context of the existing Talinga discharge. IQQM modelling, using a range seasonal release scenarios, indicates that impacts to low flow regimes could be minimised by better mimicking the pre-development flow regime.

There are conflicting opinions within the scientific community as to whether changes to community structure resulting from increased discharges during the low (or no) flow period would impact the waterways positively or negatively.

General geomorphic impacts relating to releases of permeate discharge may include:

- Exacerbation of existing gullying at the gully confluence with the main channel, particularly those more recently formed examples
- Notch erosion resulting from reduced variability of flows downstream of the release points
- Increased bank failures resulting from notch erosion
- Increased bank instabilities resulting from increased wetting of banks consisting of dispersive clays
- Exacerbated meander migration resulting from permeate discharge close to meander bends
- Increased entrainment of bed sediments, resulting in redistribution downstream.

Given the mitigation strategy of meeting environmental flow objectives and mimicking, where practicable, the pre-development flow regime, the risk assessment identified a low residual risk rating for this potential impact.

Permeate Discharge with elevated contaminant concentrations

Based on background studies undertaken on other discharge locations within the gas fields, there is the potential for permeate to have levels of some contaminants that do not meet relevant species protection levels and may therefore have a negative impact on aquatic fauna. Permeate water quality data provided by Australia Pacific LNG for the existing Spring Gully discharge indicate that all parameters are within ANZECC/ARMCANZ (2000) guidelines, except boron which had mean concentrations slightly above the 95% protection values for biota. It appears from the toxicity testing results provided in ANZECC/ARMCANZ (2000) that the most sensitive groups are likely to be algae, particularly green algae, which are important primary producers in this system. As a precautionary measure, proposed permeate concentrations should be compared with the relevant species protection levels by using the ANZECC/ARMCANZ (2000) species sensitivity distribution. Suitable permeate concentrations based on 90-95 % species protection levels are to be developed, in accordance with ANZECC/ARMCANZ 2000 and in consultation with DERM.

The risk assessment identified a medium residual risk rating for this potential impact.

Permeate Discharge with low calcium concentrations

Conversely permeate discharges might also reduce constituent concentrations, such as calcium, in receiving waters which could potentially affect microcrustaceans. Microcustraceans form a major dietary component of many of the fish species within the Condamine-Balonne and Dawson catchments, so any impact on microcrustacean populations could have potentially significant impacts on fish that rely on these taxa as their main food source (e.g. gudgeon). Monitoring calcium concentrations in receiving waters and appropriate remedial actions, including addition of calcium supplements, would enable management of such potential impacts.

Erosion of exposed surfaces at permeate discharge points

Potential impacts resulting from exposed surfaces could include:

- Bank stability issues during operation of the pipe outfall, including gully initiation
- Increased sediment delivery to the channel
- Localised smothering of riffles and infilling of pools
- Reduction in bed sediment particle size variability.

Disturbance of threatened artesian spring communities

Potential impacts to artesian spring communities (salt pipewort and artesian milfoil) associated with groundwater drawdown from well watering were assessed to be low. The groundwater modelling identified a very low risk of impact to high value discharge spring complexes that may occur near Injune, Taroom and 100 km west of Roma. The spring complexes that occur 25 kilometres north of Roma, in the outcropping areas of Gubberamunda Sandstone, are documented as “recharge” springs and hence are not expected to be affected by any reduced groundwater levels that may occur in this area.

For a period of time post-production (during the groundwater level recovery phase), the drawdown cones in the affected GAB aquifers, whilst reducing in magnitude, are projected to broaden beyond the boundaries of the CSG development areas. However, the groundwater modelling (Volume 2 Chapter 10), indicates that there is a very low risk that groundwater levels will be affected (post-CSG operation).

Erosion from exposed surfaces

While potential impacts associated with inadequate drainage control from exposed areas are likely to be more apparent during the construction phase, long-term erosion of exposed surfaces during operation, particularly adjacent to waterways, could potentially impact on channel geomorphology.

Exposed areas will need to have adequate controls and monitoring in place to minimise the risk of these impacts occurring. This impact mechanism was assessed to have a low residual risk for pipelines and roads.

Contamination of Lake Broadwater

Given the small area of Gilbert Gully associated with the Lake Broadwater catchment, the probability of impact to Lake Broadwater is negligible. No water treatments facilities or pipelines are located in the vicinity of the lake. However, before any construction work commences, hydraulic modelling should be undertaken to determine the level of connectivity between the study area and Lake Broadwater.

