Coffey Environments

Surat Gas Project

Supplementary Aquatic Ecology Assessment

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Item	Page	Section	Comments

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Attachment 1 – Summary of EPBC Act Protected Matters Search Tool and Wildlife Online Search Results

Attachment 2 – Aquatic Fauna Species Profiles

Attachment 3 – Site Photos

EXECUTIVE SUMMARY

Arrow Energy Pty Ltd is currently seeking to expand its coal seam gas operations in the Surat Basin. A voluntary Environmental Impact Statement (EIS) was submitted to the Australian and Queensland governments in December 2011. Arrow Energy is required to prepare a supplementary report to the EIS (SREIS) to present information on updates to the Project Description and to provide further consideration and/or information. AMEC Environment and Infrastructure Pty Ltd was commissioned to complete the aquatic ecology component of these requirements.

A combination of desktop investigations and field surveys were conducted. Desktop investigations included a review of relevant legislation and environmental database searches. Field surveys included a range of aquatic indicators (aquatic habitat, in-situ water quality, aquatic macrophytes, fish and turtles). All surveys were completed in accordance with relevant best practice standards and guidelines. To adhere with prescribed sampling periods, macroinvertebrate sampling was completed in May 2013, with the results presented in an addendum to this report.

This report includes an assessment of an additional site to characterise the aquatic ecosystems of the Dawson River catchment (Fitzroy Basin) in the north of the tenement. A second additional site in the Weir River catchment (Murray-Darling Basin) could not be sampled due to heavy rainfall and flooding. This site was assessed in May 2013 and the results presented in an addendum to this report.

In accordance with the original assessment completed in the EIS, aquatic ecosystems surveyed within the portion of the Project Development Area situated within the Dawson River catchment were found to be ‘moderately’ sensitive. No species of ‘conservation significance’ were recorded.

One of the key changes to the Project Description was the identification of two potential sites, within Survey Area 2 and Survey Area 9, for discharging treated or untreated coal seam gas water into watercourses. Surveys were undertaken at numerous sites within each of these receiving systems, including those situated both upstream and downstream of the proposed discharge points. The Survey Area 2 receiving system includes Bottle Tree Creek and Dogwood Creek, whilst the Survey Area 9 receiving system includes the Condamine River and potentially Crawlers Creek. Bottle Tree Creek and Dogwood Creek are small ephemeral waterways, whilst the area of the Condamine River occurring within the Project Development Area is a large semi-permanent waterway that contains large permanent pools, partly due to the presence of several weirs. The section of Crawlers Creek surveyed for this investigation was classified as a small ephemeral waterway.

Both Survey Area 2 and Survey Area 9 receiving systems were assessed as being ‘moderately’ sensitive. Four species of ‘conservation significance’ were recorded during the field surveys, including: Murray Cod (*Maccullochella peelii peelii*) - which is listed as ‘vulnerable’ under the Environment Protection and Biodiversity Conservation Act 1999 - Agassiz’s glassfish (*Ambassis agassizii*), the broad-shelled turtle (*Chelodina expansa*) and shiny nardoo (*Marsilea mutica*) - which are listed by Aquatic Conservation Assessments (ACA) as ‘priority’ species for conservation. Four exotic species were also recorded.

An assessment of the un-mitigated impacts for discharging water to the Survey Area 2 and Survey Area 9 receiving systems indicated that the discharge of treated or untreated coal seam gas water during periods of ‘low-flow’ could potentially have an impact on the

receiving environments. The risk of impacts associated with the discharge of coal seam gas water during periods of ‘high-flow’ (when dilution ratios are high) is assessed as ‘low’. Assessment of residual impacts at ‘low-flow’ was undertaken with impacts ranging from high through to low. A preliminary Environmental Flows Assessment was undertaken by geomorphology, water quality and aquatic ecology experts to develop a preliminary guideline for acceptable discharges. The residual risk of impacts associated with transfer of water between sites is assessed as ‘low’.

Qualitative assessments of aquatic values were completed at two locations that Arrow proposes to establish central gas processing facilities (Central Gas Processing Facilities CGPF 7 and CGPF 8), as well as a site identified by Arrow for a temporary workers accommodation facility F, (TWAF F). The discharge of coal seam gas water will not occur at any of these three locations.

To compliment work undertaken for the aquatic ecology technical study for the EIS, dossiers have been prepared for all species listed as Matters of National Environmental Significance (MNES) and the majority of locally significant species recorded, known to or with the potential to occur within the Project Development Area.

ABBREVIATIONS

Abbreviations	Meaning
ACA	Aquatic Conservation Assessments
AMEC	AMEC Environment and Infrastructure Pty Ltd
Arrow Energy	Arrow Coal Seam Gas (Australia) Energy Pty Ltd
ANZECC	Australian and New Zealand Environment and Conservation Council
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
AS/NZS	Australian/New Zealand Standard
AUSRIVAS	Australian River Assessment System
Back on Track	Back on Track species prioritisation framework
C	Critical priority
CE	Critically Endangered
Coffey Environments	Coffey Environments Australia Pty Ltd
DAFF	Department of Agriculture, Fisheries and Forestry
DERM	Department of Environment and Resource Management
DEHP	Department of Environment and Heritage Protection
DNRM	Department of Natural Resources and Mines
DO	Dissolved Oxygen
E	Endangered
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environment Protection and Biodiversity Conservation* Act
EP Regulation	*Environmental Protection Regulation 2008*
EPP	Environmental Protection Policy
EVNT	Endangered, Vulnerable or Near Threatened
Greentape Reduction Act	*Environmental Protection (Greentape Reduction) and Other Legislation Amendment Act 2012*
H	High priority
IDAS	Integrated Development Assessment System
IQQM	Integrated Quality Quantity Model
IUCN	International Union for Conservation of Nature
LP Act	*Land Protection (Pest and Stock Route Management) Act 2002*
M	Medium priority
MNES	Matters of National Environmental Significance
NC Act	*Nature Conservation Act 1992*
NRA	Natural Resource Assessment
NRM	Natural Resource Management

Abbreviations	Meaning
NT	Near Threatened
QMDB	Queensland Murray-Darling Basin
QWQG	Queensland Water Quality Guidelines
RNE	Register of the National Estate
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
SP Act	*Sustainable Planning Act 2009*
SREIS	Supplementary report to the EIS
ToR	Terms of Reference
V	Vulnerable
Water Act	*Water Act 2000*
WoNS	Weeds of National Significance
WQO	Water Quality Objectives
WRP	Water Resource Plan

GLOSSARY

Term	Definition
Australian River Assessment System (AUSRIVAS) Physical Assessment Protocol	This protocol is a standardised rapid method for the collection of geomorphological, physical habitat, riparian and basic water quality data. It can be used to assess the physical condition of rivers and streams and to predict the local scale habitat features that should be present at a site. It incorporates aspects of several existing physical assessment methods into a method that can be implemented to construct AUSRIVAS style predictive models (DEHP 2012a).
Declared noxious fish	Fish species that cannot be kept, hatched, reared or sold, and must be destroyed if caught. They must not be returned to the water in any form, and cannot be used as bait (alive or dead).
Endemic	Plant or animal species restricted to a certain region and found nowhere else in the world.
Exotic	Species living outside its native distributional range, which has arrived there by anthropogenic activities, either deliberate or accidental.
Fish Habitat Areas	Areas declared under the *Fisheries Act 1994* to enhance existing and future fishing activities and to protect the habitat for fish and other aquatic animals. They mainly cover inshore and estuarine habitats, as these are recognised as being highly valuable habitats for commercially and recreationally important fish and crustaceans. While normal community use and activities (including legal fishing activities) are not restricted in fish habitat areas, any works or activities that may disturb a fish habitat area require a specific permit under the provisions of the *Fisheries Act 1994*.
Macrophyte	Aquatic plants growing in or near water that are emergent, submerged or floating.
Non-indigenous fish	Fish species living in an area where they are not naturally found. A non-indigenous fish can be a native Australian species (i.e. translocated) or a non-native species (i.e. exotic). Some exotic non-indigenous fish from other countries can be kept without a permit as long as they cannot escape into the local waterways.
pH	The absolute value of the decimal logarithm of the hydrogen-ion concentration (activity), used as an indicator of acidity (pH less than 7) or alkalinity (pH greater than 7) or neutrality (pH 7).
Stream order	A number that designates the relative position of a stream in a drainage basin network, ranked from headwaters to river terminus.
Taxon	(Plural Taxa) Taxonomic group or classification, such as a phylum, order, family, genus, or species.
Translocated	Capture, transport and release or introduction of species, habitats or other ecological material from one location to another.

1. INTRODUCTION

1.1 Background

Arrow Energy Pty Ltd (Arrow Energy) proposes to expand its coal seam gas operations in the Surat Basin (the Project). A voluntary environmental impact statement (EIS) has been prepared for the Project by Coffey Environments Australia Pty Ltd (Coffey Environments), a subsidiary of Coffey International Pty Ltd.

Arrow Energy is required to prepare a supplementary report to the EIS (SREIS) to present information on changes to the Project Description and to provide further consideration and/or information. In order to satisfy these requirements, AMEC Environment and Infrastructure Pty Ltd (AMEC) was contracted by Coffey Environments to undertake the supplementary aquatic ecology assessment for the Project (this assessment).

The following key documents have been referred to in the preparation of this report:

- Aquateco (2011), *Arrow Energy Surat Gas Project Aquatic Ecology Assessment*, report prepared by Aquateco Pty Ltd for Coffey Environments.
- Alluvium (2013a), *Surat Gas Project – Supplementary Report to the EIS: Surface Water Technical Study: PART A – Geomorphology and Hydrology*, report prepared by Alluvium Consulting Australia for Coffey Environments.
- Natural Resource Assessment (NRA) (2013), *Surat Gas Project – Supplementary Report to the EIS: Surface Water Technical Study: PART B – Water Quality*, report prepared by NRA & Alluvium Consulting Australia for Coffey Environments.
- Alluvium (2013b), *Surat Gas Project – Supplementary Report to the EIS: Surface Water Technical Study: PART C — Preliminary Environmental Flows Assessment*, report prepared by Alluvium Consulting Australia for Coffey Environments.

Aquateco [2011] will herein be referred to as the 'EIS'.

1.2 Revised Project Description

The following text has been prepared by Coffey Environments and provides a summary of the revised Project Description:

> *"The main changes to the Project Description presented in the EIS, which have the potential to affect the aquatic ecology impact assessment, include modifications to the size of the Project Development Area, the identification of sites to locate four central gas processing facilities and two water treatment facilities. In addition, the updated Project Description proposes to discharge coal seam gas water under normal operations. Details of changes to the Project Description are provided below.*
>
> *Due to the relinquishment of parcels of land within Arrow Energy's exploration tenements, there has been a reduction in the overall size of the Project Development Area from 8,600 km^2 to 6,010 km^2. The majority of these relinquishments were made in the Goondiwindi development region. As a result of a smaller Project Development Area, there has been a reduction in the number of production wells anticipated to be drilled from 7,500 to approximately 6,500. In addition to single wells, multi-wells will also be drilled, which will be comprised of up to 12 wells, approximately 8 m apart.*

The sequence of the Project's development is described in terms of eleven drainage areas, as opposed to the five development regions that were presented in the original Project Description. Eight of these drainage areas will be initially developed and will each include a central gas processing facility (CGPF), which constitutes a reduction in the number of CGPF's described in the EIS from 12 to 8. Integrated processing facilities will be referred to as a water treatment facility located adjacent to a CGPF.

As part of the revised Project Description, Arrow Energy has identified four sites to locate CGPF's; CGPF7, CGPF8, CGPF2 and CGPF9, which are situated within Drainage Area 7, Drainage Area 8, Drainage Area 2 and Drainage Area 9, respectively. Two CGPF's, CGPF2 and CGPF9, will have a water treatment facility located adjacent to them; Water Treatment Facility 1 and Water Treatment Facility 2, respectively. A fifth site (temporary works accommodation facility [TWAF] F) has been identified by Arrow Energy for a construction camp. The exact locations of infrastructure within each of the five sites (including the discharge point of Water Treatment Facility 1 and Water Treatment Facility 2) have not been determined. The final siting of infrastructure will be determined through a constraints analysis.

The number of water treatment facilities has been reduced from six, as described in the EIS, to two (Water Treatment Facility 1 and Water Treatment Facility 2, co-located with CGPF2 and CGPF9, respectively). There have been changes to the volumes of water treated from these facilities per day, which were described in the EIS as having a template-built capacity of 30–60 ML per day.

The updated Coal Seam Gas Water and Salt Management Strategy provides the option that treated and untreated coal seam gas water may be discharged from each water treatment facility to a nearby watercourse as required and within prescribed, and yet to be determined, limits. Coal seam gas water may be discharged from Survey Area 2 into Bottle Tree Creek and from Survey Area 9 into either Crawlers Creek or the Condamine River.

Discharge to watercourses is a management option that addresses the variability of other coal seam gas water management options (i.e. distribution to existing and new water users for beneficial use and injection to a suitable aquifer). Surface water aspects such as watercourse type, morphology, and aquatic ecosystems at the two identified water treatment facility sites (Survey Area 2 and Survey Area 9) will dictate the management options that can be utilised at each facility site."

(From herein, all mentions of the Project Development Area and Project Description refers to the above-described 'revised' versions, unless otherwise specified.)

1.3 Scope and Objectives

The purpose of this assessment is to assess the potential impacts of the changes to the Project Description and to provide further and/or additional information on the aquatic environment. As such it is comprised of several objectives:

- Update the desktop review to incorporate changes in the Project Description;

- Incorporate additional survey sites to characterise aquatic communities in waterways located within the Dawson River catchment (Fitzroy Basin) and Weir River catchment (Murray-Darling Basin) and assess potential impacts;
- Undertake aquatic surveys at the two proposed discharge locations (Water Treatment Facilities 1 and 2) and assess the potential impacts on the downstream environments;
- Conduct site inspections of the proposed processing facilities that will not discharge water (CGPF's 7 and 8, and TWAF F); and
- Supply dossiers for aquatic species of conservation significance

The overarching purpose of the SREIS is to ensure that adequate information has been provided to ensure that the Project Terms of Reference (ToR) are satisfied.

1.4 Assumptions and Limitations

The following limitations and exclusions are applicable to this assessment:

1. (In-situ) water quality data was collected and reported solely for the purpose of providing context for the interpretation and presentation of ecological results.
2. For the purpose of assessing potential impacts to aquatic ecosystems within the Survey Area 2 and Survey Area 9 receiving systems, this assessment has assumed that the 'quality' of proposed coal seam gas water discharges (assessable by all possible physico-chemical properties) is comparable to that in the receiving system at the time of release. It is of note that differences in the chemical and physical characteristics occurring between the receiving system and the coal seam gas water have the potential to significantly impact on aquatic ecosystems. Assessing the potential impacts related to such differences has not been completed in this assessment.
3. Early-wet season macroinvertebrate surveys were conducted separately, enabling the remainder of the assessment to meet the Project's timelines and ensuring compliance with the timing requirements for AUSRIVAS sampling. Macroinvertebrate sampling of all sites was completed in May 2013 and presented as an addendum to this report.
4. Several sites at Survey Areas 2 and 9, and at SAQ-2, were not surveyed (February/March 2013) due to wet weather and high flow conditions which restricted site access for safety reasons. Results for all aquatic ecology parameters were collected at these sites in May 2013 and presented as an addendum to this report.
5. February and March field surveys took place immediately following high flow events. Whilst it is normally desirable to delay sampling until flows and ecological processes stabilise, this was not possible on this occasion. The data collected in this study has been assessed in this context and is considered to provide an adequate characterisation of aquatic ecosystems.

2. LEGISLATIVE FRAMEWORK & RELEVANT GUIDELINES

Relevant Australian, Queensland and Local Government legislation, policies and planning instruments were previously summarised in the EIS. The following provides all relevant legislation to address EIS submissions and incorporates recent changes to legislation.

2.1 Australian Government Legislation

2.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's central piece of environmental legislation and is managed by the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the Act as matters of national environmental significance.

The seven matters of national environmental significance (MNES) to which the EPBC Act applies are:

- World heritage sites
- National heritage places
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- Nationally threatened species and ecological communities
- Migratory species
- Australian Government marine areas
- Nuclear actions.

The EPBC Act confers jurisdiction over actions that are likely to have a significant environmental impact on Australian Government land, or that are carried out by an Australian Government agency (even if that significant impact is not on one of the seven matters of national environmental significance). The Project was referred to SEWPaC under this legislation on the 27th of January 2010 and has been declared a 'controlled' action.

2.2 State Legislation

2.2.1 *Environmental Protection Act 1994*

The *Environmental Protection Act 1994* (EP Act) is designed to protect Queensland's environment while allowing for development that aims to improve quality of life, now and in the future, in a way that maintains ecological processes on which life depends. This approach is termed 'ecologically sustainable development' and is achieved through a cyclical integrated management program that includes:

- Researching the state of the environment, including essential ecological processes, and determining those environmental values to be protected or achieved by consulting industry, government and the community.
- Developing environmental protection policies that include indicators, standards, waste minimisation and management advice, and promoting community involvement and responsibility.

