Australia Pacific LNG Project

Volume 3: Gas Transmission Pipeline

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 along the proposed main gas transmission pipeline (the gas pipeline) for the Australia Pacific LNG Project (the Project). This assessment includes a description of existing aquatic ecology values within waterways to be traversed by the proposed gas pipeline and identifies potential impacts on these values from construction and ongoing pipeline operations. Strategies to mitigate and monitor these potential impacts have also been identified.

The gas pipeline corridor is primarily located within the Fitzroy catchment (Dawson and Don rivers), with pipeline sections also located within the Balonne-Condamine (connecting laterals) and the Calliope River catchment as the pipeline route approaches Curtis Island (Figure 9.1).

Key issues considered in this chapter relate to:

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

Australia Pacific LNG's sustainability principles will be applied to the planning, design, construction and operation of the Project to encourage management and mitigation of any adverse impacts to aquatic environments. 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 18.

Ecological issues associated with mammals, reptiles, amphibians and riparian/terrestrial vegetation within the gas pipeline study area are addressed in Volume 3 Chapter 8, with marine ecology issues discussed in Volume 3 Chapter 10.

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 Project's terms of reference (December 2009), 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 pipeline 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 the areas potentially affected by the gas pipeline 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 gas pipeline, 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 the gas pipeline study area
- Identify and assess potential impacts on aquatic ecology, water quality and fluvial geomorphology during the gas pipeline's construction, operation and decommissioning phases
- Identify measures to 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 pipeline.

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 Australia Pacific LNG Project was lodged with DEWHA on 6 July 2009 (Referral number: 2009/4974) for a determination as to whether the proposal constitutes a controlled action requiring formal assessment under the EPBC Act. On 3 August 2009, the Project was declared a 'controlled action' as a consequence of potential impacts on 'wetlands of international importance' (Sections 16 and 17B) and 'listed threatened species and ecological communities' (Sections 18 and 18A).

Without suitable impact mitigation, the gas pipeline has the potential to affect the following aquatic matters of national environmental significance:

- Great Artesian Basin (GAB) spring communities - specifically, *Eriocaulon carsonii* (salt pipewort or button grass) and *Myriophyllum artesium* (artesian milfoil).

- *Maccullochella peelii peelii* (Murray cod).

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 to be traversed by the proposed gas pipeline, the Queensland Water Quality Guidelines (2009) apply.

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 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 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.

Fisheries Act

The *Fisheries Act 1994* promotes ecological sustainability through accountability in terms of the use, conservation and enhancement of the community's fish resources and fish habitats. All Queensland waters 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 1994*.

Nature Conservation Act

The *Nature Conservation Act 1992* provides a strategy 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 presumed extinct, or considered endangered, vulnerable, rare, near threatened or of least concern. Taking or interfering with protected flora and fauna listed under the NC 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 gas pipeline study area likely to contain important ecological values and to locate suitable sampling points for collection of additional data needed to assess potential impacts.

Established waterbodies were sampled during field deployments from late June through to early October 2009. Additional 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 along the proposed pipeline route to be assessed. Reference sites were also chosen, where possible. In the Dawson and Don catchments, most waterways along the gas pipeline route were intermittent and a number of sites were dry during sampling. Where water was present, sampling was generally confined to small (non-flowing) pools. A notable exception was site P3CE11, located on Cockatoo Creek, which is a spring fed stream.

Sampling site locations within the Fitzroy, Condamine-Balonne and Calliope River catchments are provided on Figure 9.1. Each site (where site access was granted) was surveyed once for aquatic ecology, once for geomorphology and twice for water quality. Dogwood Creek is the only watercourse that is intersected by the pipeline corridor in the Condamine-Balonne catchment. Two sites (GF1 and R1) were sampled to assess impacts associated with the gas transmission pipeline in the Condamine catchment. The Condamine-Balonne catchment was also sampled as part of the gas fields' assessment. Volume 5 Attachment 17 presents the full results of field surveys undertaken for this catchment.

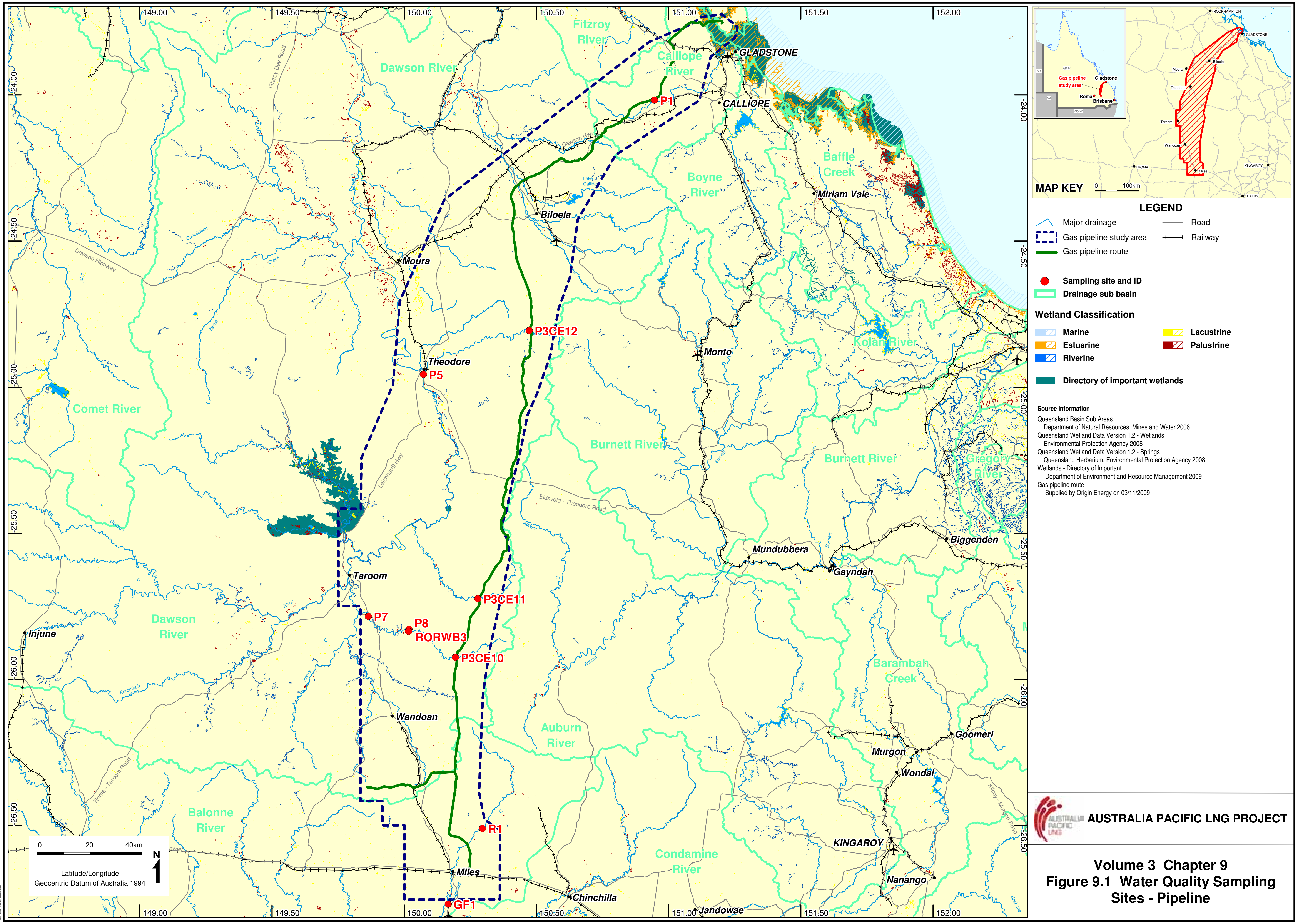
Although the field investigations are based on a single dry season survey (ecology and geomorphology) and two sampling events (water quality), a further round of wet season sampling is proposed (rainfall dependent). Results of the field surveys have been supplemented with background information for the study area. Additional results will be reported as field data becomes available.