The risk assessment identified a low residual risk rating for this potential impact.

Chemical or wastewater contamination

Accidental chemical, wastewater or brine spills have the potential to occur. The potential impacts, including toxicity to biota, depend on the size and nature of spillages, and condition of the receiving waterway.

The risks associated with operational activities in or near waterways are expected to be low with implementation of environmental management procedures.

Brine pond overflows

There is the potential for highly contaminated feed and/or brine water to enter watercourses following periods of heavy rainfall, containment failure, water treatment facility operation faults or through groundwater leaching. As reported in the surface water assessment (Volume 5 Attachment 22), due to the composition of the waters in all of the proposed storages or the physical characteristics of the ponds themselves, all of the brine pond storages associated with the gas fields are classified as high hazard dams and would therefore be regulated under the Environmental Protection Agency and DERM guidelines. Substantial detrimental impacts to local biota could occur through direct toxicity if this contaminated water was released to local watercourses. Indirect, long-term impacts may result from internal loading and cycling of metals/metalloids and nutrients. The potential for chemical contamination from brine pond overflow was identified as a medium risk.

Creek bed and bank instabilities

The major concern related to this mechanism is the long-term upstream migration of knickpoints and localised bank instabilities created by poor excavation methods. The degree of impact will depend on stream type and volume of sediment extracted and the mitigation that has been implemented after construction. The risk assessment identified a low residual risk rating for this potential impact.

Altered low flow hydrology / hydraulics

Road crossings have the potential to hinder downstream flow conveyance which could concomitantly affect downstream sediment transport and could provide a barrier to organism passage. Sediments could accumulate upstream of the crossing and bed scour could occur downstream of the crossing. Altered low flow hydraulics could also result in channel widening downstream of the crossing. However, most streams in the study area are intermittent and are unlikely to be affected for most of the year. For permanent spring-fed streams (e.g. upper Dawson), there are likely to be some minor, localised impacts on sediment transport and potentially considerable impacts on low-flow organism movement.

The risk assessment identified a low residual risk rating for this potential impact.

Enhanced breeding of mosquitoes

During the operational phase, permanent brine ponds may encourage mosquito breeding during spring and summer. Depths of more than 60cm are generally unsuitable for mosquito breeding. The risk assessment identified a low residual risk rating for this potential impact. The potential impacts and mitigation measures associated with the operation of the gas fields are summarised in Section 9.6.1.

9.5 Mitigation and management

There are several construction and operation activities associated with the proposed gas fields development that could impact on water quality, aquatic ecology or fluvial geomorphology, as identified above. This section identifies mitigation measures to reduce the risk of these impacts occurring, and estimates the residual risk remaining after these measures are taken into account.

9.5.1 Construction

Increased sediment delivery to watercourses from road and pipeline crossing construction was identified as a low risk during the construction phase, as a result of excavation and vegetation clearing within and adjacent to watercourses. Sediment control measures will be strictly adhered to throughout the construction phase to ensure any such impacts are minimised. Measures to be implemented to ensure suitable erosion and sediment control include:

- Undertake construction according to weather conditions to reduce the potential for sedimentation of watercourses
- Erosion and sediment controls to be implemented according to regulatory requirements
- Minimise, as far as practicable, removal of riparian vegetation
- Undertake rapid backfilling, stabilisation and revegetation of riparian corridors, where practicable, within and adjacent to waterway crossings.

Low level risks were also identified in relation to inadequate drainage control and altered low flow hydrology from road crossings. It is assumed that potential impacts will be mitigated by implementing good practice design and drainage control.

The residual risk of impact to Murray cod associated with increased sediment delivery and temporary diversion of watercourses during construction was assessed to be low. This was a result of their natural tolerance to high levels of total suspended solids and turbidity, artificial population maintenance through stocking and likelihood of rapid re-colonisation following barrier removal.

The residual risk of impact to artesian spring communities (salt pipewort and artesian milfoil) associated with construction activities was assessed to be low, given that actively flowing discharge springs will be avoided.

9.5.2 Operation

Key risks identified during the operational phase were associated with the proposed permeate discharges which are predicted to alter flow regimes downstream of the discharge location(s).