- Implementing and integrating environmental strategies into matters such as land-use planning and managing natural resources, ensuring actions to protect environmental values from environmental harm, monitoring contaminants in the environment, and requiring those causing environmental harm to pay costs and penalties.
- Requiring accountability, including reviewing impacts of human activities, evaluating efficiencies and effectiveness of environmental strategies, and reporting on the state of the environment.

The EP Act regulates 'environmentally relevant activities', including mining or petroleum activities or as prescribed by the *Environmental Protection Regulation 2008* (EP Regulation). The EP Act binds all parties, including the Queensland Government and its agencies and, as far as legislative power permits, the Australian Government and other state Governments. The proposed activities related to the Project are considered environmentally relevant under this legislation and therefore require issuance of environmental authority.

The *Environmental Protection (Greentape Reduction) and Other Legislation Amendment Act 2012* (Greentape Reduction Act) implemented changes to the EP Act and came into force on 31 March 2013. Amendments to the EP Regulation took effect on the 31 March 2013. The Greentape Reduction Act amends regulatory requirements to ensure applications for an environmental authority are assessed based on environmental objectives, which have clear performance outcomes. The changes will also see a shift in focus towards operational compliance, with increased site inspections by auditors to monitor environmental outcomes and increases to penalty units for non-conformance.

The Environmental Protection Policy (EPP) (Water) seeks to protect Queensland's waters whilst allowing for development that is ecologically sustainable. The EPP (Water) is intended to achieve the object of the act through identification of environmental values, derivation of water quality guidelines and objectives to enhance or protect these values and through monitoring and reporting on the condition of Queensland waters. The Queensland Water Quality Guidelines (QWQG 2009) provide a framework for assessing water quality in Queensland through the setting of Water Quality Objectives (WQO's) (refer to NRA [2013] for further detail regarding these objectives and guidelines).

2.2.2 *Nature Conservation Act 1992*

The *Nature Conservation Act 1992* (NC Act) is aimed at the conservation of biological diversity, ecologically sustainable use of wildlife, ecologically sustainable development and international criteria developed by the World Conservation Union (International Union for the Conservation of Nature and Natural Resources) for establishing and managing protected areas.

The object of the NC Act is to achieve an integrated conservation strategy for Queensland involving matters including:

- Gathering, researching and disseminating information on nature, identifying critical habitats and areas of major interest, and encouraging the conservation of nature by education and co-operative involvement of the community.
- Dedication and declaration of areas representative of the biological diversity, natural features and wilderness of Queensland as protected areas.
- Managing protected areas.

- Protecting native wildlife and its habitat.
- Ecologically sustainable use of protected wildlife and areas.
- Recognition of the interest in nature of Aborigines and Torres Strait Islanders and their co-operative involvement in nature conservation.
- Co-operative involvement of landholders.

The NC Act provides a framework for the management of protected species listed under the *Nature Conservation (Wildlife) Regulation 2006*.

2.2.3 *Fisheries Act 1994*

The main purpose of the *Fisheries Act 1994* (Fisheries Act) is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to apply and balance the principles of ecologically sustainable development and promote ecologically sustainable development.

Ecologically sustainable development, as defined by the Fisheries Act means using, conserving and enhancing the community's fisheries resources and fish habitats so that the ecological processes on which life depends are maintained; and total quality of life can be improved.

The *Fisheries Regulation 2008* provides the following definitions that are of relevance to this Project:

- 'Non-indigenous' fish are fish living in an area where they are not naturally found. A non-indigenous fish can be a native Australian species or a non-native species (i.e. exotic).
- 'Declared noxious' fish are species that cannot be kept, hatched, reared or sold, and must be destroyed if caught.
- 'Declared fish habitat areas' are identified under the Fisheries Act to enhance existing and future fishing activities and to protect the habitat for fish and other aquatic animals.

2.2.4 *Sustainable Planning Act 2009*

Any activity outside of the area of a petroleum lease (e.g. depots) will require both an assessment under the *Sustainable Planning Act 2009 (*SP Act) and relevant local government planning scheme, and development approvals under the planning scheme.

The construction and raising of a waterway barrier is classed as operational works under the SP Act, and therefore requires a development approval through the Integrated Development Assessment System (IDAS) process. Included in the development approval process is an assessment under the Fisheries Act. Under Part 5, Division 3A, Section 76 of the Fisheries Act, a waterway barrier works approval is needed to build any structure across a freshwater waterway, whether it is temporary or permanent. The purpose of this part of the Fisheries Act is to provide a balance between the need to construct dams, weirs, culverts and road crossings, and the need to maintain fish movement. Waterway barriers may be required for the Project (e.g. construction of haul road and conveyor). If approval is given, the Chief Executive of Department of Agriculture, Fisheries and Forestry (DAFF) must be satisfied that movement of fish across the waterway barrier works will be adequately provided for, if necessary by construction of a fishway.

The construction or raising of waterway barrier works may be either an assessable or self-assessable development, depending on the nature of works. This is normally determined at the detailed design phase of a project.

If the proposed waterway barrier does require a development permit, the Fisheries Queensland division within DAFF assesses whether or not an approval should be issued, and whether a fishway should be provided with the structure.

While the provision of effective fish passage may not be a mandatory requirement under current legislation, it is recommended where there would otherwise be deleterious impacts on fish communities.

2.2.5 *Water Act 2000*

The purpose of the *Water Act 2000* (Water Act) is to provide for the sustainable management of water and other resources. The Project may require approvals under the Water Act for the construction, control and management of works with respect to water conservation and protection, drainage, supply, flood control and prevention.

Under Section 269 of the Water Act, a 'riverine protection permit' is required to:

- Remove vegetation in a watercourse, wetland or spring.
- Excavate in a watercourse, wetland or spring.
- Place fill in a watercourse, wetland or spring.

As such, approval may be required to construct creeks crossings or for watercourse diversions.

A Water Resource Plan (WRP) and a Resource Operations Plan (ROP) have been prepared for the Border Rivers, Condamine-Balonne and Fitzroy Basins in Queensland under the Water Act. The WRPs set the strategic framework for the allocation and sustainable management of water within the region. WRPs are reviewed and replaced before the end of a plan's 10-year life. The ROPs are a plan prepared under the provision of the Water Act, by the Chief Executive, to implement a WRP by defining the rules that govern the allocation and management of water in order to achieve the WRP objectives.

2.2.6 *Land Protection (Pest and Stock Route Management) Act 2002*

The *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act) provides a framework for improved management of weeds, pest animals and the stock route network. Declared noxious weeds in Queensland, including aquatic weeds, are listed under the *Land Protection (Pest and Stock Route Management) Regulation 2003*:

- Class 1 declared pests are uncommon in Queensland, and if introduced, are likely to have adverse economic, environmental or social impacts. Class 1 pests established in Queensland must be eradicated from the state.
- Class 2 and 3 declared pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Landowners must take all reasonable steps to keep their land free from Class 2 pests.
- Landowners are not required to remove Class 3 pests, unless their land is next to an area of environmental significance.

2.3 Relevant Policies, Guidelines and Studies

2.3.1 Coal Seam Gas Water Management Policy 2012

This policy supersedes the Coal Seam Gas Water Management Policy 2010 and was approved by the Minister for Environment and Heritage Protection in December 2012. This policy deals with the management and use of coal seam gas water under the EP Act, and does not vary the requirements of the Water Act, so long as coal seam gas operator's 'make good' on obligations. This policy encourages coal seam gas operators to consider the feasibility of using coal seam gas water to meet these obligations as part of developing their coal seam gas water management strategies and plans.

The objective of the policy is to encourage the beneficial use of coal seam gas water in a way that protects the environment and maximises its productive use of a valuable resource.

Coal seam gas water and saline waste is to be managed consistently with the prioritisation hierarchies as follows:

- Prioritisation hierarchy for managing coal seam gas water:

  Priority 1: Coal seam gas water is used for a purpose that is beneficial to one or more of the following; the environment, existing or new water users, and existing or new water-dependent industries

  Priority 2: After feasible beneficial use options have been considered, treating and disposing coal seam gas water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values

- Prioritisation hierarchy for managing saline waste:

  Priority 1: Brine or salt residues are treated to create useable products wherever feasible

  Priority 2: After assessing the feasibility of treating the brine or solid salt residues to create useable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment.

The policy outlines management considerations for a range of water management options (refer to Table 1, DEHP 2012b). It then provides an overview of the management considerations the government expects coal seam gas operators and the administering authority for the EP Act, to have taken into account when determining the coal seam gas water management and use options that best achieve the objective of this policy.

2.3.2 Healthy HeadWaters Coal Seam Gas Water Feasibility Study

The *Healthy HeadWaters Coal Seam Gas Water Feasibility Study* is a project funded through the Commonwealth Government's Water for the Future initiative, with support from the Queensland Government (Department of Science, Information Technology, Innovation and the Arts [DSITIA]). The project seeks to '*analyse opportunities for, and the risks and practicability of, using coal seam gas (CSG) water to address water sustainability and adjustment issues in the Queensland section of the Murray-Darling Basin (QMDB)*' (DNRM 2011). The goals of the project are to facilitate the transition of irrigation communities to lower long-term water availability and secure the viability of ecological assets (DNRM 2011).

The project consists of nine activities including:

- Activity 1 – Chemistry, origins and the hydrogeology of CSG water (Completed in 2011)
- Activity 2 – Modelling and forecasting of CSG water production (Completed in 2012)
- Activity 3 – Assessment of the salinity impacts of CSG water on landscapes and surface streams (Completed in 2013)
- Activity 4 – Stream ecosystem health response to CSG water release (Completed in 2011)
- Activity 5 – Vulnerability of aquifers to CSG water extraction (In progress)
- Activity 6 – Aquifer injection feasibility (Completed in 2011)
- Activity 7 – South West Queensland water demand analysis (Completed in 2010)
- Activity 8 – Proposals for using CSG water in the Central Condamine Alluvium (Completed in 2012)
- Activity 9 – Proposals for CSG water use in the QMDB (Assessing the impact on aquatic ecosystems) (In progress).

The documents associated with Activity 4 (Stream ecosystem health response to CSG water release) relevant to aquatic ecology values of the Project Area were reviewed, including:

- Decision support system (Takahashi et al.2011c)
- Hazard characterisation (Shaw 2010)
- Direct toxicity assessment (Takahashi et al. 2011a)
- Guideline for managing flow regimes (McGregor et al. 2011)
- Biological monitoring guideline (Takahashi et al. 2011b).

These documents discuss the potential impacts to environmental values and water quality of receiving systems as a consequence of CSG releases. Based on an ecological risk assessment approach, the reports identify hazards associated with CSG water disposal into streams. Key hazards identified consisted of (Takahashi et al. 2011c, p. 2):

- *Hydrological alteration including: increase in volume and velocity of flow, decrease in low or no flow spells, and decrease in seasonality of flows*
- *Decrease in electrical conductivity (EC)*
- *Increase in water transparency*
- *Alteration of ionic composition and chemical constituents of the water*, including high sodium, low magnesium and calcium levels.

To facilitate the development of a decision support system (DSS) for the release of CSG water to streams in the QMDB a series of investigations (five reports presented above) were undertaken. The key findings and recommendations of these investigations are summarised in Takahashi et al. 2011c, p. 4. Overall, the documents associated with Activity 4 (Stream ecosystem health response to CSG water release) detailed:

- Potential hazards posed by releases of CSG water to surface streams, based on available literature and existing sampling data.
- How CSG water releases have the potential to alter water chemistry of receiving waterways, especially during low or no flow periods where there is no dilution of CSG water releases.
- Potential risks and significant impacts associated with the continuous discharge of CSG water to ecological assets in waterways, especially due to the ephemeral nature of these streams.
- Guidelines for managing the flow regime based on the potential hazards identified, including duration, timing, variability, predictability, magnitude and rate of rise and fall.
- Biological monitoring framework designed to identify sensitive indicators to determine the response of aquatic ecosystems to the release of CSG water to surface streams.

The documents also outline that there is currently very limited '*empirical understanding of the critical water requirements of Queensland's aquatic ecosystems and their response to water management regimes*' (McGregor et al. 2011, p. 8). Measuring the ecological response and impact of flow alteration is complex due to the influence of other environmental stressors on aquatic values in a waterway (McGregor et al. 2011). Subsequently, '*there is still much reliance on broad conceptual relationships and expert opinion*' and '*current scientific understanding therefore remains the starting point of any assessment process, with the caveat that errors associated with subsequent estimates of risks are likely to be high*' (McGregor et al. 2011, p. 8).

2.3.3 Weeds of National Significance

Weeds of National Significance (WoNS) is a National initiative that is outside of the legislative framework but provides a useful condition assessment tool. The inaugural WoNS was a list of the top twenty weeds as endorsed by the Agricultural and Resource Management Council of Australia and New Zealand, Australia and New Zealand Environment and Conservation Council and Forestry Ministers in 1999. This list was updated with the inclusion of a further twelve weed species in April 2012.

Weeds of National Significance are determined by their:

- Invasiveness
- Impacts
- Potential for spread
- Socio-economic and environmental values.

2.3.4 Aquatic Conservation Assessments

Aquatic Conservation Assessments (ACA) using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) (refer to Fielder, Davidson & Barratt [2011]) have been conducted by the Queensland Department of Environment and Heritage Protection

(DEHP; formerly the Department of Environment and Resource Management [DERM]) to assess the conservation values of wetlands in Queensland (DERM 2009a).

An ACA provides baseline wetland conservational and ecological information which can be utilised in conjunction with field survey results in the Project Development Area to determine the impact of proposed developments and prioritise areas for protection, regulation or rehabilitation. Incorporated into each ACA is the identification of 'Priority' species for conservation purposes.

2.3.5 Back on Track Actions for Biodiversity

The Back on Track species prioritisation framework (Back on Track) is an initiative of the DEHP that:

- Prioritises Queensland's native species to guide conservation management and recovery.
- Enables the strategic allocation of limited conservation resources for achieving greatest biodiversity outcomes.
- Increases the capacity of government, Natural Resource Management (NRM) bodies and communities to make informed decisions by making information widely accessible.

3. ASSESSMENT METHODOLOGY

3.1 Study Area

The Study Area for this assessment is shown in **Figure 3.1** and is comprised of aquatic habitat situated within the Project Development and some adjacent catchment areas. It is of note that the Project Development Area considered for this assessment differs to that considered in the EIS (refer to **Section 1.3**).

The focal point of this supplementary assessment relates specifically to aquatic ecosystems within the following:

- Dawson catchment (Fitzroy Basin)
- Weir River catchment (Murray-Darling Basin)
- Survey Area 2 receiving system for Water Treatment Facility 1 (Murray-Darling Basin)
- Survey Area 9 receiving system for Water Treatment Facility 2 (Murray-Darling Basin).
- The proposed location for establishment of CGPF7
- The proposed location for establishment of CGPF8
- The proposed location for establishment of TWAF F.

Inclusion of aquatic habitat situated outside of the Project Development Area was required to adequately characterise aquatic ecosystems potentially impacted by Project activities. This is because impacts can be transmitted downstream via modified water quality or quantity; the extent of which depends upon the nature and severity of impact, as well as the prevailing hydrologic conditions (e.g. high or base-flow).

3.2 Approach

In order to fulfil the Project scope outlined in **Section 1.3**, a combination of desktop investigations and field surveys were completed.