Further details of the gas pipeline sampling program and methods are provided in Volume 5 Attachment 18.

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 (ANZECC) guidelines for the protection of aquatic ecosystems (Australia and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) 2000) and the Queensland Water Quality Guidelines (DERM 2009). Comparisons were also made to other relevant published and unpublished information.

Water quality was not sampled twice at all sites owing to a lack of surface water at the time of field assessment. Most of the watercourses sampled were not flowing at the time of survey.



Volume 3 Chapter 9
Figure 9.1 Water Quality Sampling Sites - Pipeline

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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 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 (SEAP) 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 SEAP)
- 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) (2003) rapid assessment method was used to rate reach-based habitat/geomorphic condition. This technique provided a comprehensive habitat assessment and enabled comparisons with other 'State of the Rivers' and AUSRIVAS assessed sites within each catchment. 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).

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 landuse, 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, endemic or otherwise noteworthy species.

The assumptions and limitations of the baseline and impact assessment methodologies are further described in Volume 5 Attachment 18.

9.3 Existing environment

The gas pipeline corridor is primarily located within the Fitzroy catchment (Dawson and Don rivers), with pipeline sections also located within the Balonne-Condamine (connecting laterals) and the Calliope River catchment as the pipeline route approaches Curtis Island.

The Condamine River catchment extends for approximately 500km and is a major tributary of the Darling River, located in the upper Murray-Darling catchment.

The Fitzroy River catchment incorporates the sub-catchments of the Don and Dawson River catchments. Waterways across this region typically contain little or no flow for much of the year except for the wetter, summer months (December-March). A notable exception was site P3CE11, located on Cockatoo Creek, which is a spring fed stream.

The Calliope catchment has a sustained base flow due to its connection to shallow underlying aquifers. It is a largely unregulated river with direct connections to the marine environment.

9.3.1 Water quality

Water quality in the Condamine-Balonne and Fitzroy catchments is characterised as having high turbidity, suspended solids and nutrients linked to land use practices, loss of riparian vegetation and modification of flow regimes (Condamine-Balonne Water Committee (CBWC) et al. 2002; EECO 2009; Fitzroy Basin Association (FBA) 2008). The Fitzroy catchment also has extensive mineral deposits and highly fertile soils and therefore supports a large number of mines (particularly coal) and a high level of agricultural production. In contrast, the Calliope River is generally characterised by low to moderate turbidity and nutrient levels, although water quality in this catchment is highly seasonal.

Water quality at the sites sampled in the Fitzroy (Dawson), Condamine-Balonne and Calliope River catchments was moderate to poor, with ammonia and total nitrogen levels generally exceeding the Queensland Water Quality Guidelines (DERM 2009), with the exception of GF1 (Dogwood Creek) during the first sampling occasion.

Conductivity was also generally higher than the prescribed trigger levels (30 to 350µS/cm), particularly so in the Calliope River and Cockatoo Creek. Dissolved oxygen was within or close to the relevant levels 90 to 110%, except at Kroombit and Cockatoo Creeks. Turbidity readings were mostly within or greater than the QWQG of 2-25 NTU. Four sites within the Dawson catchment had turbidity readings in excess of 25 NTU. Three of these sites recorded values between 46 and 63 NTU, the fourth registered 618 NTU. The lowest turbidity levels were recorded on the Calliope River. The elevated turbidity and TSS levels are not considered unusual for these catchments.

Concentrations of major cations (calcium, magnesium, sodium and potassium) were at acceptable levels. Hydrocarbons and pesticides were not present in detectable concentrations at any of the sites sampled.

Water quality across the catchments generally reflected the impact of landuse in the 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. FBA 2008; CBWC et al. 1999 and 2002).

It is anticipated that wet season sampling during early 2010 will confirm expectations of an improvement in water quality indicators in line with the typical seasonal variability of water quality.

9.3.2 Fish and macrocrustaceans

Regional overview

Fish surveys undertaken in the Calliope (C & R 2005), and Dawson and Don (Berghuis and Long 1999) river systems yielded a total of 58 freshwater fish species (Table 9.1). Thirty-four fish species were previously recorded from the Calliope catchment compared with 20 from the Dawson and Don rivers and an additional 16 species from field surveys undertaken in the Condamine-Balonne. Three species of macrocrustaceans were previously recorded from the Calliope and Condamine-Balonne catchments.