This could impact on downstream aquatic communities and result in bed scour and bank erosion, with impacts likely to be greater on smaller tributaries than the Condamine River. As such, it is proposed discharge points will be located only within geomorphologically stable reaches.

Any water discharged would also seek to meet environmental flow objectives, as advised by the Queensland Government, established under the Condamine-Balonne Resource Operations Plan. Further modelling using IQQM is required to accurately determine the rate and timing of releases that would be required to best reflect the natural flow regime. Assuming all mitigation controls are implemented, the risks associated with permeate discharge would be medium.

Increased baseflow resulting from permeate discharge is unlikely to directly impact Murray cod populations as spawning requires a combination of elevated temperature (>15 °C) and flow, as well as a preceding complex chain of physiological, biochemical and behavioural changes.

Elevated boron concentrations in the permeate discharge could potentially be toxic to aquatic organisms. Permeate water quality discharge limits will be determined in consultation with regulatory agencies. This may require further investigation into the permeate toxicity for local specific species.

The potential for chemical contamination from brine pond overflow was identified as a medium risk. Requirements for dam design and construction are addressed in the surface water assessment (Volume 5 Attachment 22) to minimise any potential impacts from this scenario.

Low risks were also identified in relation to inadequate drainage control and altered low flow hydrology from road crossings. The potential impacts associated with road crossings will be further mitigated by implementing good practice design and drainage control.

The residual risk of impact to Narran Lakes in relation to operational discharges was assessed to be low. In the absence of detailed modelling, it was inferred that any discharge water that reached Beardmore Dam would have undergone substantial mixing and assimilation and the additional water would form part of the Resource Operations Plan rules for the St George Water Supply Area. This could improve water availability to Narran Lakes. Further modelling is proposed to confirm this.

The residual risk of impact to Lake Broadwater was assessed to be low, although hydraulic modelling was recommended to determine the level of connectivity between Gilbert Gully and Lake Broadwater.

There is a low risk of increased mosquito populations as a result of the proposed gas fields' development. If monitoring results reveal mosquito management is required, mosquito management measures will be implemented in accordance with Mosquito Management Code of Practice for Queensland (Queensland Health 2002). These may include a mix of monitoring, plus biological and chemical controls.

The impact assessment undertaken for this study was based on dry season field surveys, as this is the most common condition for waterways in the study area. Further monitoring during the wet season is proposed to describe seasonal variations in water quality and aquatic biota. Ongoing monitoring of flow, aquatic biota, water quality and geomorphology upstream and downstream of discharge locations is also proposed.

9.6 Conclusions

9.6.1 Assessment outcomes

Table 9.5 provides a summary of the potential impacts on aquatic ecology within the study area and how mitigation measures are proposed to meet regulatory requirements, as well as the sustainability objectives of the proposed gas fields' development.

Table 9.5 Summary of environmental values, sustainability principles, potential impacts and mitigation and measurement measures