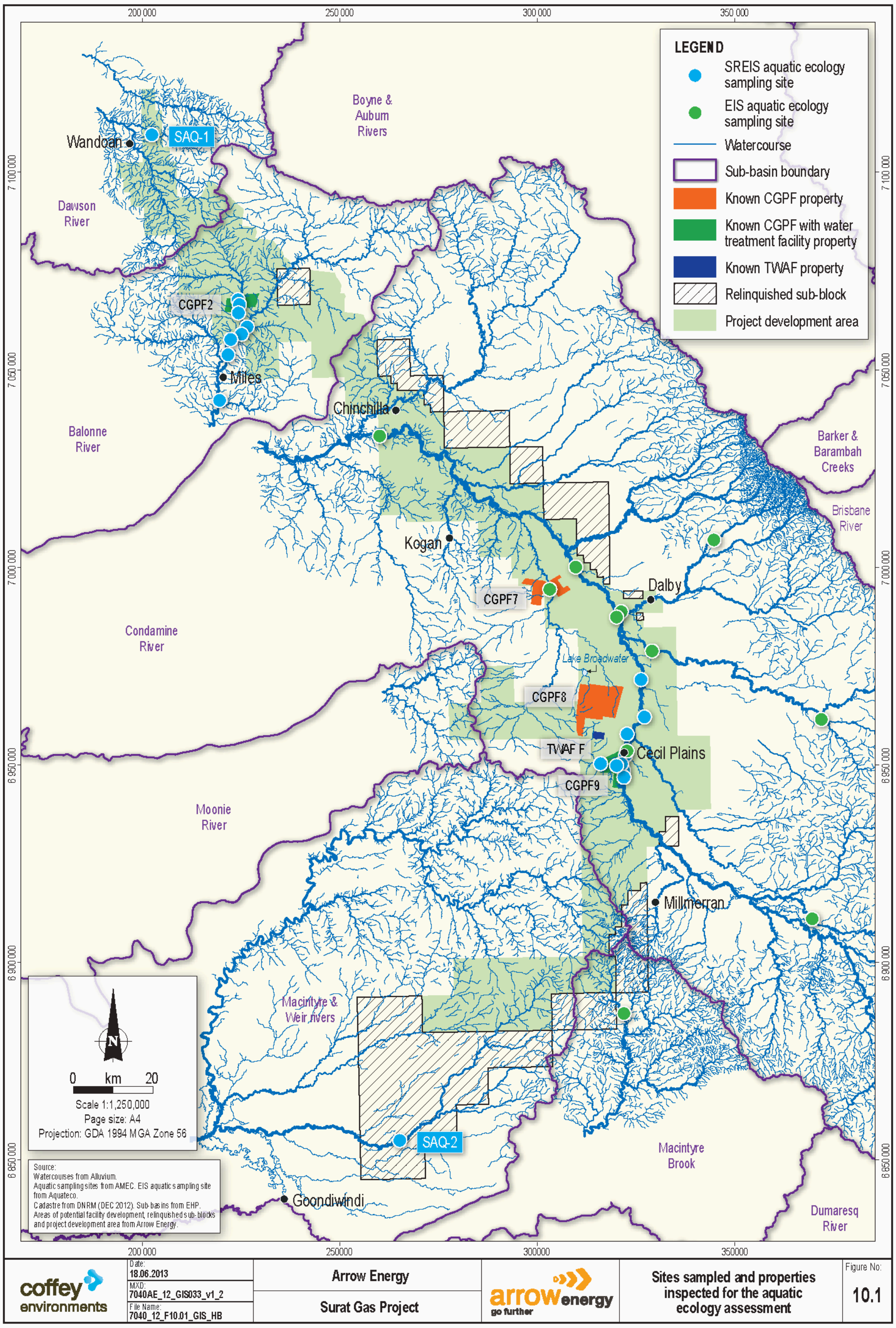

Figure 3.1 Map of SREIS Survey Sites

3.3 Desktop Assessment

A comprehensive review of literature relevant to the Project was completed for the EIS. This supplementary assessment included, but was not limited to, a review of the following key information sources in relation to the Project Development Area (or within a 10 km radius of SREIS survey sites situated outside of the Project Development Area), prior to commencement of the field survey:

- Areas of conservation significance, species and ecological communities identified in SEWPaC EPBC Act Protected Matters Search Tool (**Attachment 1**).
- Species data from DEHP Wildlife Online databases (refer to **Attachment 1**). Reviews focussed on Endangered, Vulnerable or Near Threatened (EVNT) flora and fauna species
- Results from the Back on Track species prioritisation framework for the Condamine Natural Resource Management (NRM) region (DERM 2010a), Border Rivers Maranoa-Balonne NRM region (DERM 2010b) and Fitzroy NRM region (DERM 2010c) Back on Track Actions for Biodiversity to identify priority conservation species.
- Aquatic Conservation Assessments for the riverine and non-riverine wetlands of the Queensland Murray-Darling Basin (QMBD) (Fielder, Davidson & Barratt 2011) to obtain species data and identify priority conservation species.
- Aquatic Conservation Assessments for the riverine (Inglis & Howell 2009a) and non-riverine wetlands of the Great Barrier Reef catchment (Inglis & Howell 2009b) to obtain species data and identify priority conservation species.
- Information on species ecology (distribution, habitat requirements, etc.): fish – Lintermans (2007), Pusey, Kennard & Arthington (2004) and Allen *et al.* (2003); reptiles - Cann (2008) and Wilson & Swan (2008); mammals - Van Dyck & Strahan (2008); invertebrates - Gooderham & Tsyrlin (2002); and waterplants - Sainty & Jacobs (2003).
- Reviews of relevant State and Australian Government legislation (**Section** 2).

The results of the desktop assessment were used to inform both site selection and survey methodologies utilised during field surveys. The results from the desktop assessment were also used to collate a species-specific 'dossier' for the two MNES listed (Murray Cod, *Maccullochella peelii peelii,* and Fitzroy River Turtle, *Rheodytes leukops*) and eight locally significant species. These dossiers are presented in **Attachment 2**.

3.4 Field Assessment

3.4.1 Site Selection

Overview

To meet the objectives of this supplementary assessment (**Section 1.3**) sites were included to address:

1. Further characterisation of the aquatic environment as provided in (Aquateco, 2011)that includes the:
    a. Dawson catchment (Fitzroy Basin)
    b. Weir River catchment (Murray-Darling Basin)

2. Change to the Project Description; regarding the option for discharge of treated or untreated coal seam gas water at two locations:
   a. Water Treatment Facility 1 receiving system (Bottle Tree Creek) - Survey Area 2
   b. Water Treatment Facility 2 receiving system (Crawlers Creek or Condamine River) Survey Area 9
3. Change to the Project Description regarding the establishment of proposed coal seam gas processing facilities at two locations:
   a. CGPF7
   b. CGPF8

   No discharge will occur at either site.
4. Change of the Project Description regarding the establishment of a construction camp (TWAF F).

A total of 22 sites were selected for the field survey as part of this assessment. Information regarding the site locations and other specifics is presented in **Table 3.1** and **Figure 3.1**. Sites were selected for inclusion in this assessment based on the following criteria:

- Situated on waterways within, or in proximity to, the Project Development Area;
- Representative of aquatic conditions throughout the local region;
- Enabled further characterisation of aquatic ecosystem values as presented in the EIS in accordance with the requirements of the Project ToR;
- Situated on public land or upon property for which landholder access had been granted; and
- Readily accessible.

Due to the differing nature of potential impacts (**Section 1**), varying numbers of sites were surveyed for each of the above described purposes (**Table 3.1**). A single site was situated in the Dawson catchment and another within the Weir River catchment, for each of purposes 1a and 1b, respectively. This level of survey effort was warranted as; only a small portion of the Project Development Area occurs within each of the catchments, the hydrology of tributaries within these catchments is highly ephemeral, aquatic habitat within these catchments is relatively uniform in terms of key biophysical attributes, and the risk of impact to aquatic ecosystems is relatively low.

For purposes 2a and 2b, eight and ten sites were included, respectively. For the receiving systems associated with Survey Area 2 and Survey Area 9, sites were situated upstream of the discharge point and progressively downstream (refer to Sections *Survey Area 2 Receiving System* and *Survey Area 9 Receiving System*). This increased survey effort reflects the nature of activities anticipated in these areas, which necessitate a more comprehensive understanding of potentially affected aquatic ecosystems.

Only a single 'site' was included for each of purposes 3a, 3b and 4. The term 'site' is applied cautiously as the survey effort involved a visual inspection to identify if surface water aquatic ecosystems were present (refer to **Section 3.4.3.7**). No sampling was completed for any aquatic indicators at this site.

Survey Area 2 Receiving System

Key waterways within the Survey Area 2 receiving system are Dogwood Creek and Bottle Tree Creek, which is a first-order tributary of Dogwood Creek. Eight survey sites were located 'longitudinally' throughout this system in order to characterise aquatic values, including three and six sites on Bottle Tree Creek and Dogwood Creek, respectively (**Figure 3.2**). Based upon the amended Project Description (**Section 1.2**), the location of the Survey Area 2 discharge point may be on Bottle Tree Creek, somewhere between survey sites DA2-2 and DA2-4 (the most downstream site in Bottle Tree Creek). Irrespective of the final Project design, site DA2-1 is likely to remain upstream of the proposed discharge point. Sites DA2-6 to DA2-9 are located on Dogwood Creek downstream of the confluence with Bottle Tree Creek and thus would be the receiving environment of discharged coal seam gas water. Site DA2-5 is situated on Dogwood Creek upstream of the Bottle Tree Creek confluence and thus would not receive coal seam gas water. It is also of note that several, small, un-named, drainage lines confluence with Bottle Tree Creek and Dogwood Creek within the Survey Area 2 receiving system; most notably, between sites DA2-1 and DA2-2.

Survey Area 9 Receiving System

The key waterways within the Survey Area 9 receiving system are the Condamine River and Crawlers Creek, which is a first-order tributary of the Condamine River. Nine survey sites were positioned 'longitudinally' throughout this system in order to characterise aquatic values including seven sites in the Condamine River and two sites in Crawlers Creek (**Figure 3.3**). Based on the amended Project Description (**Section 1.2**), the location of the Survey Area 9 discharge point may be on either the Condamine River, or Crawlers Creek between sites DA9-21 and DA9-22. It is also of note that several, small, un-named, drainage lines confluence with Condamine River within the Survey Area 9 receiving system.

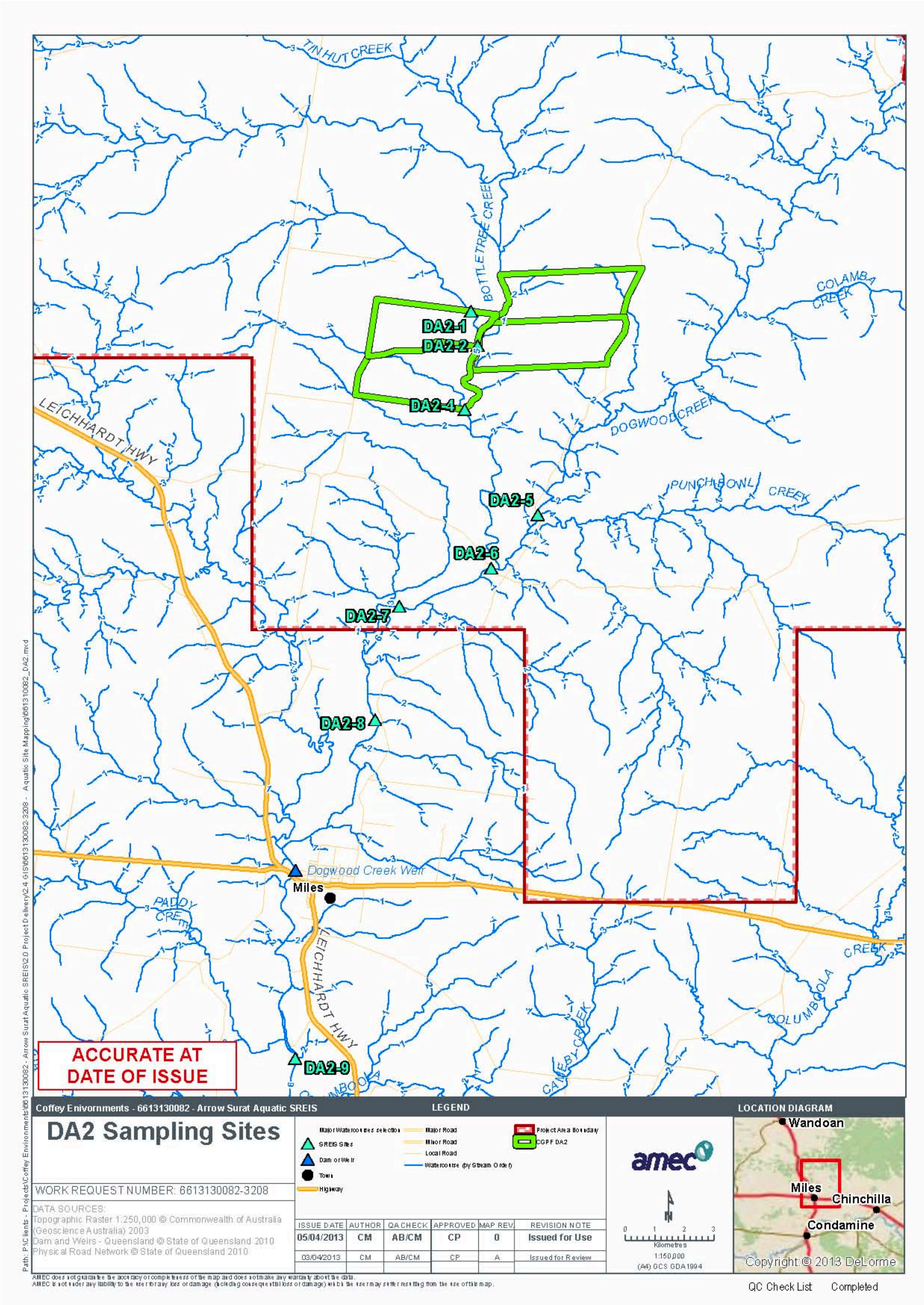

Figure 3.2 Survey Area 2 Receiving System Site Network

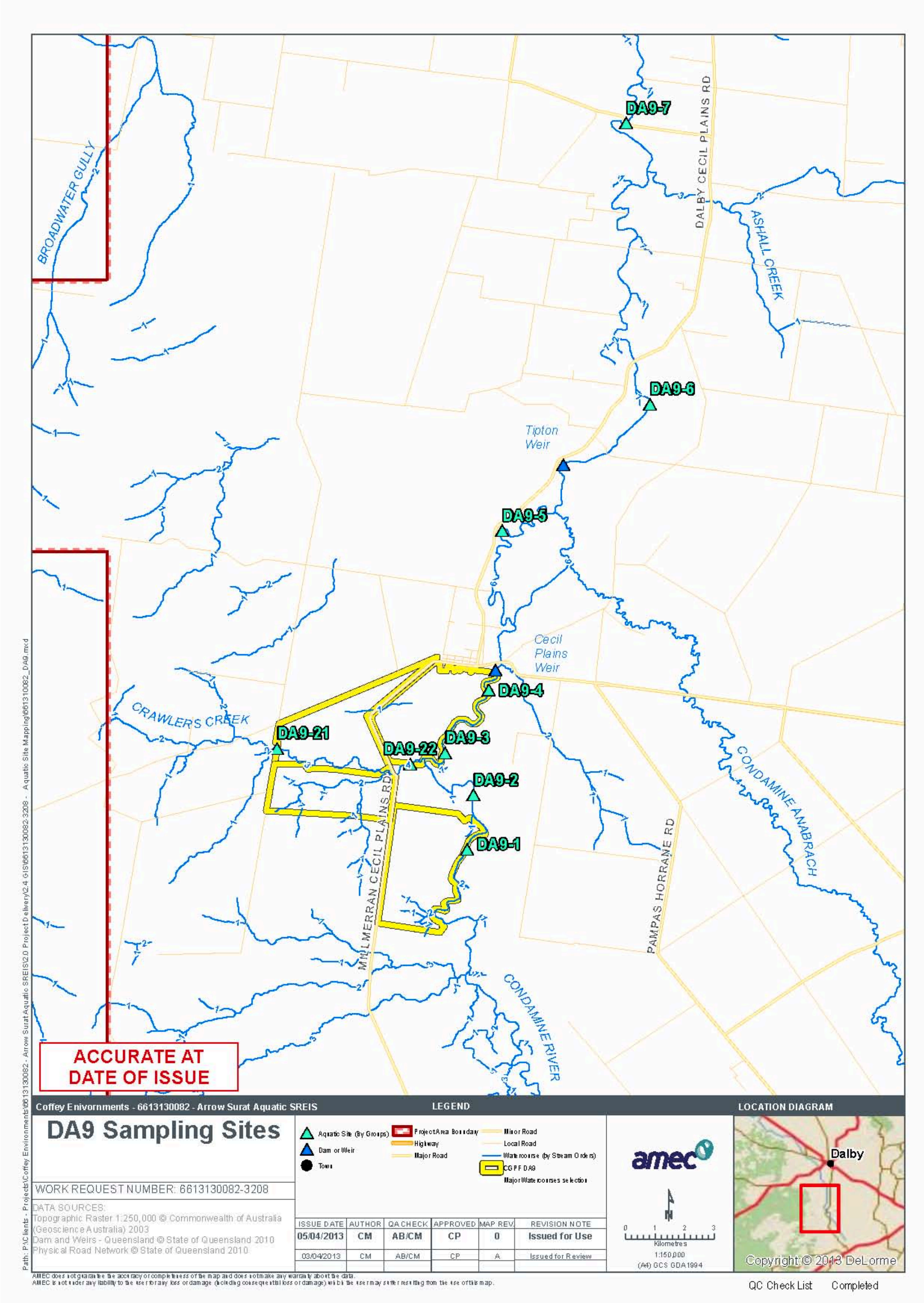

Figure 3.3 Survey Area 9 Receiving System Site Network

Table 3.1 Summary of SREIS Survey Site Information

Site Code	Purpose[1]	Basin	Sub-Basin	Catchment	Waterway	Wetland Type[2]	Stream Order[4]	Elevation (m)	GPS Coordinate[3] (UTM WGS 84, Zone 55J)	
									Latitude	Longitude
SAQ-1	1a	Fitzroy	Dawson	Dawson River	Weringa Creek	Riverine	3	261	-26.10315	150.02512
SAQ-2	1b	Murray-Darling	Condamine-Balonne	Weir River	Commoron Creek	Riverine	3	245	-28.41009	150.60281
DA2-1	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	5	318	-26.48431	150.23480
DA2-2	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	5	317	-26.49485	150.23687
DA2-4	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	5	314	-26.51435	150.23288
DA2-5	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	5	310	-26.54654	150.25520
DA2-6	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	5	310	-26.56294	150.24098
DA2-7	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	6	307	-26.57455	150.21282
DA2-8	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	6	305	-26.60924	150.20546
DA2-9	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	6	298	-26.71285	150.18096
DA9-1	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	362	-27.58947	151.19456
DA9-2	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	361	-27.57285	151.19647
DA9-3	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	360	-27.55998	151.18783
DA9-4	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	359	-27.54071	151.20118
DA9-5	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	355	-27.49195	151.20533
DA9-6	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	353	-27.45327	151.25054
DA9-7	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	6	349	-27.36719	151.24324
DA9-21	2b	Murray-Darling	Condamine-Balonne	Condamine River	Crawlers Creek	Riverine	3	370	-27.55860	151.13644
DA9-22	2b	Murray-Darling	Condamine-Balonne	Condamine River	Crawlers Creek	Riverine	4	360	-27.56339	151.17722
CGPF7	3a	Murray-Darling	Condamine-Balonne	Wilkie Creek	NA	NA	NA	NA	-27.15998	151.00740
CGPF8	3b	Murray-Darling	Condamine-Balonne	Wilkie Creek	NA	NA	NA	NA	-27.41879	151.13499
TWAF F	4	Murray-Darling	Condamine-Balonne	Wilkie Creek	NA	NA	NA	NA	- 27.49218	151.12928

Notes:
1. Described in **Section 3.4.1**.
2. Defined by DEHP (2013).
3. Coordinate denotes middle point of the 100 m site reach for all sites except CGPF7, CGPF8 and TWAF F, for which the coordinate indicates the centre-point of the visual inspection area (refer to **Section 3.4.3.7**).
4 Strahler (1952) method of stream order classification.