Table 9.1 Fish and macrocrustaceans previously recorded in the Calliope, Fitzroy[1] and Condamine-Balonne catchments

Fish Species	Common Name	Calliope[2]	Dawson[3]	Don[3]	Condamine Balonne[4]
Megalops cyprinoides	Oxeye herring	✓			
Ambassis agassizii	Agassiz's glassfish / Olive perchlet	✓	✓		✓
Ambassis vachelli	Vachelli's perchlet	✓			
Anguilla reinhardtii	Longfinned eel	✓			
Glossamia aprion	Mouth almighty	✓	✓	✓	
Neoarius graeffei	Blue catfish	✓	✓	✓	
Craterocephalus stercusmuscarum	Fly-specked hardyhead	✓	✓	✓	
Strongylura kreffti	Freshwater longtom	✓	✓	✓	
Lates calcarifer	Barramundi	✓			
Scatophagus argus	Spotted scat	✓			
Nematalosa erebi	Bony Bream	✓	✓	✓	✓
Herklotsichthys castelnaui	Southern herring	✓			
Morgunda adspersa	Purple-spotted gudgeon	✓		✓	✓
Gobimorphus australis	Striped gudgeon	✓			-
Hypseleotris galii	Firetailed gudgeon	✓			✓
Hypseleotris spp	Carp gudgeons				✓
Hypseleotris sp.A	Midgley's carp gudgeons	✓	✓	✓	✓
Hypseleotris compressa	Empire gudgeon	✓	✓	✓	
Philypnodon grandiceps	Flathead gudgeon		✓		✓

Fish Species	Common Name	Calliope[2]	Dawson[3]	Don[3]	Condamine Balonne[4]
Oxyeleotris lineolatus	Sleepy Cod		✓	✓	✓
Thryssa hamiltoni	Hamilton's anchovy	✓			
Glossogobius giurus	Flathead goby	✓			
Redigobius bikolanus	Speckled goby	✓			
Arrhamphus sclerolepis	Southeast snub-nosed garfish	✓			
Lutjanus argentimaculatus	Mangrove jack	✓			
Melanotaenia splendida	Eastern rainbowfish	✓	✓		
Mugil cephalus	Sea mullet	✓			
Liza subviridis	Flat-tailed mullet	✓			
Mugilidae spp.	Mullet	✓			
Gadopsis marmoratus	River blackfish				✓
Hypseleotris klunzingeri	Western carp gudgeon				✓
Craterocephalus amniculus	Darling River hardyhead				✓
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				✓
Retropina semoni	Australian smelt				✓
Craterocephalus stercusmuscarum	Fly specked hardyhead				✓
Bidyanus bidyanus	Silver perch				✓
Cyprinus carpio	Common carp				✓
Carassius auratus	Goldfish				✓
Gambusia holbrooki	Gambusia				✓
Pseudomugil signifer	Pacific blue-eye	✓	✓		
Tandanus tandanus	Freshwater catfish	✓	✓	✓	✓
Neosilurus hyrtlii	Hyrtl's tandan	✓	-	✓	✓

Fish Species	Common Name	Calliope[2]	Dawson[3]	Don[3]	Condamine Balonne[4]
Notesthes robusta	Bullrout	✓	-	-	
Acanthopagrus australis	Yellowfin bream	✓	-	-	
Amniataba percoides	Barred grunter	✓	✓	✓	
Scortum hillii	Leathery grunter	-	✓	✓	✓
Leiopotherapon unicolor	Spangled perch	✓	✓	-	✓
Hephaestus fuliginosus	Sooty grunter	✓	-	-	✓
Macquaria ambigua oriens	Fitzroy yellowbelly / Golden perch	-	✓	✓	-
Scleropages leichardti	Southern saratoga / Spotted barramundi	-	✓	✓	-
Crustacean Species					
Macrobrachium sp.	Prawn	✓	-	-	✓
Caridina indistincta	Brush-clawed shrimp	✓	-	-	-
Cherax quadricarinatus	Red Claw	✓	-	-	✓

[1] Fitzroy catchment – Dawson and Don Rivers
[2] C & R Consulting (2005)
[3] Berghuis and Long (1999)
[4] Clayton et al. (2008), FRC (2009), Hydrobiology (2006), EM 2005 and 2008, and DPI & F (2007)

Notable fish species previously collected from the gas pipeline study area include *Scleropages leichardti* (saratoga or spotted barramundi) which is only found in, and is endemic to, the upper reaches of the Fitzroy catchment where it is reported to be 'relatively uncommon' (Allen et al 2002; Berghuis and Long 1999). *Scortum hillii* (leathery grunter) and the subspecies *Macquaria ambigua oriens* (Fitzroy yellowbelly) are also endemic to the Fitzroy River system. None of these species are listed threatened species.

Table 9.2 provides an overview of the habitat requirements and sensitivity[1]/significance of these species.

[1] Sensitivity is defined in this context as the relative susceptibility of a given species to be adversely affected by an environmental variable

Table 9.2 Overview of significant fish species known from the Fitzroy[1], Condamine-Balonne and Calliope catchments

Species	Common name	Distribution and abundance	Habitat and food	Sensitivity/significance
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.
Macquaria ambigua oriens	Fitzroy Yellow belly / Golden Perch	Endemic to the Fitzroy River System, where it is reported to be relatively common.	Specific information regarding this subspecies is not available. Prefers warm, slow moving, turbid sections of streams and is also found in lakes, backwaters and impoundments	Not listed as threatened, but endemic to the Fitzroy River Basin. Is favoured by recreational fishers and some populations are maintained in several impoundments within the catchment. It is considered relatively common throughout the catchment.
Maccullochella peeli peeli	Murray cod	Formally 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 in-stream cover (e.g. large woody debris, undercut banks or overhanging vegetation). Diet consists of fish, crayfish and frogs.	Relatively abundant throughout their range, but recruitment to the adult population is believed to be unsustainably low. 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.

Species	Common name	Distribution and abundance	Habitat and food	Sensitivity/significance
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 Redlist. Only small populations remaining. Potential threats include river regulation (migration barriers). Tolerates a wide temperature range. Irregularly stocked in many localities within the Murray-Darling catchment.
Ambassis agassizii	Agassiz's glassfish (Olive perchlet)	Known to be present in coastal streams from northern NSW to north Qld. 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 alien 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.
Craterocephalus amniculus	Darling River hardyhead	Relatively common but confined to upper reaches of Darling River near NSW-Qld 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 red list. Potential threats include water abstraction, altered flow regimes, habitat destruction and predation / competition from alien species.

[1] Fitzroy catchment – Dawson and Don Rivers

References: Allen et al. (2002), Pusey et al. (2004), Clayton et al. (2008), Faulks et al. (2008) and Lintermans (2009).