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
Health and diversity of natural aquatic ecosystems	Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas.	Disturbance to Matters of National Environmental Significance and other notable species	Increased total suspended solids and physical disturbance to artesian spring communities during pipeline and road construction. Aquifer drawdown from well water extraction during the operational phase, causing impacts on artesian spring communities. .	Avoid construction of roads or pipelines through artesian spring communities. Implement effective sediment and erosion controls. Minimise clearing of riparian vegetation. Implement groundwater management measures as detailed in Volume 2 Chapter 10.	Low
		Reduced habitat diversity. Habitat fragmentation.	Removal of riparian vegetation and excavation of road and pipeline crossings during construction resulting in the direct removal of aquatic flora and fauna.	Minimise footprint of disturbance Undertake backfilling, stabilisation and revegetation of riparian corridors to address the Australian Pipeline Industry Association Code of Environmental Practice	Low
	Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.	Change to habitat or water quality causing an adverse impact on flora and fauna species.	Increased total suspended solids and turbidity from vegetation removal, and pipeline and road construction	Implement erosion and sediment controls to address regulatory requirements. Undertake construction with consideration of wet weather. Monitor water quality, prior, during and post construction.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
		Altered sediment transport. Temporary barrier to fish. Altered flow	Temporary diversion of watercourses during construction of road and pipeline crossings	Undertake construction with consideration of wet weather. Monitor rehabilitation and water quality, prior, during and post construction.	Low
		Changes to water quality Impacts to aquatic flora and fauna	Accidental spills during construction and operations causing chemical or wastewater contamination	Machinery and vehicles to be maintained in good working order Storage, handling and spill containment to address regulatory requirements Include spill response strategies in Environmental Management Plan. Implement stormwater management measures	Low
		Changes to habitat and fluvial geomorphology	Drainage from exposed areas during construction causing increased bank erosion (gullying)	Undertake construction with consideration of wet weather Implement erosion and sediment controls to address regulatory requirements Monitor channel and banks until rehabilitation is stable. Following high flow events pipeline water crossings will be inspected	Low
		Enhanced breeding of mosquitoes	Standing water during construction or operations (water storages)	Minimise standing water. Open water storage areas will be designed to be deeper than 0.6m to prevent waterborne insects breeding.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
				Management of mosquitoes will involve minimising ponding, particularly within 5km of a population centre, and, if required, further measures will be implemented in accordance with Mosquito Management Code of Practice for Queensland (Queensland Health 2002)	
		Impacts to aquatic flora and fauna Increased erosion Bank instabilities Changes to habitat	Permeate discharge during operations resulting in an alteration of flow regimes	Locate discharge point within geomorphologically stable reach and undertake hydraulic modelling to ensure minimal bank erosion and bed scour. Design discharge scenarios (volume and timing) that seek to meet Water Resource Plan environmental flow objectives and mimic, where practicable, the pre-development flow regime (recognising the practicalities and timing of establishing beneficial use). Implement bed and bank stabilisation techniques as required Monitor channel and banks until rehabilitation is stable. Pipeline water crossings will be inspected following high flow events. See Adaptive associated water management Volume 2 Chapter 12 regarding proposed discharge of treated water.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
		Changes to water chemistry (elevated contaminant concentrations – boron) Impacts to aquatic fauna	Permeate discharge during operational phase	Determine suitable permeate triggers percentage and associated monitoring program to protect aquatic biota in consultation with regulatory agencies (DERM). Ongoing monitoring of aquatic ecology (fish and macroinvertebrates) and water quality (boron) upstream and downstream of discharges.	Medium (for boron) Low (for others)
		Changes to water chemistry (low calcium concentration)	Permeate discharge during operational phase	Adjust calcium concentrations of permeate to meet required background cation and anion proportions. Ongoing monitoring of aquatic ecology (fish and macroinvertebrates) and water quality (major ions) upstream and downstream of discharges.	Low
		Changes to water quality Toxicity effects on aquatic flora and fauna	Brine pond overflows during operations causing chemical contamination of watercourses	Design ponds to address potential dam failure scenarios to minimise potential impacts to watercourses. Implement pond rehabilitation plan upon decommissioning	Low
		Scour of buried pipeline at creek crossings causing changes to fluvial geomorphology, erosion, increased turbidity	Pipelines	Monitor channel and banks until rehabilitation is stable. Following high flow events pipeline water crossings will be inspected.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
		Changes to fluvial geomorphology, increased sediment and turbidity Bed scour and associated bank erosion (including mass failure)	Permeate discharge point/s from discharges to waterway during operations.	Locate discharge point within geomorphologically stable reach Monitor channel and banks until rehabilitation is stable. Following high flow events pipeline water crossings will be inspected.	Low
		Altered flow hydrology/hydraulics Barrier to organisms and sediment transport	Road crossings during the operational phase	Design road watercourse crossings to not impede flow and therefore organism passage.	Low

9.6.2 Commitments

To manage the potential impacts on water quality, aquatic ecology and habitat and fluvial geomorphology associated with the construction, operation and decommissioning of the proposed gas fields' infrastructure, Australia Pacific LNG will:

- Develop and implement water quality and aquatic ecology monitoring programs for the permeate discharge
- Design discharges to watercourses to mimic the variability of natural flows to the best extent practicable, and meet regulatory requirements (recognising the practicalities and timing of establishing beneficial use)
- Develop and implement geomorphology monitoring programs for the permeate discharge
- Locate discharge point within geomorphologically stable reach
- Design watercourse crossings to not impede flow and therefore the passage of organisms.
- Design and implement erosion and sediment control devices according to regulatory requirements (Queensland Guidelines for Erosion and Sediment Control)
- Develop and implement mosquito monitoring and mitigation in accordance with the Mosquito Management Code of Practice for Queensland, for ponded waters associated with petroleum development.

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