NA Not applicable; 'site' was not situated upon riverine or other wetland habitat (refer to **Section 3.4.3.7**).

3.4.2 Classification of Waterways with respect to Surface Water Permanence

The classification of waterways (e.g. drainage lines, creeks, streams and rivers) with respect to flow permanence is an important distinction to make for the purpose of characterising aquatic ecosystems potentially impacted by the Project. Definitions of permanent, semi-permanent, and ephemeral waterways, which have been adopted throughout this report, are presented in **Table 3.2**.

In Australia, there are no standard definitions used consistently to classify stream type with respect to permanence of surface water. The wide range of temporal and spatial variability in lotic (flowing) systems throughout Australia, as well as interest from a number of technical disciplines (e.g. hydrology, fluvial geomorphology, ecology), has led to the development of numerous sets of definitions. For the purposes of this investigation a combination of literature sources were referenced.

Table 3.2 Definitions of Waterway Type^

Waterway Type	Definition
Permanent*	A waterway with a well-defined channel that normally flows throughout the entire hydrological cycle. Stream flow persists during both high rainfall (typically during wet-season/summer) and low rainfall (dry-season) periods, albeit at differing magnitudes. In drought years permanent waterways may cease to flow, however, non-flowing, connected, pools will persist throughout the waterway channel.
Semi-permanent**	A waterway with a well-defined channel that contains water for more than 70% of the time on average. These waterways have high flow during high rainfall periods (typically during wet-season/summer). During dry season these waterways are reduced to a series of non-flowing, semi-connected or disconnected pools. A portion of dry/exposed stream bed will persist throughout dry-season.
Ephemeral waterway***	A waterway that contains surface water flow through all or part of a defined channel, only following heavy and sustained precipitation events (typically during the wet-season/summer). Flowing surface waters persist for only a small fraction of the hydrological cycle. Typically, following periods of flow, surface water will persist in the form of non-flowing, disconnected pools, separated by areas of dry/exposed stream bed. For the majority of the year, however, surface water (either flowing or non-flowing) will be absent.

Notes:
^ Definitions apply to ('riverine') waterways only, not off stream ('palustrine' or 'lacustrine') wetlands.
* Sourced: Charlton (2009), Allaby (2010) and NACC (2012)
** Sourced: Silcock (2009)
*** Sourced: Allaby (2010), NACC (2012) and Smithson et al. (2008)

Three common points of focus across the literature for developing such definitions included:

1. Permanence of stream flow

2. Permanence of water; either flowing or non-flowing
3. Portion of dry/exposed channel.

These three points have been integrated into the definitions adopted for this investigation.

It should be recognised that a certain degree of flexibility must be applied when assigning these definitions to a particular stream. Waterways are prone to altering hydrological regimes with respect to differing temporal (i.e. 1 month, 1 year, 10 years or 100 years) and spatial scales (i.e. 1 km, 10 km, 100 km or 1000 km). In particular, Australian semi-permanent and ephemeral waterways exhibit a high degree of variability in stream flow (magnitude, onset and duration) on an inter-annual basis. Accordingly, when considering which definition is most applicable, scale is critically important.

3.4.3 Survey Methodology

A general summary of survey effort completed at each site is provided in Table 3.3. Specific details are provided below for each survey category. Macroinvertebrate surveys were conducted in May 2013 with sampling methodology and results provided in the addendum to this report.

3.4.3.1 Aquatic Habitat

Aquatic habitat was assessed in accordance with Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (DNRM 2001). Habitat bio-assessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat condition assessment score (Table 3.4).

According to this system sites with scores:

- >110 were considered to be in excellent condition
- Between 75 and 110 were considered to be in good condition
- Between 39 and 74 were considered to be in moderate condition
- ≤38 were considered to be in poor condition.

Whilst the AUSRIVAS method is an accepted standard for undertaking aquatic habitat assessments, it is less appropriate for ephemeral systems in Queensland than for more permanent waterways; using this method, even pristine ephemeral systems are rarely classed as being in excellent condition, due to the nature of the ephemeral waterways. Nevertheless, it is a useful system for comparing sites within the Study Area.

Table 3.3 Summary of SREIS Survey Effort

Site	Water Quality	Aquatic Habitat	Macrophytes	Macroinvertebrates	Fish and Turtles	Other Vertebrates	Qualitative Visual Survey
SAQ-1	✓a	✓a	✓a	✓c	✓a	✓a	NA
SAQ-2	✓c	✓c	✓c	✓c	✓c	✓c	NA
DA2-1	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-2	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-4	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-5	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-6	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-7	✓a	✓a	✓a	✓c	✓a	✓a	NA
DA2-8	✓c	✓c	✓c	✓c	✓c	✓c	NA
DA2-9	✓c	✓c	✓c	✓c	✓c	✓c	NA
DA9-1	✓b	✓b	✓b	✓c	✓b	✓b	NA
DA9-2	✓b	✓b	✓b	✓c	✓b	✓b	NA
DA9-3	✓b	✓b	✓b	✓c	✓b	✓b	NA
DA9-4	✓b	✓b	✓b	✓c	✓b	✓b	NA
DA9-5	✓c	✓b	✓c	✓c	X	X	NA
DA9-6	✓c	✓b	✓c	✓c	X	X	NA
DA9-7	✓c	✓b	✓c	✓c	X	X	NA
DA9-21	✓b	✓b	✓b	✓c	✓b	✓b	NA
DA9-22	✓b	✓b	✓b	✓c	✓b	✓b	NA
CGPF7	NA	NA	NA	NA	NA	NA	✓a
CGPF8	NA	NA	NA	NA	NA	NA	✓a
TWAF F	NA	NA	NA	NA	NA	NA	✓a

Notes:
✓ Survey completed.
X Survey not completed.
N/A Not applicable.

a. Survey completed 18–28 February 2013.
b. Survey completed 18–22 March 2013.
c. Survey completed 8–15 May 2013.

Table 3.4 Habitat Bio-Assessment Scores

Habitat Category	Category Score Range			
	Excellent	Good	Moderate	Poor
Bottom substrate/available cover	16–20	11–15	6–10	0–5
Embeddedness	16–20	11–15	6–10	0–5
Velocity/depth category	16–20	11–15	6–10	0–5
Channel alteration	12–15	8–11	4–7	0–3
Bottom scouring & deposition	12–15	8–11	4–7	0–3
Pool/riffle, run/bend ratio	12–15	8–11	4–7	0–3
Bank stability	9–10	6–8	3–5	0–2
Bank vegetative stability	9–10	6–8	3–5	0–2
Streamside cover	9–10	6–8	3–5	0–2
TOTAL Score for the Site	**111–135**	**75–110**	**39–74**	**0–38**

3.4.3.2 Water Quality

All sample collection was completed in accordance with the DERM Monitoring and Sampling Manual 2009 (DERM 2010d) and AS/NZ 5667.6:1998 (Guidance on sampling of rivers and streams) (AS/NZS 1998).

Physico-chemical analysis of surface samples consisted solely of *in-situ* measurement. A summary of the parameters measured and their associated measurement precision are presented in **Table 3.5**. The measurement of all *in-situ* parameters was performed using an Aquaread multi-probe meter (model AP-2000).

Table 3.5 In-situ Water Quality Measurement Parameters

Parameter	Units	Measurement Precision
Water temperature	ºC	± 0.1
pH	pH Units	± 0.1
Dissolved oxygen	mg/L	± 0.1
Electrical conductivity	µS/cm	± 1
Turbidity	NTU	±0.1

3.4.3.3 Macrophytes (Aquatic Flora)

Aquatic flora was assessed visually over the 100 m survey reach at each site. Emergent, floating and submerged macrophytes were identified along each bank (up to 5 m from the stream edge) and their presence recorded. A description of the composition of native and exotic species, and their growth form was prepared.

3.4.3.4 Fish

Fish surveys were completed in accordance with the DERM Sampling and Processing Manual 2009 (DERM 2010d).

Ecological assessments of fish assemblages are based on the probability of capture for each species being proportional to its absolute abundance at each site. The use of multiple sampling methods increases the probability of capturing all species in heterogeneous habitats such as those found in aquatic environments within the Study Area. The sampling techniques adopted for this study included:

- Electrofishing (backpack or boat)
- Fyke netting
- Box trapping.

These methods are described in detail in the following sections. The use of the above-mentioned sampling methodologies was contingent upon the habitat and flow conditions present at any given site. A combination of these techniques was appropriate for use at most sites (refer to **Table 3.6**).

The method of sampling, species, length (mm) and abundance of fish species captured or observed were recorded at each site. Native fish were returned to the water, while ‘noxious species’ were euthanised humanely, in accordance with AMEC’s animal ethics and fisheries scientific collection permits. The sampling was conducted under General Fisheries Permit No. 153414 and Animal Ethics Approval No. CA 2012/02/589.

It is of note that the sampling program completed for this assessment has been designed for the purpose of identifying the maximum diversity of species present, and generates semi-quantitative data only. Whilst this type of assessment is the most appropriate for satisfying the Project ToR, it only allows gross associations to be made within the primary data-set or between secondary biotic and/or abiotic data-sets.

Fish surveys were not possible at sites DA9-5, DA9-6 and DA9-7 due to steep banks and deep water.

Table 3.6 Fish and Turtle Sampling Effort Summary

Site	Fish Sampling Technique				
	Backpack EF[1]	Boat EF[1]	Fyke Netting[2]	Box Trapping[2]	Cathedral Netting[2]
DA2-1	1,200	NA	2	10	NA
DA2-2	650	NA	2	10	NA
DA2-4	1,200	NA	2	10	NA
DA2-5	700	NA	2	10	NA
DA2-6	700	NA	2	10	NA
DA2-7	670	NA	2	10	NA
DA9-1	NA	1,080	NA	10	2
DA9-2	NA	1,080	NA	10	2
DA9-3	NA	1,080	NA	10	2
DA9-4	NA	1,080	NA	10	2
DA9-21	1,200	NA	2	10	NA
DA9-22	1,200	NA	2	10	NA
SAQ-1	1,200	NA	2	10	NA

Notes:
✓ Habitat present; survey completed.
X Habitat absent.
NA Not applicable.
1 Seconds ‘power on’.
2 number of nets set.

Electrofishing Methods (Backpack and Boat)

All electrofishing was conducted in accordance with the Australian Code of Electrofishing Practice (NSW Fisheries 1997).

Backpack electrofishing was undertaken in shallower waterways that were safely wadeable. A Smith-Root backpack unit (LR24 model) was utilised by a Senior Electrofishing Operator while an appropriately trained assistant aided in the collection of fish for identification and measurement. Sampling was carried out over a site reach spanning approximately 100 m (where sufficient water was available), with care being taken to sample all macro and microhabitat types. Electrofishing was conducted for 1,200 seconds power on time at each site, dependent on habitat availability and operator safety.

Boat electrofishing was used to sample the larger, deeper waterways where backpack electrofishing could not effectively be utilised. An electrofishing boat fitted with a Smith-Root 7.5 Generator Powered Pulsator electrofishing unit was used by a Senior Electrofishing Operator while an appropriately trained assistant aided in the collection of fish for identification and measurement. Sampling was carried out over a site reach spanning approximately 100 m (where sufficient water was available), with care being taken to sample all macro and microhabitat types. Twelve replicate 90 second ‘power on’ shots (total of 1,080 seconds) were taken at all sites where boat electrofishing was undertaken. Catch data from each replicate shot were pooled for each site.

Fyke Netting

Fyke netting is a passive fish sampling technique utilised to target large-bodied fish and turtles, which may not be commonly caught with other sampling techniques. Fyke netting is used in relatively shallow, slow flowing reaches. Where sufficient water depth and flow conditions allowed, two fyke nets (single or double wing as appropriate) were baited with cat food. Single wing nets were deployed perpendicular to the shoreline with the wing extending to the shoreline and the cod-end buoyed to allow trapped turtles access to the surface to breathe. Double wing fyke nets were set parallel to the shoreline or strategically aligned close to fish and turtle holding structure with the cod end suspended or buoyed to prevent turtle drowning. The cod was tied off to a stake above the water level and a float placed inside to maintain an air-space to reduce the risk of drowning of air-breathing animals (e.g. turtles, platypus).

Box Trapping

Box trapping is a passive fish sampling technique, which funnels fish moving both upstream and downstream (DERM 2010d). Box trapping targets small bodied pelagic and benthic species. A total of 10 unbaited box traps were set for at least two hours in proximity to snags and other stream side vegetation. Bait trapping was carried out where there was sufficient habitat and water depth, and currents were slow enough to prevent bait traps being swept off the substratum or washed downstream.

3.4.3.5 Turtles

Modified fyke nets or opera house turtle nets baited with oily fish were used (as appropriate for site conditions) to concurrently sample fish and turtles within pools. Single wing nets were deployed perpendicular to the shoreline with the wing extending to the shoreline and the cod-end buoyed to allow trapped turtles access to the surface to breathe. Double wing fyke nets were set parallel to the shoreline or strategically aligned close to fish and turtle holding structure with the cod end suspended or buoyed to prevent turtle drowning. Opera house turtle nets were used in the post wet-season sampling period to sample the open water areas and were buoyed to prevent turtle drowning. Captured animals were photographed and the number of animals caught at each site was recorded prior to releasing them unharmed to the site of capture.

3.4.3.6 Other Vertebrates

Aquatic vertebrates other than fish and turtles, including, platypus, water rats, frogs and semi-aquatic reptiles, were not specifically targeted as part of this assessment. Incidental sightings and by-catch were recorded at each site with the photos and co-ordinates provided to Ecosmart for the terrestrial fauna surveys associated with the Project (Ecosmart 2013).

3.4.3.7 Qualitative Visual Survey

The purpose of survey at sites CGPF7 and CGPF8, and TWAF F was to identify the presence of general aquatic values (i.e. rivers, creeks, off-stream wetlands, etc.). As such, surveys at these sites were restricted to a visual inspection to describe aquatic values and potential sensitive areas to be considered in the future development of these sites.

3.4.4 Survey Timing

The original schedule of works included two phases of 'post-wet' season sampling:

- Water quality, aquatic habitat, macrophytes, fish, other vertebrates and qualitative visual inspection in February, March and May 2013
- Macroinvertebrate sampling in May 2013. The decision to complete macroinvertebrate sampling as a standalone event, following the initial round of surveys, was made to allow for survey during the defined AUSRIVAS (DNRM 2001) 'autumn' sampling window. The timing of sampling for other indicators was less critical and was driven by Project time constraints.

High rainfall during February forced sampling to be aborted approximately halfway through the survey effort due to high flows and saturated tracks restricting site access. Sites at SAQ-1, CGPF7, CGPF8 and most sites at Survey Area 2 were sampled during February (19^{th}–24^{th}), whilst most sites at Survey Area 9 were sampled during March (18^{th}–24^{th}) once flow levels had receded and water levels had stabilised (**Figure 3.4**). As originally scheduled, macroinvertebrate sampling for all sites was completed during May 2013 with results presented as an addendum to this report. The additional sites at Survey Area 2, Survey Area 9 and SAQ2 were sampled in May at the same time as the macroinvertebrate sampling and presented in the addendum to this report (**Figure 3.4**).

The division of sampling between February, March and May is not expected to impact on the ability to adequately characterise aquatic ecosystems in accordance with the requirements outlined in the Project ToR.

3.4.5 Data Analysis

Water quality, aquatic habitat, macrophytes, fish and other vertebrates have been presented graphically and in tabular format, as appropriate. Analysis of macroinvertebrate data is described in the addendum to this report.

For consistency with the EIS, surface water quality results relating to sites situated within the Murray Darling Basin were evaluated against the ANZECC Guidelines for ‘lowland rivers’ for ‘moderately disturbed’ aquatic ecosystems in ‘south-east Australia’ (which includes south-east Queensland) (ANZECC 2000). These values are presented in **Table 3.7**. Results relating to site SAQ-1 were compared against the QWQG (2009) for ‘slightly to moderately disturbed’ ‘upland streams’ situated in ‘central coast Queensland’. These values are presented in **Table 3.8**.