Field survey results

Samples collected from the seven sites in the Calliope, Don, Dawson and Condamine (Dogwood Creek) catchments yielded a total of 650 fish belonging to 17 species, including 13 native and two introduced. The number of fish collected at each of these sites is presented in Table 9.3. Native fish were more abundant than exotic species at all sites, with the exception of site R1 on Dogwood Creek. *Gambusia holbrooki* (eastern gambusia), the only exotic species, was recorded in low numbers in the Don and Dawson catchments. Gambusia and *Carassius auratus* (Goldfish) accounted for more than half of the catch at site R1 on Dogwood Creek (Figure 9.2).

Additionally, 74 macrocrustaceans comprised of two native species were found at two sites. Macrocrustaceans were most abundant at Kroombit Creek in a deep pool habitat with an established macrophyte fringe. Red claw, a translocated species, was present in high numbers at one site on Bungaban Creek.

The Calliope River, the least developed catchment, had the highest diversity (12 species) and second highest abundance (130) of fish, reflecting relatively natural habitat values that include riparian and aquatic vegetation assemblages, a natural flow regime and an absence of significant fish passage barriers. No exotic species were recorded from site P1 on the Calliope River.

The highest abundance of fish (242) was recorded at Cockatoo Creek (Dawson River Catchment) from shallow and clear water within a spring fed watercourse which provides permanent dry season refugia.

Fish species caught in the Dawson and Don catchments were consistent with past survey results (Berghuis and Long 1999). Similarly, the high species diversity and lack of exotic fish species in the Calliope River is consistent with data reported by C & R Consulting (2005).

There is anecdotal evidence to suggest that the lower than expected catches in the Calliope River were related to an unusual pool drying event during 2009.

No fish species listed under the EPBC Act or Queensland Nature Conservation (Wildlife) Regulation 2006 legislation were caught during the dry season surveys. However, notable fish species may be present throughout the catchments, where suitable habitat exists.

Table 9.3 Abundance and species richness of fish and macrocrustaceans in the Dawson, Don, Calliope and Condamine catchments[1]

Catchment	Site	Total no. of fish	No. of fish species	Total no. of crustaceans	No. of crustacean species
Calliope	P1	130	12	0	0
Dawson	P3CE10	14	3	72	2
	P3CE11	242	6	2	0
	P7	113	7	0	0
Don	P4LL	105	7	0	0
Condamine	GF1	1	1	0	0
	R1	55	6	0	0

[1] Dry season surveys

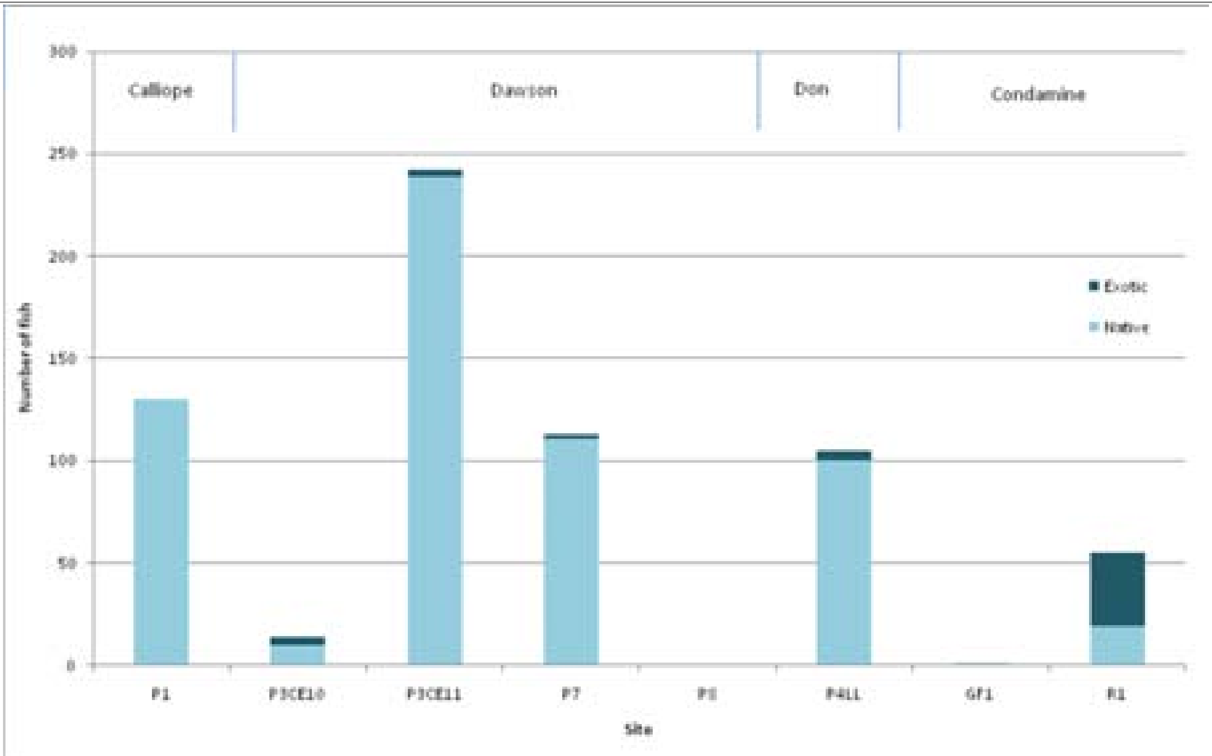

Figure 9.2 Fish abundance at each site, showing proportion of native versus exotic species

9.3.3 Macroinvertebrates

Macroinvertebrate edge sweep samples were collected at 5 sites during the dry season in the Calliope (one site), Dawson (three sites) and Condamine (one site) catchments granted (Table 9.4). An additional six sites were dry, did not contain sufficient habitat to sample, or could not be sampled as site access was not. Taxa richness ranged between 15 and 40 species with all sites registering three or more PET (Plecoptera, Ephemeroptera and Trichoptera) 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/habitat conditions.

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

Catchment		Abundance	Richness	No. PET Taxa
Calliope	(P1)	173	34	3
Dawson	(P7)	201	29	3
	(P8)	346	27	0
Dawson	(P3CE11)	705	40	4
Condamine-Balonne	(GF1)	71	15	0

The Stream invertebrate grade number –average level version 2 (SIGNAL2) is a scoring system designed to reflect water quality and ecosystem health. Macroinvertebrates collected from the gas pipeline route during dry season sampling were indicative of assemblages subject to either high salinity or nutrient levels. 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 were indicative of elevated turbidity and nutrient levels and perhaps typical of intermittent flow regimes. Results of the SIGNAL2 scoring system are presented in Volume 5 Attachment 18.