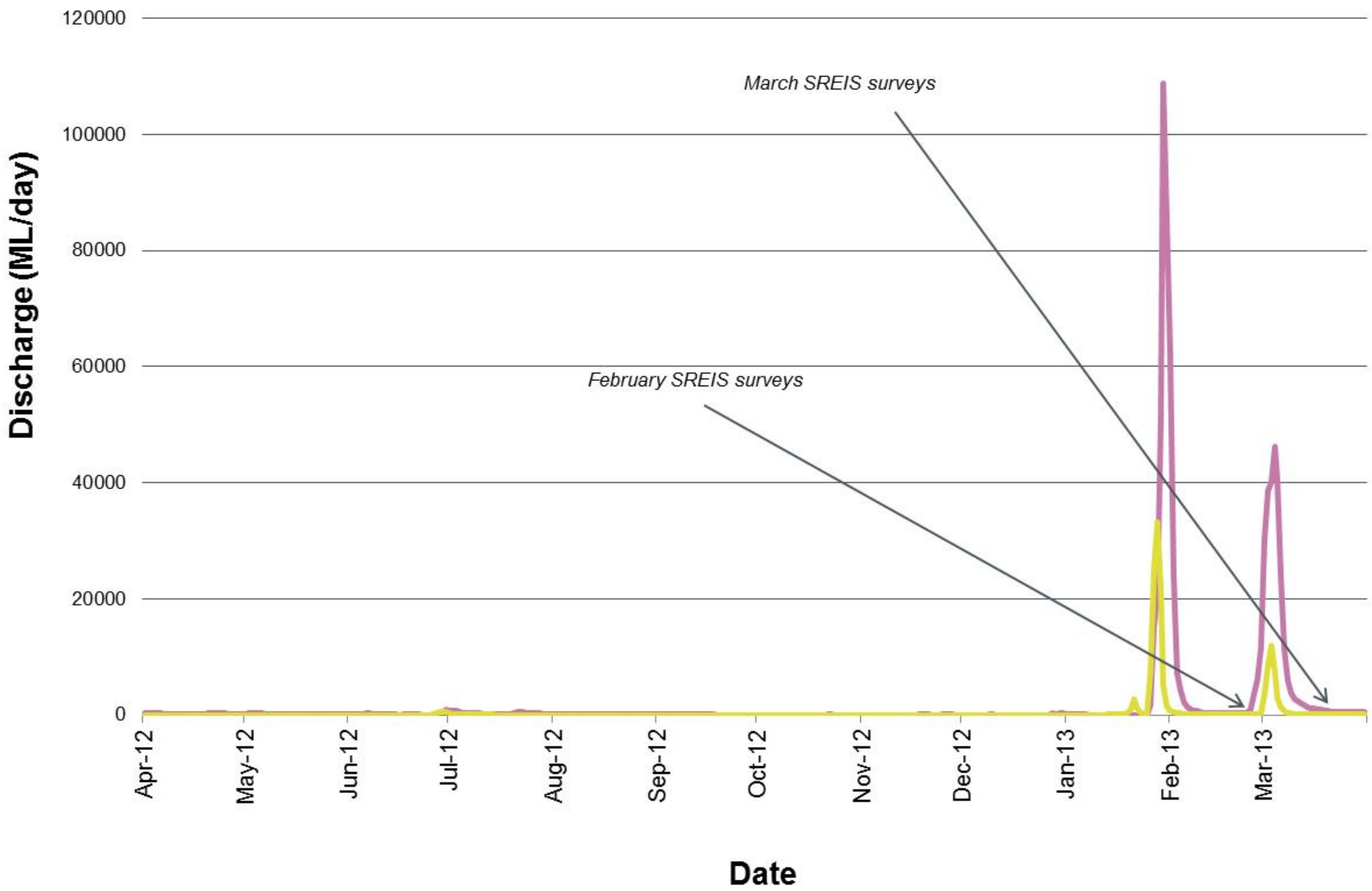

Figure 3.4 Indicative Stream-Flow of Dogwood Creek (Survey Area 2)^ and Condamine River (Survey Area 9)* within the Study Area

Notes: Purple line denotes 'Dogwood Creek at Gil weir' (DERM Station # 422202B) - ^ Data source: DNRM 2013a; Green line denotes 'Condamine River at Cecil Plains weir' (DERM Station # 422316A) - * Data source: DNRM 2013b. Discharge on the y axis refers to natural stream discharge.

Table 3.7 ANZECC Guidelines for 'lowland rivers' in south-east Australia (ANZECC 2000)

Water type	DO (% sat)		Turbidity (NTU)		pH		Conductivity (µS/cm)	
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Lowland Streams	85	110	6	50	6.5	8.0	125	2,200

Table 3.8 QWQG Guidelines for 'upland streams' 'central coast Queensland' (QWQG 2009)

Water Type	DO (% sat)		Turbidity (NTU)		pH		Conductivity (µS/cm)	
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Upland Streams	90	110	NA	25	6.5	7.5	130	510

Note: NA indicates absence of guideline trigger value.

3.4.6 Taxonomic Nomenclature and Conservation Status

The significance of flora and fauna in this report are described as per their listings in the:

- EPBC Act as 'critically endangered' (CE), 'endangered' (E) or 'vulnerable' (V)
- NC Act as 'endangered' (E), 'vulnerable' (V), 'near threatened' (NT)
- DEHP Back on Track species prioritisation framework (DERM 2010a; DERM 2010b) as 'critical priority' (C), 'high priority' (H), 'medium priority' (M)
- ACA Assessments (Fielder *et al.* 2011; Inglis & Howell 2009a; Inglis & Howell 2009b) as a 'priority'.

3.5 Impact Assessment

The assessment of impacts expands on the method detailed in the EIS to address site and species specific impacts and is outlined below. This method quantifies a significance rating of impacts as a function of the sensitivity of freshwater aquatic values (**Table 3.10**) and the magnitude of the impact (**Table 3.11**), using the matrix shown in **Figure 3.5** and the descriptions presented in **Table 3.9**.

		Sensitivity of Freshwater Ecosystems or Species		
		High	**Moderate**	**Low**
Magnitude of Impact	**High**	Major	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Negligible

Figure 3.5 Significance Impact Assessment Matrix for Aquatic Ecosystems or Species

Table 3.9 Description of Impact Ratings

Impact Category	Description
Major	Typically associated with long term, widespread or very severe impacts on iconic environmental values of natural or international conservation significance.
High	May relate to lower magnitude impacts on iconic environmental values, or may be the result of long term, widespread or severe impacts to species of state significance, existing assemblages of flora and fauna, or the fundamental processes that enable their persistence.
Moderate	Are associated with severe impacts on less sensitive environmental values, or to less severe impacts on environmental values of state or national significance, existing assemblages of flora and fauna, or the fundamental processes that enable their persistence.
Low	Are those that are relatively short term, low severity and localised, and that affect environmental values that are marginal or are tolerant of such disturbance events.
Negligible	Of such low magnitude or affect such low value ecosystems that no mitigation or avoidance strategies are warranted.

Sensitivity Criteria for Aquatic Ecosystems or Species

The sensitivity of a particular aquatic ecosystem to impacts associated with the project is determined by considering the attributes listed in **Table 3.10**. Following assessment of an ecosystem against each of these assessment criteria, it was assigned an overall sensitivity ranking as per 'best of fit'.

Table 3.10 Sensitivity Criteria for Aquatic Ecosystem or Species Values

Sensitivity Attribute	Assessment Criteria
Conservation status	● Is the waterway/ species listed as having special conservation status (e.g., wild rivers, world heritage, Ramsar listing)? ● Does the waterway potentially support species of conservation significance (e.g., EPBC/Nature Conservation listed species)? ● Does the waterway support commercial or recreational fisheries or other legislatively managed values? ● Is the waterway highly valued as an ecotourism destination (e.g. river cruises)?
Intactness	● Does the aquatic ecosystem represent pristine, undisturbed wilderness, or has it been impacted by urbanisation and industrial operations, or agricultural activities? ● Is the aquatic ecosystem within the site an important corridor for movement of aquatic fauna between other areas of high quality aquatic habitat? ● Does the aquatic ecosystem at the study site represent high quality habitat in an otherwise highly disturbed system?
Uniqueness	● Is aquatic habitat unique in terms of flora/fauna species and communities, aquatic ecology processes and habitat value?
Resilience to change	● Are the aquatic species, communities, values and processes within the waterway tolerant of prolonged or permanent disturbance events, or are they sensitive to short-term, moderate impacts?
Replacement potential	● How rapidly and how completely will aquatic species, ecosystems, communities and processes recover following an impact or disturbance event?

The criteria used to evaluate the sensitivity of impacts expected on aquatic ecosystems or species as a result of the Project are presented in **Table 3.12**.

Magnitude of Impact

The magnitude of impacts associated with project activities during construction, operation, maintenance and decommissioning of the project have been assessed following the categories outlined in **Table 3.11**.

Table 3.11 Magnitude of Impact to Aquatic Ecosystems or Species

Impact Magnitude Category	Summary Description
Geographic extent of impact	Will the potential impact disturb aquatic systems/ species across a wide spatial range, or will impacts be localised?
Duration of impact	Is the impact a very short term issue (e.g., excavator noise during trenching), or will the effects persist for some time following the disturbance (e.g., oil spill, land contamination)? Will the impact have a permanent or long term effect on the extent or integrity of a habitat, species or community?
Severity of impact	Is the effect of the impact severe (e.g., fish kill, loss of entire aquatic community) or is it likely to be within the natural variability of the system? Is the impact likely to threaten the sustainability or conservation status of a habitat, species or community?

The criteria used to evaluate the magnitude of impacts expected on aquatic ecosystems or species as a result of the Project are presented in **Table 3.13**.

Table 3.12 Criteria used to evaluate the Sensitivity of Aquatic Ecosystems or Species

Sensitivity Attribute	Sensitivity		
	High	***Moderate***	***Low***
Conservation Status	● wild river status ● world heritage status ● Ramsar status ● EPBC or NC Act listed communities or species ● high value fishery ● international eco-tourism destination	● local government management ● moderate/marginal fishery values ● state or local eco-tourism destination ● species of conservation interest (currently unlisted)	● no formal conservation value ● no fisheries value ● local or no ecotourism value ● no species, habitat or communities or special conservation significance
Intactness	● undisturbed, pristine aquatic system ● high quality aquatic habitat ● important movement corridor ● nursery/spawning area	● moderately disturbed aquatic system ● moderate to good quality habitat ● limited passage of aquatic fauna ● limited spawning/nursery opportunities	● highly disturbed aquatic system ● poor quality aquatic habitat ● minimal value as movement corridor for fauna ● minimal value for spawning/nursery
Uniqueness	● unique on a national or international scale in terms of biota, communities or processes	● unique on a regional scale in terms of biota, communities or processes	● unique on a local scale in terms of biota, communities or processes
Resistance to change	● poor tolerance to disturbance events, minor impacts may have catastrophic effect	● moderately tolerant or adaptive species or communities	● highly tolerant or adaptive species or communities able to survive significant disturbance impacts
Replacement potential	● disturbance likely to cause irreparable damage or permanent loss of values	● species or communities likely to exhibit moderate to good recovery following disturbance	● species or communities capable of rapidly recovering/regenerating after disturbance events

Table 3.13 Criteria used to evaluate the Magnitude of Project Impacts

Impact Magnitude Category	Magnitude of Impact		
	High	***Moderate***	***Low***
Geographic extent of impact	● impact has potential to affect aquatic species or ecosystems over a wide spatial range (>20 km)	● impact has the potential to affect aquatic species or ecosystems within a 0.5 - 20 km radius	● impact has the potential for localised effects on aquatic species or ecosystems up to 0.5 km away
Duration of impact	● impact period is from 2 years to perpetuity	● impact affects aquatic species or ecosystems for 3 months to 2 years	● impact is short term (<3 months)
Severity	● potential for complete loss of aquatic species or communities (i.e. shift to a fundamentally new assemblage)	● potential for temporary or partial loss of aquatic species or communities	● potential for minor, short-term impairment of aquatic species or communities

4. DESCRIPTION OF ENVIRONMENTAL VALUES

4.1 Literature Review

A literature review was previously prepared for the Project Development Area and presented in the EIS. The following provides an update of this information (where required) to reflect changes to the project description and to provide additional information.

4.1.1 Areas of Conservation Significance

4.1.1.1 International

The EPBC Act Protected Matters Search Tool results identified that the 'Ramsar' listed Narran Lake Nature Reserve occurs more than 300 km downstream of the Project Development Area. The site covers an area of 5,531 ha and is part of the Narran River wetland system in the Condamine-Balonne catchment (SEWPaC 2011). The Narran Lake Nature Reserve provides important habitat for several waterbird species listed under international migratory bird conservation agreements and holds significant value to Indigenous people (SEWPaC 2011).

4.1.1.2 National

There were no Australian Government Heritage Places, Reserves or Marine Areas identified in the desktop studies as occurring within 10 km of the Project Development Area.

The Barakula State Forest Area at Miles, listed on the Register of the National Estate (RNE) was identified in the EPBC Act Protected Matters Search Tool results as occurring within 10 km of the Project Development Area. The impacts of the Project on this area have been addressed in the Terrestrial Ecology report (Ecosmart 2013).

There are two wetlands listed under the Directory of Important Wetlands in Australia within the Condamine-Balonne catchment; Lake Broadwater and The Gums Lagoon (DEHP 2012c).

Lake Broadwater occurs within the Project Development Area and flows into Wilkie Creek, Broadwater Gully and the Condamine River (SEWPaC 2010). The lake is relatively undisturbed and an important regional example of a semi-permanent freshwater lake, with diverse aquatic flora and fauna (SEWPaC 2010).

The Gums Lagoon is upstream and over 40 km from the Project Development Area and as such is not likely to be impacted by the Project.

4.1.1.3 State

There are no 'declared fish habitat areas' within or immediately downstream of the Project Development Area.

4.1.2 Ecological Communities of Conservation Significance

No aquatic ecological communities of conservation significance were identified within 10 km of the Project Development Area.

4.1.3 Species of Conservation Significance

4.1.3.1 Flora

No listed aquatic flora species were identified in the database searches. A number of riparian flora species and frog species that may utilise aquatic habitats were identified and have been discussed in the Terrestrial Ecology report (Ecosmart 2013).

4.1.3.2 Fauna

The desktop study identified one EPBC Act listed nationally significant fish species (Murray Cod, *Maccullochella peelii peelii*) and reptile species (Fitzroy River Turtle, *Rheodytes leukops*) as potentially occurring or having suitable habitat available in the Project Development Area.

Detailed information regarding distribution, habitat and threats to these species is presented in **Attachment 2**.

4.1.4 Pest Species of Significance

4.1.4.1 Flora

Aquatic weeds Salvinia (*Salvinia molesta*) and Hymenachne (*Hymenachne amplexicaulis*) are declared as Class 2 pests under the LP Act and listed as a WoNS. Both these species were identified during desktop studies as potentially occurring within the Project Development Area. Neither species was recorded during SREIS or the EIS field surveys.

4.1.4.2 Fauna

One exotic fauna species known to utilise aquatic habitats, cane toad (*Rhinella marina*), was found to occur within the Project Development Area and has been addressed as part of the Ecosmart (2013) report.

4.1.5 Aquatic Conservation Assessments

Using expert panels, the ACAs assessed flora and fauna species richness in the riverine and non-riverine wetlands present within the section of the Murray Darling Basin situated within Queensland (Fielder, Davidson & Barratt 2011). The assessment included:

- 415 species of native and 48 exotic aquatic dependent plant taxa
- 23 native species of fish
- 9 mammal species
- 11 native reptile species, including four species of turtle
- 14 exotic fauna species, including one invertebrate and 11 species of fish.

In the Fitzroy Catchment, the AquaBAMM assessments identified flora and fauna species richness in the riverine and non-riverine wetlands (Inglis & Howell 2009a; Inglis & Howell 2009b) to include:

- 167 species of native and 91 exotic aquatic dependent plant taxa
- 59 species of native fish
- 4 mammal species
- 14 native reptile species, including seven species of turtle
- 20 exotic fauna species, including one crustacean and seven fish species.

4.1.5.1 Flora

The ACA study identified 20 priority flora species in the riverine and non-riverine wetlands of the Condamine-Balonne catchment, 15 species in the Border Rivers catchment and 31 species in the Fitzroy catchment (Fielder, Davidson & Barratt 2011; Inglis & Howell 2009a; Inglis & Howell 2009b). Of these priority flora species identified, macrophytes that have the potential to occur in the Project Development Area are presented in (**Table 4.1**). Riparian vegetation has been assessed separately in the Terrestrial Ecology report (Ecosmart 2013).