Macroinvertebrate functional feeding groups provide another means of assessing broad-scale aquatic ecosystem health. Specialist feeders (such as shredders and scrapers) are generally 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, sites P1 on the main Calliope River and P3CE11 on Cockatoo Creek had the highest proportions of shredders compared to other sites, likely due to their good fringing and overhanging vegetation (Figure 9.3). Overall, all sites were dominated by less sensitive taxa.

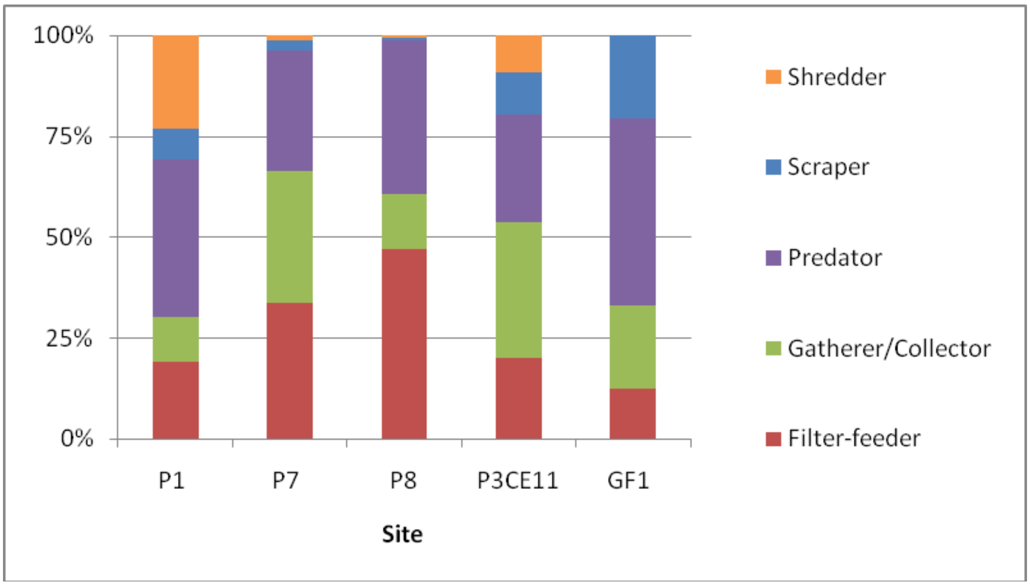

Figure 9.3 Relative proportion of functional feeding groups during dry season surveys

A reasonably diverse assemblage of tolerant species was found in watercourses to be traversed by the proposed pipeline. This finding is consistent with results from other macroinvertebrate assessments within the Calliope River (C & R Consulting 2005), Dawson (Department of Natural Resources 1997; FRC 2009) and Condamine-Balonne (Clayton et al. 2008) river catchments.

9.3.4 Fluvial geomorphology

A detailed climatic and hydrological description and a broad-scale assessment of the waterways to be traversed by the proposed gas pipeline revealed the following:

- Summer-dominated flows occur within the catchments
- Considerable flow variability occurs in all catchments from year-to-year
- The Dawson catchment waterways are characterised by extended periods of no to low flow
- Remnant pools in the Dawson River and Condamine-Balonne river catchments can persist through the dry season, particularly in the waterway mainstreams
- The Calliope River is perennial with a stable baseflow maintained through connection with shallow aquifers.

Seven assessed pipeline sites in the Dawson and Don catchments exhibited variable geomorphic characteristics. This variability was largely a reflection of their relative positions within the catchments and their respective local and upstream processes which includes water abstractions and agricultural land uses. Most sites have experienced considerable disturbance, mostly in the form of vegetation clearance. Bed aggradation was a common feature although three sites had stable beds with good geomorphic features. Banks were generally stable and riparian and floodplain vegetation and channel diversity was variable across the sites.

The general trend within all downstream assessment sites within the Condamine-Balonne catchment was one of infilling, with all sites undergoing moderate aggradation, mostly sourced from gullying. Banks varied from moderately unstable to stable. Dogwood Creek at GF1 was particularly unstable in sections due to erodible bank material (dispersive clays).

A single site was assessed on the Calliope River. This site exhibited stable bed and banks with limited evidence of aggradation and reasonable bed variability. C & R Consulting (2005) suggest groundwater percolation has extended the periods of baseflow in the Calliope which has in turn maintained waterholes and riffle habitats. Riparian vegetation was well developed along both banks although vegetation clearance was considered the dominant form of disturbance.

A detailed hydrological description of the proposed gas pipeline route is presented in Volume 3 Chapter 11.

9.3.5 Aquatic habitat, macrophytes and wetlands

Aquatic habitat

Four of the seven sites located in the Dawson River Catchment had poor aquatic habitat ratings. Reasons for the poor rating include extensive bank erosion, cattle droppings in creek beds, and significant upstream development. The remaining three Dawson catchment sites and the single site assessed on the Calliope River had good aquatic habitat ratings coincident with relatively high stream shading scores and low grazing use.

The reference site located on Dogwood Creek (R1) was the only site to record an aquatic habitat rating of high.

Macrophytes

Few macrophytes were recorded throughout the study area. The Calliope River site had a good coverage and species richness of submerged, floating and emergent taxa (20%) compared with the other sites in the Dawson catchment as shown in Table 9.5. The site on Cockatoo Creek also recorded good fringing emergent macrophyte coverage (10%), although the community mainly consisted of two species - *Juncus usitatus* (common rush) and *Typha orientalis* (cumbungi). No macrophytes were recorded from the Dogwood Creek (Condamine-Balonne) sites. No notable macrophyte species were recorded throughout the catchments.

Table 9.5 Macrophytes recorded at the gas pipeline sites

	Calliope	Fitzroy Basin (Dawson and Don sub-catchments)					
Native Species	P1	P4LL	P5	P7	P8	P3CE10	P3CE11
Spiny headed matrush (*Lomandra longifolia*)	-	-	-	-	-	✓	-
Common rush (*Juncus usitatus*)	-	-	-	-	-	✓	✓
Cumbungi (*Typha orientalis*)	-	-	-	-	-	-	✓
Azolla spp.	✓	-	-	-	-	-	-
Duckweed (*Lemna* spp.)	✓	-	-	-	-	-	-
Hornwort (*Ceratophyllum demersum*)	✓	-	-	-	-	-	-
Pondweeds (*Potamogeton* spp.)	✓	✓	-	-	-	-	-
Water ribbon (*Triglochin procerum*)	✓	-	-	-	-	-	-
Sedge (*Cyperus* spp.)	✓	-	✓	-	-	-	-
Slender knotweed (*Persicaria decipiens*)	-	✓	-	-	-	-	-
Exotic Species							
Para Grass (*Urochloa mutica*)	-	-	✓	-	-	-	-

Wetlands

The only wetlands of national importance known to occur in the vicinity of the pipeline corridor are the Great Artesian Basin (GAB) spring wetlands. These occur on the outer edge of the GAB in Queensland, NSW 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 Red list. Of these, two species of plant (artesian milfoil and salt pipewort) are known to occur within the Springsure Supergroup (DEWHA 2001). Both of these species are known to occur in Cockatoo Creek (Figure 9.4).

Salt pipewort requires active or 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 spring flow, trampling by feral animals and excavation (Environmental Protection Agency (EPA) 2005).

Artesian milfoil (*Myriophyllum artesium*) has also only been found in wetlands fed by flowing artesian water (Fensham et al 2004). Although these species were not 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.

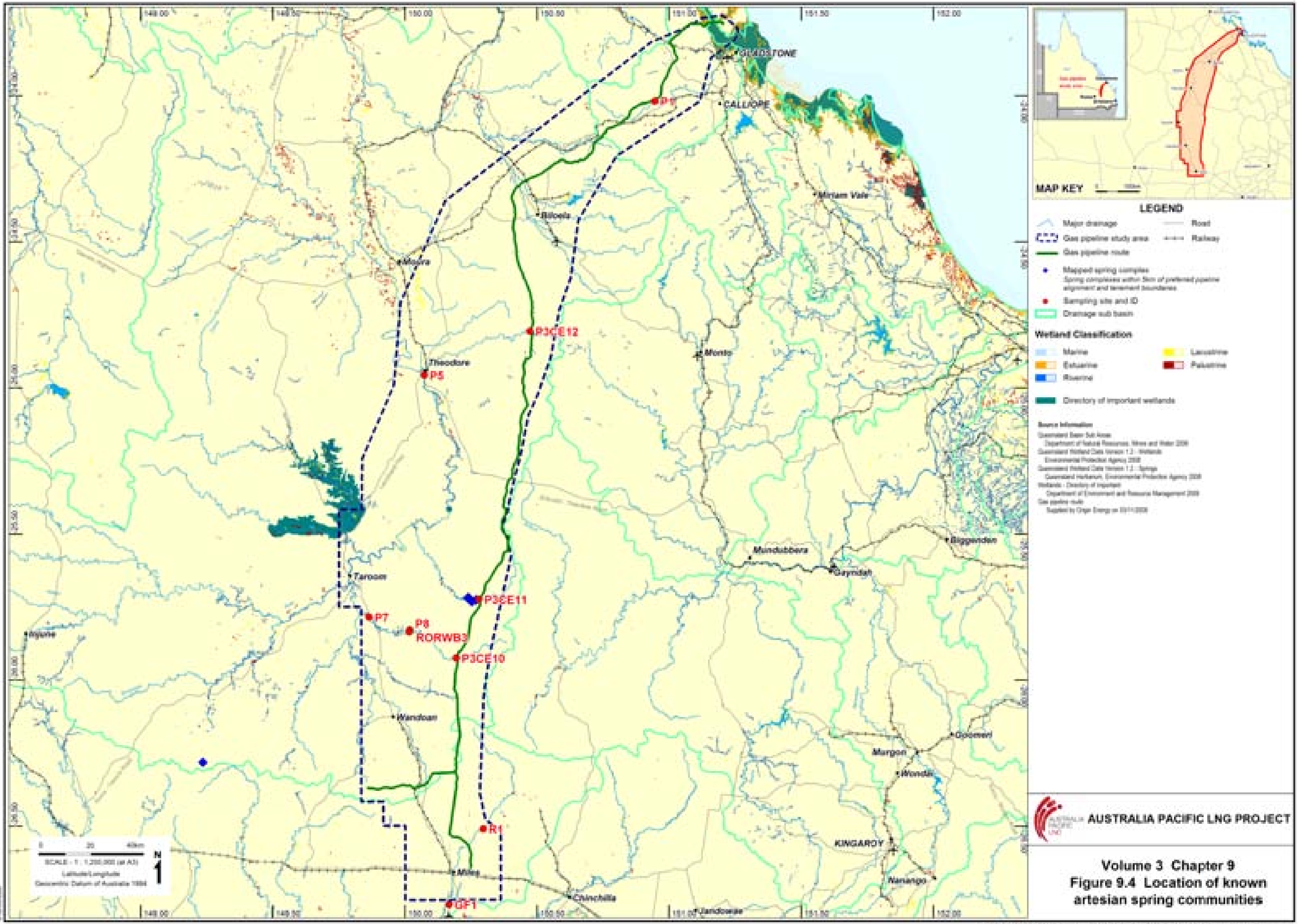

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Figure 9.4 Location of known artesian spring communities

9.4 Potential impacts

The overall risk of potential impact to water quality, aquatic ecology and fluvial geomorphology was assessed for each identified impact mechanism and for each of the relevant construction and operation activities. The extent of potential impacts was also assessed on a local and regional scale. For each impact mechanism, the default risk was the highest risk associated with water quality, aquatic ecology and fluvial geomorphology. This ensures that a conservative approach will be applied to mitigating potential impacts.

9.4.1 Construction impacts

Waterways within the gas pipeline study area could potentially be impacted during the construction phase through the construction of temporary roads, pipelines and associated infrastructure. The main impact mechanism likely to affect the aquatic environment during this phase is sediment mobilisation through the clearing of vegetation adjacent to waterways and bank or bed excavation. However, other impacts may also present a risk to aquatic biota, such as accidental chemical spills, effluent generated from construction camps, direct removal of aquatic flora and fauna from excavation and a range of geomorphic impacts. Temporary standing waterbodies and pools created during the construction phase may also provide suitable mosquito and biting midge breeding habitat.

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, and the construction of open-cut pipeline trenches and temporary 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 (e.g. 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 (e.g. 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 pipeline crossings and temporary roads. Sediment control measures, in accordance with regulatory requirements, will be strictly adhered to throughout the construction phase to ensure any impacts will be mitigated.