Table 4.1 Priority Macrophytes of the Border Rivers, Condamine-Balonne and Fitzroy Catchments

Scientific Name	Common Name	Border Rivers	Condamine-Balonne	Fitzroy	Comments
Bacopa monnieri	Herb of grace	✗	✓	✗	Usually grows on the edge of freshwater or brackish pools or streams, sometimes submerged.
Baumea articulata	Jointed twigrush	✓	✓	✓	Grows in standing water of lagoons, deeper swamps, and streams.
Baumea rubiginosa	Soft twigrush	✗	✗	✓	Usually found in standing water or depressions forming palustrine swamps, which are restricted in their distribution.
Ceratophyllum demersum	Hornwort	✓	✓	✗	Widespread, in water to 10 m deep, tolerant of low light levels.
Damasonium minus	Starfruit	✓	✓	✗	Grows in shallow freshwater in a range of habitats; widespread.
Eleocharis dulcis		✗	✗	✓	Forms significant macrophyte beds.
Eleocharis sphacelata	Tall spikerush	✗	✗	✓	Forms significant macrophyte beds.
Gahnia sieberiana	Sword grass	✗	✗	✓	Forms significant macrophyte beds.
Leersia hexandra	Swamp rice grass	✗	✗	✓	Forms significant macrophyte beds.
Lepironia articulata		✗	✗	✓	Forms significant macrophyte beds.
Ludwigia peploides subsp. montevidensis	Water primrose	✓	✓	✗	Species is found on a variety of landforms, but mostly on freshwater swamp/soaks or lake/river banks.
Marsilea drummondii	Common nardoo	✓	✓	✗	Widespread in inland areas, in moist depressions, around waterholes.
Marsilea hirsuta	Hairy nardoo	✓	✓	✗	Widespread, mostly in shallow swamps or flood plains.
Marsilea mutica	Shiny nardoo	✓	✓	✗	Widespread, often in deeper water than other species

Scientific Name	Common Name	Border Rivers	Condamine-Balonne	Fitzroy	Comments
Monochoria cyanea		×	×	✓	Forms significant macrophyte beds.
Myriophyllum simulans		×	×	✓	Forms significant macrophyte beds.
Myriophyllum verrucosum		×	×	✓	Forms significant macrophyte beds.
Najas tenuifolia	Water nymph/thin-leaved naiad	✓	✓	✓	Grows in freshwater less than 3 m deep; widespread.
Nelumbo nucifera	Pink waterlily	×	✓	✓	Occurs in deep lagoons and deep slow-moving streams.
Nymphaea gigantea, Nymphoides exiliflora		×	×	✓	Forms significant macrophyte beds.
Ottelia alismoides		×	×	✓	Forms significant macrophyte beds.
Phragmites australis	Common reed	×	×	✓	Forms significant macrophyte beds.
Schoenoplectus mucronatus		×	×	✓	Forms significant macrophyte beds.
Typha orientalis	Broad-leaved cumbungi	×	×	✓	Forms significant macrophyte beds.
Triglochin procerum	Water ribbons	✓	✓	×	Grows in stationary or flowing freshwater in a variety of habitats.
Vallisneria nana	Ribbonweed	×	✓	✓	Grows in still or slow moving waters up to 70 cm deep.

Source: Adapted from Fielder, Davidson & Barratt 2011, pp. 8-11; Inglis & Howell 2009a; Inglis & Howell 2009b.

4.1.5.2 Fauna

The ACA study identified three invertebrate species, eight species of fish, one aquatic mammal and one turtle species, which are priority species and are found in the Condamine-Balonne catchment (Fielder, Davidson & Barratt 2011) (**Table 4.2**).

In the Border Rivers catchment there were two invertebrate species, seven species of fish, one aquatic mammal (discussed in 3D, 2013) and one turtle that are priority species (Fielder, Davidson & Barratt 2011) (**Table 4.2**).

The ACA also identified 1 exotic invertebrate and 11 exotic fish species as potentially occurring in the Border Rivers and Condamine-Balonne catchments:

- *Cherax quadricarinatus* (Redclaw crayfish)
- *Carassius auratus* (Goldfish)
- *Carassius carassius* (Crucian carp)
- *Cyprinus carpio* (European carp) – declared noxious fish under the Fisheries Act
- *Gambusia holbrooki* (Mosquitofish) – declared noxious fish under the Fisheries Act
- *Oncorhynchus mykiss* (Rainbow trout)
- *Perca fluviatilis* (Redfin perch)
- *Poecilia latipinna* (Sailfin molly)
- *Poecilia reticulata* (Guppy)
- *Salmo trutta* (Brown trout)
- *Tilapia mariae* (Spotted tilapia) – declared noxious fish under the Fisheries Act
- *Xiphophorus maculatus* (Platy).

Rainbow trout and brown trout are unlikely to occur within the Project Development Area, as it is outside the environmental tolerances of these species (Allen *et al.* 2003).

In the Fitzroy catchment the ACA identified two invertebrate species, 11 fish species and one turtle priority species (Inglis & Howell 2009a; Inglis & Howell 2009b) outlined in **Table 4.3**.

Table 4.2 Priority Aquatic Fauna in the Border Rivers and Condamine-Balonne Catchments

Scientific Name	Common Name	Riverine	Non-riverine	Border Rivers	Condamine-Balonne	Likelihood of Occurrence in the Study Area
Invertebrates						
Euastacus jagara	Jagara hairy crayfish	✓	×	×	✓	A higher altitude species not expected within the Project Development Area.
Euastacus sulcatus	Lamington spiny crayfish	✓	×	✓	✓	A higher altitude species not expected within the Project Development Area.
Euastacus suttoni	New England crayfish	✓	×	✓	✓	A higher altitude species not expected within the Project Development Area.
Fish						
Ambassis agassizii	Agassiz's glassfish	✓	✓	✓	✓	Species has the potential to occur within the Project Development Area.*
Bidyanus bidyanus	Silver perch	✓	×	✓	✓	Species has the potential to occur within the Project Development Area.*
Craterocephalus amniculus	Darling River hardyhead	✓	×	✓	✓	Species has the potential to occur within the Project Development Area.*
Gadopsis marmoratus	River blackfish	✓	×	✓	✓	Species has the potential to occur within the Project Development Area.*
Mogurnda adspersa	Southern purple spotted gudgeon	✓	×	✓	✓	Species has the potential to occur within the Project Development Area.*
Galaxias olidus	Mountain galaxias	✓	×	✓	✓	A higher altitude species not expected within the Project Development Area.
Porochilus rendahli	Rendahl's catfish	✓	✓	×	✓	Species has the potential to occur within the Project Development Area.*

Scientific Name	Common Name	Riverine	Non-riverine	Border Rivers	Condamine-Balonne	Likelihood of Occurrence in the Study Area
Tandanus tandanus	Eel-tailed catfish	✓	×	✓	✓	Species has the potential to occur within the Project Development Area.*
Aquatic Reptiles						
Chelodina expansa	Broad-shelled river turtle	✓	✓	✓	✓	Species has the potential to occur within the Project Development Area.
Eulamprus kosciuskoi	Alpine water skink	✓	✓	✓	×	A higher altitude species not expected within the Project Development Area.
Physignathus lesueurii	Eastern water dragon	✓	✓	✓	✓	Species has the potential to occur within the Project Development Area.

Note: * Allen *et al.* 2003; Pusey *et al.* 2004.
Source: Adapted from Fielder, Davidson & Barratt 2011, pp. 33-38.

Table 4.3 Priority Aquatic Fauna in the Fitzroy Catchments

Scientific Name	Common Name	Riverine	Non-riverine	Likelihood of Occurrence in the Study Area
Invertebrates				
Euastacus eungella	Eungella spiny crayfish	✓	×	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.*
Euastacus monteithorum	Monteith's crayfish	✓	×	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.*
Fish				
Hephaestus fuliginosus	Sooty Grunter	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Kuhlia rupestris	Jungle perch	✓	×	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Lates calcarifer	Barramundi	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Macquaria ambigua	Golden perch	✓	×	Species is likely to occur within the Project Development Area.**
Megalops cyprinoides	Oxeye herring/tarpon	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Mugil cephalus	Sea mullet	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Myxus petardi	Pinkeye mullet	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**
Ophiocara porocephala	Spangled gudgeon	✓	✓	Species is unlikely to occur within the Project Development Area as it is outside its normal distribution.**

Scientific Name	Common Name	Riverine	Non-riverine	Likelihood of Occurrence in the Study Area
Scleropages leichardti	Southern saratoga	✓	✓	Species has the potential to occur within the Project Development Area.**
Scortum hillii	Leathery grunter	✓	✓	Species has the potential to occur within the Project Development Area.**
Strongylura krefftii	Freshwater longtom	✓	✓	Species has the potential to occur within the Project Development Area.**
Aquatic Reptiles				
Elseya albagula	White-throated snapping turtle	✓	×	Species has the potential to occur within the Project Development Area.***

Notes:
* Furse & Coughran 2010a; Furse & Coughran 2010b.
** Allen *et al.* 2003; Pusey *et al.* 2004.
*** Limpus et al. 2007; Georges & Merrin 2008; SunWater 2012.

The ACA also identified one exotic invertebrate and six exotic fish species as potentially occurring in the Fitzroy catchment:

- *Cherax quadricarinatus* (Redclaw crayfish)
- *Carassius auratus* (Goldfish)
- *Gambusia holbrooki* (Mosquitofish) – declared noxious fish under the Fisheries Act
- *Poecilia reticulata* (Guppy)
- *Tilapia mariae* (Spotted tilapia) – declared noxious fish under the Fisheries Act
- *Xiphophorus maculatus* (Platy)
- *Xiphophorus helleri* (Swordtail).

Semi-aquatic amphibians, reptiles and avifauna have been addressed separately in the Terrestrial Ecology report (Ecosmart 2013).

4.1.6 Back on Track Actions for Biodiversity

4.1.6.1 Flora

There were 12 priority flora species identified in the Condamine NRM region Actions for Biodiversity (DERM 2010a) and 20 priority flora species identified in the Border Rivers Maranoa-Balonne NRM Region (DERM 2010b). In the Fitzroy NRM region, 36 priority flora species were identified (DERM 2010c). None of these species were identified as macrophytes. Priority species identified within the project development area are addressed separately in the Terrestrial Ecology report (3D 2013).

4.1.6.2 Fauna

The Condamine NRM region Actions for Biodiversity identified this region as containing one 'critical' priority freshwater aquatic species; Murray Cod (*Maccullochella peelii peelii)* (DERM 2010a).

In the Border Rivers Maranoa-Balonne NRM Region there is one species of freshwater fish (Murray Cod, *Maccullochella peelii peelii*) and turtle (Bell's turtle, *Wollumbinia belli*) listed as 'critical' and 'high' priority aquatic species respectively (DERM 2010a; DERM 2010b).

It is of note that the Murray Cod is stocked locally within the section of the Condamine River occurring within the Project Development Area. It is unknown whether the specimens of this species captured during SREIS surveys (refer **to Section 4.2.5**) were of wild or stocked origin. Regardless, the species is known to inhabit the catchment, was identified by both state and federal database searches as potentially occurring within the Study Area, and is protected under the EPBC Act.

Bell's turtle (*Wollumbinia belli*) is unlikely to occur in the Project Development Area as this species has a very restricted distribution. The species is only known to occur in the headwaters of the Namoi and Gwydir Rivers, west of Armidale in New South Wales and in Bald Rock Creek in southeastern Queensland (International Union for Conservation of Nature [IUCN] 1996). Consequently, a species profile for Bell's turtle has not been included in **Attachment 2** as this species is unlikely to occur in the Project Development Area.

In the Fitzroy NRM Region, the ornate rainbowfish (*Rhadinocentrus ornatus*), Fitzroy River turtle (*Rheodytes leukops*) and white-throated snapping turtle (*Elseya albagula*) were identified as 'high' priority freshwater species (DERM 2010c).

Detailed information regarding distribution, habitat and threats to these species is presented in **Attachment 2**.

The ornate rainbowfish is locally common, but highly restricted in its distribution (Allen *et al.* 2003). The species occurs in a narrow strip of coastal freshwater streams from Rockhampton (Queensland) to Coffs Harbour (New South Wales) (Allen *et al.* 2003). A species profile for the ornate rainbowfish has not been included in **Attachment 2** as this species is unlikely to occur in the Project Development Area.

4.2 Field Survey

The information presented in this section provides a summary of field survey results for each of the aquatic indicators sampled (water quality, aquatic flora, macroinvertebrates, fish and reptiles). The addendum to this report describes the results of field surveys in May 2013 (macroinvertebrates for all sites sampled and indicators for sites not completed in February-March 2013).

In accordance with the objectives of this assessment (**Section 1.3**), the discussion of results for each aquatic indicator are presented in the following order; Survey Area 2, Survey Area 9 and Weir River catchment (SAQ-1). Results from qualitative visual surveys of CGPF7, CGPF8 and TWAF F are presented in **Section 4.5**.

4.2.1 Hydrological Conditions

The following sections provide a brief description of hydrological conditions at the survey sites and provide context for the characterisation of the 'existing environment'. An overview of climatological conditions within the general region of the Study Area is provided in the EIS.

Alluvium completed a geomorphology and hydrology study within the Survey Area 2 and Survey Area 9 receiving systems (Alluvium 2013a). This study included a review of hydrological data, hydrologic modelling and a gauged daily flow analysis of Dogwood Creek and the Condamine River (discussed in the Gauged Daily Flow Analysis section below). A literature review of the importance of environmental flows and a spells analysis for Dogwood Creek and the Condamine River was also completed by Alluvium (discussed in the Literature Review and Spells Analysis sections below) (Alluvium 2013b). A workshop was then undertaken with key consultants (Alluvium, AMEC, NRA, 3D Environmental and Coffey Environments) involved in the project to determine potential management options for CSG water releases (discussed in the Workshop Assessment section below) (Alluvium 2013b).

Gauged Daily Flow Analysis

A gauged daily flow analysis was completed by Alluvium (2013a) for two gauged streams within the Study Area:

- Dogwood Creek at Gil weir (gauge number 422202B), which is situated within the Survey Area 2 receiving system, for the period spanning February 1950 - February 2013

- Condamine River at Cecil Plains weir (gauge number 422316A), which is situated within the Survey Area 9 receiving system, for the period spanning November 1972 -January 2013.

Gauged daily flows were assessed to determine the average number of zero, low and high flow days per month in the catchment, based on historical gauging data. The catchment area of Dogwood Creek at Gil weir is 3,010 km^2 (DNRM 2013a), while the catchment area of the Condamine River at Cecil Plains weir is 7,795 km^2 (DNRM 2013b).

The flow analysis found that Dogwood Creek recorded a high number of zero or low flow (between 0 and 2 cumecs) days throughout the year. Based on monthly averages, 207 days per year recorded zero flow. On average, October recorded the highest number of zero flow days (16.0 days), while February recorded the lowest number of zero flow days (8.8 days). The highest number of flow days greater than five cumecs occurred during February (7.0 days) and March (6.6 days). Dogwood Creek recorded a higher number of flow days greater than five cumecs throughout the year (an average 4.7 days per month per year) when compared to the Condamine River at Cecil Plains (an average of 1.8 days per month per year). This result is likely to be related to the smaller catchment area of Dogwood Creek. The flow analysis indicated that Dogwood Creek has a highly variable flow regime dominated by extended low flow periods typically from March through to November. Intermittent high flow events are a hydrological feature during the summer months (with the period from December through to February representing the typical high flow season). However, these flow seasons were highly variable particularly between wet, average, dry and drought periods.

The flow analysis also indicated that the Condamine River had a high number of zero or low flow (between 0 and 2 cumecs) days throughout the year. September recorded the highest number of average zero flow days (22.3 days), while February recorded the lowest number of average zero flow days (11.4 days). The Condamine River generally recorded a low number of days with a flow greater than 5 cumecs throughout the year, with an average of 1.8 days per month per year. The highest average number of these days occurred during January (3.7 days) and February (3.8 days). The flow analysis indicated that the Condamine River has a highly variable flow regime with extended low flow periods typically occurring in March through to October. Intermittent high flow events occur during the summer months (with the period from November through to February representing the typical high flow season). However, these flow seasons were highly variable particularly between wet, average, dry and drought periods.

Environmental Flows Literature Review

The literature review completed by Alluvium (Alluvium 2013b) identified that there are six flow events related to key ecological functions of all stream types in the Murray-Darling Basin: cease to flow; base flows; low flow freshes; high flow freshes; bankfull flows; and overbank flows.

The literature review also cited the Bunn and Arthington (2002) paper and outlined that '*despite this growing recognition of the importance of the various flow components we are currently limited in our ability to predict and quantify the biotic response of each component*' (Alluvium 2013b, p. 6).

To determine potential ecological responses to changed flow regimes as a result of controlled water discharges, Alluvium examined a study undertaken in the Mount Lofty Ranges catchments by VanLaarhoven & van der Wielen (2009) for the South Australian

Government and their own study completed for the Murray Darling Basin Authority in 2010 (Alluvium 2010).

However, VanLaarhoven & van der Wielen (2009) proposed low risk limits for how much a flow component could decrease (20%) or increase (25%) while still maintaining core refuge habitat or critical life-cycle processes supported by that flow component (refer to table 2-1, Alluvium 2013b).

The Alluvium (2010) report proposed the adoption of a deviation target of 20% from natural as being likely to provide for the ongoing ecological functioning of stream systems (refer to table 2-2, Alluvium 2013b).