Direct removal of aquatic flora and fauna during excavation of road and pipeline crossings (rain-fed systems)

Riparian vegetation may 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 species are known to occur in rainwater fed systems throughout the gas pipeline study area. Impacts associated with removal of aquatic macrophytes from rainwater fed systems during construction are likely to be negligible.

Disturbance to notable fish species associated with increased TSS and turbidity from pipeline and road construction

Three endemic fish species are known within the Fitzroy catchment, although none were caught during the dry season surveys. All of these are adapted to high turbidity and suspended solids levels as a response to the highly variable and intensive rainfall patterns, soil instability and land uses within the catchments. Increased sediment delivery can lead to scouring or infilling of fine scale habitat structure and smother food resources. Most streams in the Dawson and Condamine-Balonne catchments are intermittent and are dry, or recede to a series of unconnected pools, for a large part of the year. Appropriately timed construction, should avoid sediment related impacts. For permanent water bodies, particularly in those less turbid streams in the Dawson catchment, some impacts to fish populations may occur, although this is likely to be short lived. No notable fish species are known to occur in the Calliope catchment.

Disturbance to threatened artesian spring communities associated with pipeline and road construction

The EPBC listed salt pipewort and artesian milfoil are known to be associated with artesian springs within vicinity of the pipeline (Cockatoo Creek). Increased delivery of sediments and nutrients associated with road or pipeline crossings could reduce light availability and smother habitats. Based on the proposed gas pipeline route, the likelihood of impacts occurring would be minimal. However, if the route changes realignment would avoid potential impacts on the GAB springs.

Temporary diversion of watercourses during construction of road and pipeline crossings

Diversion of watercourses during construction of temporary roads and pipeline crossings could increase sediment transport and present a temporary barrier to fish passage. Most streams in the study area are intermittent and, assuming that construction is timed to avoid wet season flows, most are unlikely to be flowing during the construction period. Permanent streams are likely to experience some short-term impacts associated with sediment mobilisation (sites P3CE11 – Cockatoo Creek and P1 – Calliope River). Sediments may accumulate upstream of the crossing and scour would occur downstream. However, assuming suitable control measures will be implemented, any impacts are likely to be localised and temporary.

Poorly constructed pipeline crossings also have the potential to hinder downstream flow conveyance which will concomitantly affect downstream sediment transport and provide a barrier to organism passage. Altered low flow hydraulics could also result in channel widening downstream of the crossing. This impact is not predicted to occur due to engineering design and construction, with the profile of the creek bed to be maintained.

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 (gullying) due to inadequate drainage control from exposed areas

Overland runoff and resultant gullying is already a common occurrence throughout the study area, particularly in sections with cleared vegetation. As such, the initiation, or exacerbation, of gullying (and resulting sediment-laden runoff and bank instabilities) is a concern during construction, particularly in relation to pipeline trenches and road crossings within and adjacent to watercourses. Banks consisting of highly erodible soils (cracking/dispersive clays) are of particular concern. 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.

The implementation of drainage controls will minimise the risk of this impact occurring.

Trenching and relaying 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 banks without vegetation.

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 reduce the risk of this impact occurring to low.

Enhanced breeding of mosquitoes through ponding of water during construction

Macroinvertebrate sampling undertaken during the dry season collected few mosquito larvae (Family: Culcidae) throughout the gas pipeline study area, with nearly all collected from a site on Bungaban Creek. The potential impact of mosquito breeding as a result of construction is likely to be low due to a combination of limited breeding habitat, low population densities and a lack of large natural wetlands adjacent to the proposed waterway crossings.

9.4.2 Operational Impacts

The potential operational impacts include sediment mobilisation and erosion from exposed areas and accidental spills at watercourse crossings.

Erosion from exposed areas

While impacts 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. Un-rehabilitated gas pipeline right of ways are of concern, particularly in areas of erodible soils (cracking / dispersive clays).

Potential operational impacts resulting from this impact mechanism include:

- Bank instabilities, including gully initiation or enhancement
- Increased sediment delivery to channel (refer to Section 9.4.1)
- Reduction in channel capacity
- Smothering of riffle habitat
- Pool infilling
- Reduction in bed sediment particle size variability.

Exposed areas will need to be carefully monitored and have adequate controls in place to minimise the risk of these impacts occurring.

Chemical contamination of watercourses

There is low potential for hydrocarbons, chemicals or wastewater to contaminate watercourses from accidental spills. Whilst the potential impacts would depend on the size and nature of spills, with effective environmental management procedures near waterways, the potential impacts are expected to be low.

Altered low flow hydrology / hydraulics resulting from temporary road crossings

Poorly constructed road crossings have the potential to hinder downstream flow conveyance which will concomitantly affect downstream sediment transport and provide a barrier to organism passage. Sediments would accumulate upstream of the crossing and bed scour would occur downstream of the crossing. Altered low flow hydraulics could also result in channel widening downstream of the crossing. As there will be no permanent road crossings (only temporary for any maintenance activities) and most streams in the study area are intermittent, watercourses are unlikely to be affected for most of the year. For permanent spring-fed streams (e.g. Cockatoo Creek), there may be some minor, localised impacts on sediment transport The potential impact will be significantly reduced through engineering design controls as outlined in Section 9.5.

9.5 Mitigation and management

There are several construction and operation activities that could potentially impact on water quality, aquatic ecology or fluvial geomorphology.

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 potential impacts are minimised. Measures to be implemented to ensure suitable erosion and sediment control include:

- Undertake construction within the dry season if practicable to reduce the potential for impact of sediment delivery into the watercourses
- Ensure sediment and erosion control devices are implemented according to regulatory requirements and stream conditions
- Removal of riparian vegetation is minimised as far as reasonably practicable
- Promptly undertake backfilling and stabilisation and revegetation of riparian corridors, where practicable, within and adjacent to waterway crossings.
- Design watercourse crossings to not impede flow and therefore organism passage, and restore creek bed profile post construction.

The residual risk of impact to artesian spring communities (particularly salt pipewort and artesian milfoil) associated with construction activities was assessed to be low, as actively flowing discharge springs will be avoided. Any realignment of the pipeline route or proposed road crossings (temporary) would also avoid artesian spring communities.

9.5.2 Operation

Low risks were identified in relation to erosion from exposed areas and chemical contamination from accidental spills.

The impact assessment undertaken for this study was based on limited dry season data. As most streams in the study area are intermittent, water quality and aquatic ecology would be expected to naturally exhibit large seasonal variations. Further monitoring during the wet season is proposed to establish seasonal variations in water quality and aquatic ecology. Pre, during and post construction monitoring upstream and downstream of pipeline crossings is to be undertaken.