Spells Analysis

A spells analysis was undertaken to determine the frequency and duration of flow components (cease to flow, low freshes, high freshes and bankfull flow) which are related to key ecological functions. The spells analysis for the Dogwood Creek at Gil weir and Condamine River at Cecil Plains weir was undertaken initially for all years with available flow data (Alluvium 2013b). Subsequently the data was separated into the different climatic conditions (drought, dry, average and wet years) so that the spells analysis could be performed for each condition (Alluvium 2013b). Results from the analysis completed by Alluvium (2013b) are presented below.

Dogwood Creek at Gil Weir

The results of the spells analysis for all years of flow data found the existing flow regime in Dogwood Creek at Gil weir is comprised of the following components:

- Cease to flow lasting on average for about half the low flow season, and a month of the high flow season
- Low freshes of 20 ML/d occurring on average 3-4 times per low flow season and lasting for 15 days
- High freshes (flow exceeded 20% of the time) of 83 ML/d occurring on average 1-2 times per high flow season and lasting for 10 days
- High freshes (flow exceeded 5% of the time) of 1,292 ML/d occurring on average 1-2 times per high flow season and lasting for 4 days
- Bankfull flow of 12,275 ML/d occurring once every 2 years and lasting for on average 3 days.

Note that there is no baseflow in either the high or low flow season due to the flow exceedance on 80% of days equalling zero (i.e. there is no flow on more than 20% of days in both seasons).

Results of the spells analysis for Dogwood Creek at Gil weir under each of the climatic conditions (drought, dry, average and wet years) found that the flow components remain the same with the exception of baseflows, which are introduced in wet years (1 ML/d during the low flow season and 1.9 ML/d during the high flow season).

Condamine River at Cecil Plains Weir

The results of the spells analysis for all years of flow data found the existing flow regime in Condamine River at Cecil Plains weir is comprised of the following components:

- Cease to flow lasting on average for 1 month of the low flow season, and half a month of the high flow season
- Low freshes of 244 ML/d occurring on average 3-4 times per low flow season and lasting for 15 days
- High freshes (flow exceeded 20% of the time) of 425 ML/d occurring on average 3 times per high flow season and lasting for 8 days
- High freshes (flow exceeded 5% of the time) of 4,859 ML/d occurring on average 1-2 times per high flow season and lasting for 5 days
- Bankfull flow of 23,466 ML/d occurring once every 2 years and lasting for on average 4 days.

Note that there is no baseflow in either the high or low flow season due to the flow exceedance on 80% of days equalling zero (i.e. there is no flow on more than 20% of days in both seasons).

Results of the spells analysis for Condamine River at Cecil Plains weir under each of the climatic conditions (drought, dry, average and wet years) again found that the flow components remain the same with the exception of baseflows, which are introduced in wet years.

Preliminary Environmental Flows Workshop Assessment

A workshop assessment was undertaken on Wednesday 15th May 2013 to identify potential environmental impacts of discharging coal seam gas at CGFF2 and CGPF9 and rank their risks to formulate an acceptable deviation from the natural flow regime. The workshop included personnel from Alluvium, AMEC, NRA, 3D Environmental and Coffey Environments.

The workshop initially included the identification of risks and opportunities to watercourse geomorphology, hydrology, water quality, aquatic ecology and land use in relation to the discharge of coal seam gas water (Alluvium 2013b, p. 22).

Utilising the outcomes of the literature review and spells analysis, the workshop participants developed an agreed set of guidelines to facilitate the development of an operating strategy for the discharge of coal seam gas water.

Based on what was known from studies undertaken in other river systems, a 20% deviation from the current condition flow metrics identified in the spells analysis was considered by the workshop participants to represent an acceptable level of deviation that would limit the extent of adverse impacts on geomorphology, water quality and aquatic ecology in the subject watercourses (Alluvium 2013b). However, these outcomes were dependent on a number of baseline assumptions (outlined in Alluvium 2013b, p. 21) and the implementation of an adaptive management approach, including the implementation of a monitoring program, to verify this assertion.

Ecological Description

The two key waterways within the Survey Area 2 receiving system, Bottle Tree Creek and Dogwood Creek, are both ephemeral waterways. During the wet season, following heavy and sustained precipitation (including conditions that occurred during field surveys for this assessment), surface water flows occur. For the majority of the time during which surface water does persist, aquatic habitat within these systems would be characterised by a series of semi-connected and disconnected pools. It is also of note that hydrological conditions within both Bottle Tree Creek and Dogwood Creek will be temporally variable on an inter-year basis as a consequence of variability in the timing of onset, intensity and duration of the ‘wet-season’.

There are two waterways at site Survey Area 9; the Condamine River and Crawlers Creek. Within the Study Area, the Condamine River is considered to be a semi-permanent waterway; although large permanent pools exist upstream of (and are caused by the presence of) Cecil Plains weir; which is situated between sites DA9-4 and DA9-5. A second, smaller weir is also situated between sites DA9-6 and DA9-7.

Sites DA9-1 to DA9-4 are situated on the Condamine River upstream of Cecil Plains weir, within the zone of impoundment. At these sites, the Condamine River is a large, high order, semi-permanent waterway; characterised by extensive areas of uniform pool habitat. Sites DA9-5 to DA9-7 are situated downstream of the Cecil Plains weir and have a wide macro-channel with greater geomorphological diversity than upstream sites. During the wet-season and following precipitation, all sites would experience high flow levels. During the drier months of the year, permanent pool habitat would persist at all sites.

The description of Bottle Tree Creek and Dogwood Creek provided above is also applicable to Crawlers Creek. The section of Crawlers Creek surveyed for this assessment is a small, low order, ephemeral waterway. Stream flow at sites DA9-21 and DA9-22, both situated on Crawlers Creek, occurs for a limited period of time during the wet-season. Several small, shallow pools are likely to persist for a short period following these flow events, before the site would become predominantly dry for the majority of the hydrological cycle.

Site DA9-22 is situated on Crawlers Creek approximately 250 m upstream from the confluence point with the Condamine River. The area of the Condamine River adjacent to the Crawlers creek confluence is impounded by the presence of Cecil Weir. As such, depending upon prevailing stream-flow levels in the Condamine River, hydrological conditions in the lower areas of Crawlers Creek (potentially at site DA9-22), may be influenced by impounded water from the Condamine River.

Site SAQ-1 is situated on Weringa Creek within the Dawson River sub-basin of the Fitzroy River Basin. At site SAQ-1, Weringa Creek is a small, low order, semi-permanent waterway. During the drier months, surface water persists in a series of numerous semi-connected and disconnected waterholes.

4.2.2 Physical Habitat

The information presented in this section provides a summary of key physical aquatic habitat characteristics present at survey sites. A general summary of key physical habitat features at each survey site is presented in **Table 4.4**. Photos of each site are presented in **Attachment 3**.

Reach Habitat

A summary of macrohabitat features occurring at each survey site is presented graphically in **Figure 4.1**.

A variety of macrohabitats were observed in the Survey Area 2 receiving system at the time of survey. Run habitat, characterised by relatively shallow water (<2 m) and sandy substrate (refer to following Section - *Substrate*) occurred at all sites in this system and was the dominant habitat type at four of the six sites (DA2-2, DA2-5, DA2-6 and DA2-7).

Sandy pool habitat was also common, occurring at all sites and being the dominating habitat type at DA2-4 and DA2-7. Riffle habitat was largely absent, although very small sections (5%) were present at four sites (DA2-1, DA2-2, DA2-5 and DA2-6). Rocky pool habitat was observed at a single site (DA2-1) (refer to following Section - *Substrate*) and was attributable to the presence of bedrock at this site. No dry stream bed occurred at any site at the time of these surveys.

Table 4.4 Summary of Key Habitat Characteristics at SREIS Survey Sites

Site ID	Hydrology	Stream Width		Dominant Substrate	Habitat Type			Adjacent Land-Use	Mean Riparian Zone Vegetation width (m)	Bank Erosion	AUSRIVAS Habitat Assessment Rating
		Mean (m)	Max. (m)		Dominant	Other	Micro				
DA2-1	Ephemeral	6	8	Bedrock	Pool (rocky)	Run, riffle[2], pool (sandy)	Detritus, structural woody habitat, undercut bank	Natural, light grazing	20	Limited	102
DA2-2	Ephemeral	3	4	Sand	Run[1]	Pool (sandy), riffle[2]	Detritus, structural woody habitat, macrophytes[3]	Natural	20	Limited	91
DA2-4	Ephemeral	3	5	Sand	Pool (sandy)	Run[1]	Detritus, structural woody habitat, undercut bank, macrophytes[3]	Natural	20	Limited	98
DA2-5	Ephemeral	3	7	Sand	Run[1]	Pool (sandy), riffle[2]	Detritus, structural woody habitat, macrophytes[3]	Natural	20	Limited	108
DA2-6	Ephemeral	3	8	Sand	Run[1]	Pool (sandy), riffle[2]	Detritus, structural woody habitat, macrophytes[3]	Natural	20	Limited	88
DA2-7	Ephemeral	4	8	Sand	Run[1], pool (sandy)	-	Detritus, structural woody habitat, undercut bank, macrophytes[3]	Natural	20	Limited	69
DA9-1	Semi-permanent	30	35	Silt/clay	Pool (sandy)	Run	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	20	Moderate	66
DA9-2	Semi-permanent	27.5	30	Silt/clay	Pool (sandy)	-	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	20	Moderate	59

Site ID	Hydrology	Stream Width		Dominant Substrate	Habitat Type			Adjacent Land-Use	Mean Riparian Zone Vegetation width (m)	Bank Erosion	AUSRIVAS Habitat Assessment Rating
		Mean (m)	Max. (m)		Dominant	Other	Micro				
DA9-3	Semi-permanent	22.5	25	Silt/clay	Pool (sandy)	-	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots	Grazing, cropping	20	Moderate	62
DA9-4	Semi-permanent	22.5	25	Silt/clay	Pool (sandy)	-	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots	Light grazing, rural acreage, recreation (boat ramp)	15	Moderate	66
DA9-5*	Semi-permanent	30	40	Silt/clay	Pool (sandy)	Run, riffle	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots	Grazing, cropping	15	Moderate	74
DA9-6*	Semi-permanent	25	30	Silt/clay	Pool (sandy)	Run, riffle	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	10	Moderate	86
DA9-7*	Semi-permanent	27.5	35	Silt/clay	Pool (sandy)	Run	Detritus, structural woody habitat, undercut bank, deep pool, backwater, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	20	Moderate	72
DA9-21	Ephemeral	4.5	7	Silt/clay	Pool (sandy)	-	Detritus, structural woody habitat, undercut bank, deep pool, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	7	Moderate	57

Site ID	Hydrology	Stream Width		Dominant Substrate	Habitat Type			Adjacent Land-Use	Mean Riparian Zone Vegetation width (m)	Bank Erosion	AUSRIVAS Habitat Assessment Rating
		Mean (m)	Max. (m)		Dominant	Other	Micro				
DA9-22	Ephemeral	3.5	5	Silt/clay	Pool (sandy)	Run[1], riffle[2]	Detritus, structural woody habitat, undercut bank, deep pool, overhanging vegetation, tree roots, macrophytes[3]	Grazing, cropping	15	Moderate	61
SAQ-1	Semi-permanent	8	10	Silt/clay	Pool (sandy)	Pool (rocky)	Detritus, structural woody habitat, undercut bank	Natural, light grazing	20	Moderate	80

Notes:
1 Run macrohabitat would only persist during the wet-season; during the drier months this macrohabitat feature would be a shallow sandy pool.
2 Riffle macrohabitat would only persist during the wet season; during the drier months this macrohabitat feature would be dry rocky bed.
3 Emergent macrophytes that were present within the wetted width of the channel; does not include floating or submerged macrophytes (which were absent from all SREIS survey sites).
* Habitat survey completed from roadside due to restricted site access.

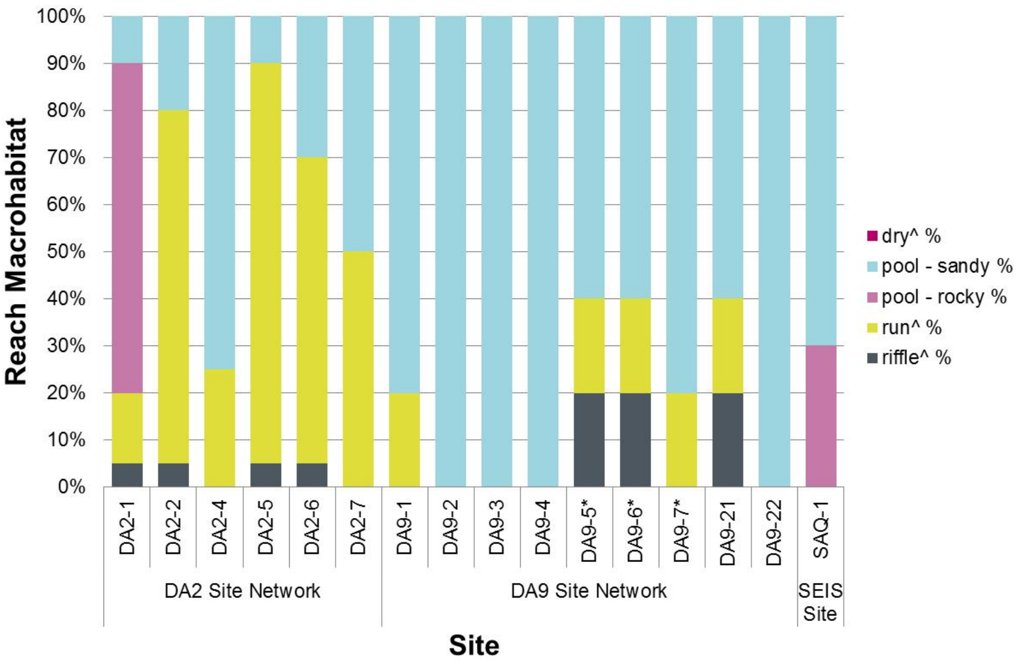

Figure 4.1 Reach Macrohabitat Characteristics of Survey Sites

Notes:
* Survey completed from roadside due to restricted site access.
^ Indicates high degree of seasonal variability in habitat type – refer to accompanying text).
No macrohabitat classified as 'dry' was recorded during SREIS field surveys

When considering the description of macrohabitat within the Survey Area 2 receiving system it is important to consider the ephemeral nature of both Bottle Tree Creek and Dogwood Creek as well as the prevailing hydrological conditions at the time of sampling (refer to preceding Section – *Hydrological Conditions*). This description of macrohabitat within the Survey Area 2 receiving system accurately characterises conditions during the wet-season, but does not reflect the majority of the hydrological cycle. For the majority of the hydrological cycle, flowing surface water does not persist and the systems retract into a series of disconnected 'refugial' waterholes. Run and riffle habitat is expected to be transient and would replace dry creek bed and discrete pool habitat that exists during the drier months.

Key microhabitat features identified within the Survey Area 2 receiving system included woody debris (refer to following Section – *Woody Debris*), emergent macrophytes situated within the instream area (**Section 3.4.3.3**) and undercut banks. The persistence of each of these features would depend upon the prevailing hydrological conditions.

Sandy pools (including pool habitat dominated by silt/clay substrate - as per the definition of 'sandy pool' presented by DNRM (2001)) were the predominant habitat type within the Survey Area 9 receiving system. Sandy pool habitat was the dominant habitat type at all sites, with levels ranging from 60–100%. Riffle habitat was sparse, occurring in low amounts (20%) at three of the nine sites (DA9-5, DA9-6 and DA9-21). Similarly, run habitat was present in low amounts (20%) at four sites. The prevalence of sandy pool habitat between sites DA9-1 and DA9-4 is attributable to the positioning of these sites within the section of Condamine River impounded by the Cecil Plains weir. The presence of run and riffle habitat at sites DA9-5 and DA9-6 is reflective of the flow conditions at the time of sampling with these sites downstream of the Cecil Plains weir. Although not to the same extent as that occurring at sites DA9-5 and DA9-6, it is of note that flow conditions are also regulated at site DA9-7, due to its downstream proximity to a second small weir.

Macrohabitat within Crawlers Creek at site DA9-21 consisted of a mixture of sandy pool (60%), run (20%) and riffle (20%). The prevalence of sandy pool habitat at site DA9-22 (100%) may be influenced by the sites proximity to impounded waters within the Condamine River.

Microhabitat features observed throughout the Survey Area 9 receiving system included woody debris (refer to following Section – *Woody Debris*), undercut banks, deep pool habitat (>2 m), large backwater areas, overhanging vegetation, submerged tree roots and emergent macrophytes situated within the instream area (**Section 3.4.3.3**).

Macrohabitat at site SAQ-1 was dominated by sandy pool habitat (70%), with some areas of rocky pool habitat (30%). Microhabitat features present included woody debris (refer to following Section – *Woody Debris*) and undercut banks.

Substrate

A summary of aquatic substrate characteristics occurring at each SREIS survey site is presented graphically in **Figure 4.2**.

At all sites within the Survey Area 2 receiving system, sand was the dominant substrate type, with the exception of DA2-1 which was dominated by bedrock (covered with sand in small patches). Bedrock, cobble, pebble and silt/clay were present in notable proportions at site DA2-5, but were largely absent at other sites.

Silt/clay was the dominant substrate type at all sites in the Survey Area 9 receiving system, with most sites also observed to have a significant proportion of sandy substrate (20-30%). Low proportions of bedrock were also present at site DA9-22.