9.6 Conclusions

9.6.1 Assessment outcomes

Table 9.6 provides a summary of the potential impacts on aquatic ecology within the study area and how mitigation measures are proposed to meet regulatory requirements and the sustainability objectives of the proposed pipeline development.

Table 9.6 also summarises the risk assessment undertaken for aquatic ecology and water quality. The potential risks have been identified including causes and consequences, and the residual risk after mitigation measures have been implemented has been calculated. The residual risk is categorised as either negligible, low, medium, high, or very high. A full description of the risk assessment method is provided in Volume 1 Chapter 4.

Table 9.6 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 Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.	Disturbance to Matters of National Environmental Significance and other notable species	Increased total suspended solids (TSS) and physical disturbance to artesian spring communities and notable fish species during pipeline and road construction.	Avoid construction of roads or pipelines through or adjacent to artesian mound springs in the vicinity of Cockatoo Creek. Implement effective sediment and erosion controls. Minimise clearing of riparian vegetation.	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 disturbance footprint Undertake backfilling, stabilisation and revegetation of riparian corridors to address the Australian Pipeline Industry Association Code of Environmental Practice	Low
		Change to habitat or water quality causing an adverse impact on 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
		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.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
				Design watercourse crossings to not impede flow and therefore organism passage. Creek bed profile to be maintained. Monitor rehabilitation and water quality, prior, during and post construction.	
		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 free from fuel and oil leaks 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

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
		Enhanced breeding of mosquitoes	Standing water during construction or operations (water storages)	Minimise standing water. Develop and implement mosquito management guidelines for construction related activities in accordance with the 'Mosquito Management Code of Practice for Queensland '	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

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 pipeline, Australia Pacific LNG will:

- Design and implement erosion and sediment control devices according to regulatory requirements (Queensland 'Guidelines for Erosion and Sediment Control')
- Design watercourse crossings so they do not impede flow and therefore the passage of organisms.

References

Allen, GR, Midgley, SH and Allen, M 2002, *Field Guide to the Freshwater Fishes of Australia*, Western Australian Museum, Perth.

Australia and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) 2000, *National Water Quality Management Strategy: Australian and New Zealand Guidelines for fresh and marine water quality,* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand, ISBN 09578245 0 5 (set).

Berghuis, AP and Long, PE 1999, 'Freshwater fishes of the Fitzroy Catchment, central Queensland', *Proceedings of the Royal Society of Queensland,* vol. 108, pp. 13-25.

Chessman, B 2003, *SIGNAL2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Health Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

Clayton, PD, Fielder, DP, Barratt, PJ and Hill, C 2008, *Aquatic Conservation Assessments (ACA), using AquaBAMM, for freshwater wetlands of the Condamine River catchment,* Environmental Protection Agency, Brisbane.

Condamine-Balonne Water Committee (CBWC), Lee, LJ, McNeil, VH, Spence, GA, and Department of Natural Resources 1999, *Water Quality in the Condamine-Balonne Catchment: Water quality monitoring and information dissemination project – final report*, Condamine-Balonne Water Committee and Department of Natural Resources, Dalby.

Condamine-Balonne Water Committee (CBWC), Lee, LJ, Cook, B and Gaffney, J 2002, *Water Quality Objectives for the Condamine-Balonne Catchment: Development of local Water Quality Objectives for the Condamine Balonne Project – Technical Report*, Condamine-Balonne Water Committee, Dalby.

C & R Consulting 2005, *Ecological Assessment for the Calliope River Catchment Water Resource Plan,* report to the Department of Natural Resources and Mines, Brisbane.

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

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2001, *The Community of Native Species Dependant on Natural Discharge of Groundwater from the Great Artesian Basin*, viewed November 2009, <http://www.environment.gov.au/biodiversity/threatened/communities/gabsprings.html>

Department of Natural Resources 1997, *River Health: An Overview of the Fitzroy River Catchment,* Water Monitoring Group, Resource Management.

EECO Environmental Engineering 2009, *Talinga Development Project: Reverse Osmosis Permeate Discharge Assessment*, unpublished report prepared for AUSTRALIA PACIFIC LNG.

Environment Australia 2001, *Australia Wide Assessment of River Health: Queensland AusRivas Sampling and Processing Manual*, Monitoring River Health Initiative Technical Report no. 12, Commonwealth of Australia and QLD Department of Natural Resources and Mines, Canberra and Porcklea.

Environmental Protection Agency (EPA) 2005, *Wetland Management Profile: Great Artesian Basin Spring Wetlands,* Ecosystem Conservation Branch - Environmental Protection Agency, Brisbane.

Faulks, LK, Gilligan, DM and Beheregaray, LB 2008, 'Phylogeography of a threatened freshwater fish (Mogurnda adspersa) in eastern Australia: Conservation implications', *Journal of Marine and Freshwater Research,* vol. 59, pp. 89-96.

Fensham RJ, Fairfax, RJ and Sharpe, PR 2004, 'Spring wetlands in seasonally arid Queensland: floristics, environmental relations, classification and conservation values', *Australian Journal of Botany,* vol. 52, pp. 583-595.

Fitzroy Basin Association (FBA) 2008, *Fitzroy Basin Water Quality Improvement Report: December 2008,* Johnston, N, Peck, G, Ford, P, Dougall, C, and Carroll, C, (eds.) Fitzroy Basin Association, Rockhampton.

FRC Environmental 2009, *Santos coal seam gas fields: aquatic ecology impact Assessment*, unpublished technical report.

Lintermans, M 2009, *Fishes of the Murray-Darling Basin: An introductory guide,* Murray Darling Basin Commission publication No. 10/07, Canberra.

Murray Darling Basin Commission (MDBC) 2003, *Physical Habitat Theme Pilot Audit Technical Report – Sustainable Rivers Audit*, Murray Darling Basin Commission Publication 10/04, Canberra.

New South Wales Fisheries Management 1997, *Australian Code of Electrofishing Practice*, ISBN 0 7310 9412 3, New South Wales Fisheries Management Publication no. 1.

Pusey, B, Kennard, M and Arthington, A 2004, *Freshwater Fishes of North-Eastern Australia,* CSIRO Publishing.

Rawer-Jost, C, Böhmer, J, Blank, J and Rahmann, H 2000, 'Macroinvertebrate functional feeding group methods in ecological assessment', *Hydrobiologia*, vol. 422-423 (8), pp. 225-232.