The aquatic substrate at site SAQ-1 was composed of almost equal parts of silt/clay (40%), sand (30%) and boulder (30%).

Riparian Zone

A summary of key riparian vegetation classes occurring at each SREIS survey site is presented graphically in **Figure 4.3**.

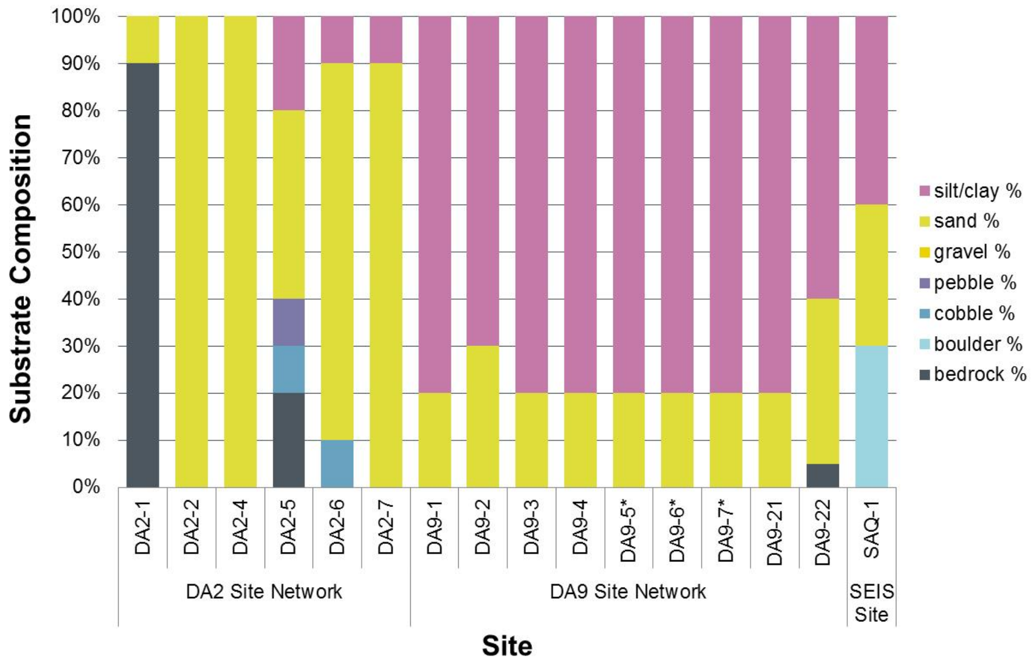

Figure 4.2 Substrate Characteristics of SREIS Survey Sites

Notes:
* Survey completed from roadside due to restricted site access.
No gravel substrate type was recorded during SREIS field surveys

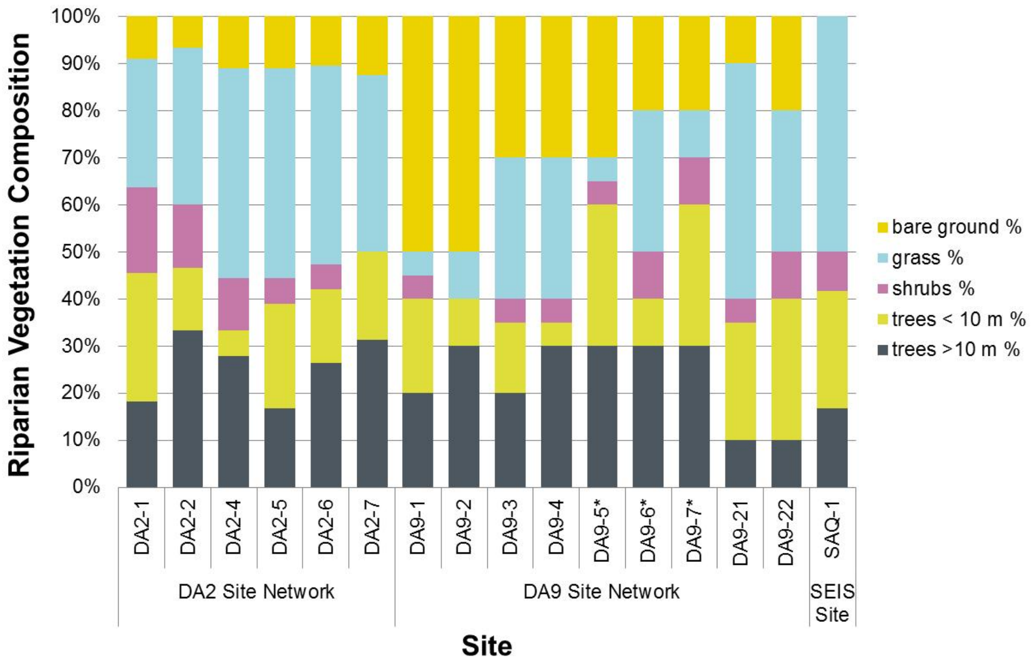

Figure 4.3 Riparian Vegetation Characteristics of SREIS Survey Sites

Note: * Survey completed from roadside due to restricted site access.

The relative composition of riparian vegetation was variable across the Survey Area 2 receiving system, although some general patterns were observed. Bare ground and shrubs were generally observed in low proportions (10–20%). Small trees (<10 m) and tall trees (>10 m) were generally present in approximately equal proportions (20–25%). At all sites grasses were the most dominant vegetation class (20–40%).

The adjacent land-use was recorded as ‘natural’ at all of the sites within the Survey Area 2 receiving system, with the exception of DA2-1 at which light grazing was also recorded (**Table 4.4**). Likely due to the prevalence of ‘natural’ land-use (refer to DNRM [2001] for definition), the rate and extent of bank erosion was limited throughout the Survey Area 2 site network (**Table 4.4**).

The relative composition of riparian vegetation was variable across the Survey Area 9 receiving system. In contrast to the Survey Area 2 system, the proportion of both bare ground and grasses fluctuated widely (10–50%) between sites, with both classes recorded as being dominant or equally dominant at several sites. Shrubs were mostly present in low proportions (5–10%). Small trees and tall trees abundance fluctuated between sites (5–30%), with both classes recorded as being co-dominant at several sites.

The adjacent land-use was recorded as grazing at all sites within the Survey Area 9 receiving system (**Table 4.4**). This observation likely explains that bank erosion occurred at moderate to extensive levels throughout the Survey Area 9 site reach. The finding of a relatively high proportion of bare ground (20–50%) at sites DA9-1–DA9-7 is also likely attributable to an adjacent land-use of grazing.

The riparian vegetation at site SAQ-1 was dominated by grasses (50%), with approximately equal parts of small trees and tall trees (20%), and a low proportion of shrubs (10%). No bare ground was present at this site.

Woody Debris

A summary of woody debris and structural woody habitat occurring at each SREIS survey site is presented graphically in **Figure 4.4**.

Woody debris were generally sparse within the Survey Area 2 receiving system, the presence of the larger size categories (logs and branches) and the lower size categories (sticks and detritus) being low (5–20%) at all sites.

Within the Survey Area 9 receiving system, logs were generally absent or present in low amounts (10%), with the exception of DA9-6 (30%). Branches were present in moderate amounts (30–50%) at the majority of sites. Levels of the smaller size classes, sticks and detritus, were variable throughout the Survey Area 9 receiving system, ranging from low (5–20%) to moderate (30%).

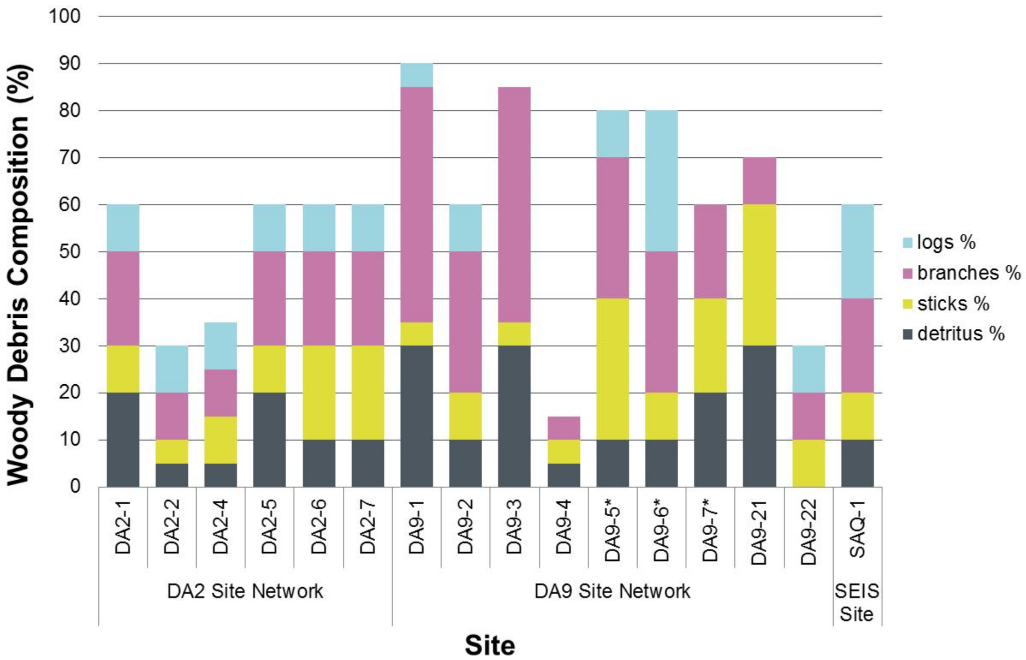

Figure 4.4 Woody Debris Composition^ of SREIS Survey Sites

Note *: Survey completed from roadside due to restricted site access; ^ values indicate % of stream bed 'covered' by woody debris type.

Woody debris levels were low at site SAQ-1. Limited logs (20%), branches (20%), sticks (10%) and detritus (10%) were present.

4.2.3 Water Quality

The information presented in this section provides a summary of *in-situ* water quality for each survey site. These results represent a single point in time and have been included in this assessment for the sole purpose of providing context for interpreting ecological values. Snapshot data of this type are of very limited value in assessing the overall waterway health as they do not reflect the range of hydrological and other conditions that can alter water quality.

A more comprehensive description of water quality values associated with the Project – including the incorporation of an increased list of measurement parameters, expanded site network and historical data – has been provided in Alluvium (2013a).

Temperature

Water temperature results are presented graphically in **Figure 4.6**. A descriptive statistical summary of water temperature results within the Survey Area 2 and Survey Area 9 receiving systems is presented in **Table 4.5** and **Table 4.6**, respectively.

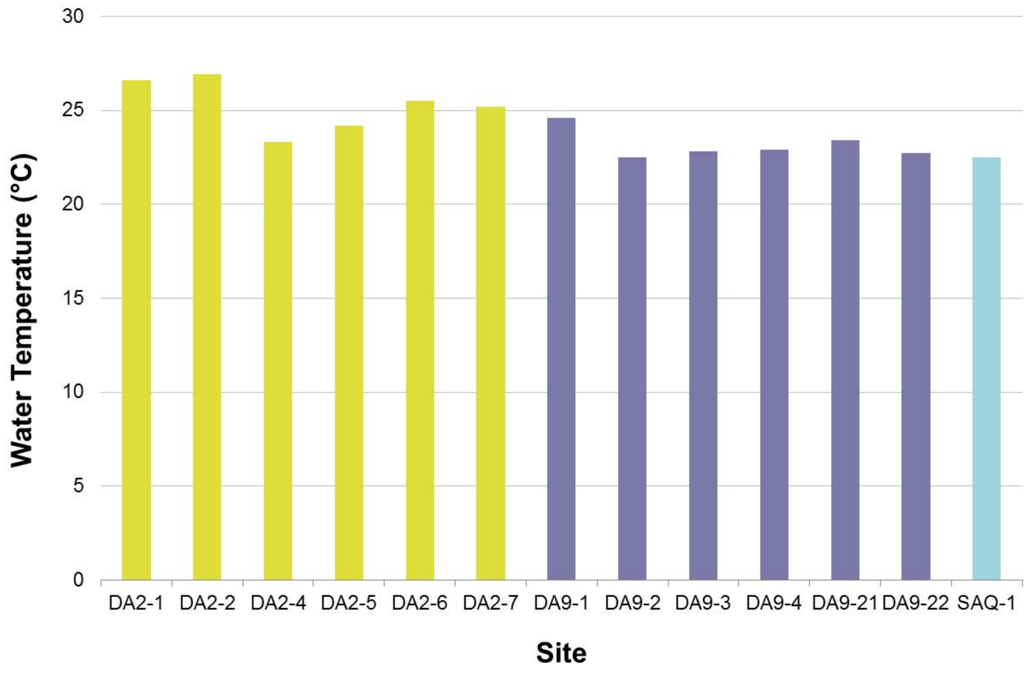

Figure 4.5 Water Temperature of SREIS Survey Sites

Note: Green colouring indicates site situated within the Survey Area 2 receiving system; **purple** colouring indicates site situated within the Survey Area 9 receiving system; **blue** colouring indicates site situated within the Dawson Catchment.

Water temperature was spatially variable throughout both the Survey Area 2 and Survey Area 9 receiving systems. No trends were discernable with respect to site location (i.e. upstream or downstream the proposed discharge points). These observations are likely attributable to variation in the time of day that sampling was undertaken and canopy cover at each of the sites.

The water temperature of predominantly shallow (<2 m) lotic (riverine) water-bodies, such as those sampled as part of this assessment, is expected to undergo natural fluctuations spatially and temporally, with respect to a variety of factors. Key factors include time of the year (season), time of day, depth at which the measurement was collected, morphology and hydrology (width, depth and flow rate) and other abiotic characteristics of the water body (e.g. level of shading, ambient air temperature, evaporative cooling). No national, state, regional or local guidelines exist to guide the assessment of expected water temperatures within the water-bodies surveyed.

pH

pH results are presented graphically in **Figure 4.6**. A descriptive statistical summary of pH within the Survey Area 2 and Survey Area 9 receiving systems is presented in **Table 4.5** and **Table 4.6**, respectively.

pH was neutral to slightly acidic across the Survey Area 2 receiving system and within the relevant ANZECC (2000) guidelines at two of the sites surveyed. Non-compliant sites were within 0.5 of a pH unit below the lower ANZECC (2000) guideline limit. No trends were discernable with respect to location within the Survey Area 2 receiving system (i.e. upstream or downstream the proposed discharge point).

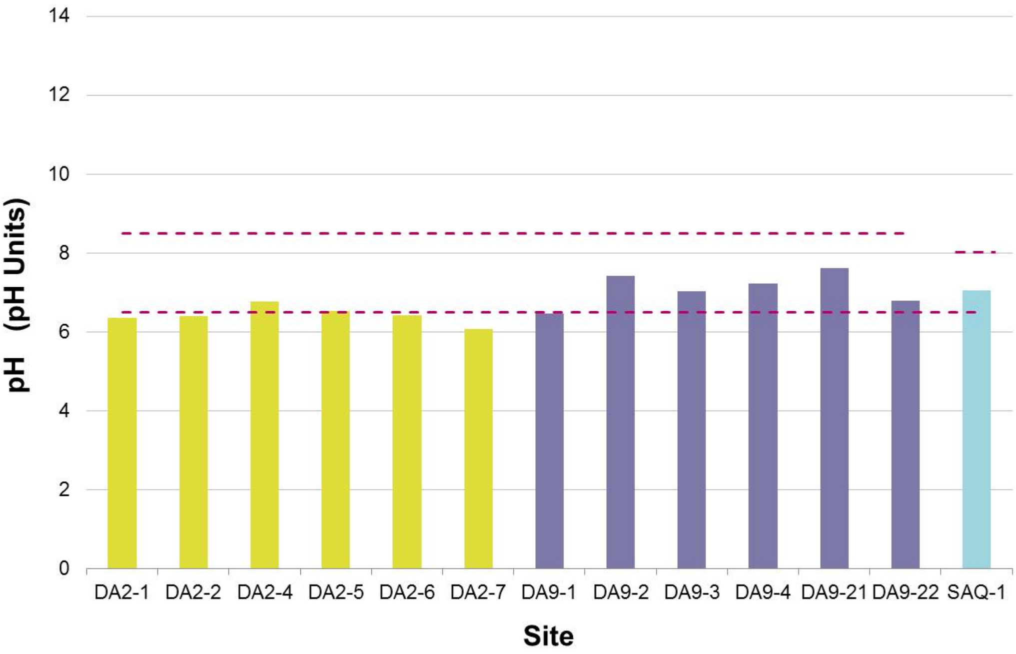

Figure 4.6 pH of SREIS Survey Sites

Note: Green colouring indicates site situated within the Survey Area 2 receiving system; **purple** colouring indicates site situated within the Survey Area 9 receiving system; **blue** colouring indicates site situated within the Dawson Catchment; **purple** dashed horizontal lines indicate relevant water quality guideline limits applicable to the site (**Section 3.4.5**).

Within the Survey Area 9 receiving system, pH was within the ANZECC (2000) guideline range at all sites except DA9-1 which was marginally below. No trends in results were discernable with respect to location within the Survey Area 9 receiving system (i.e. upstream or downstream the proposed discharge point).

The pH level at site SAQ-1 was within the relevant ANZECC (2000) guideline range.

Electrical Conductivity (EC)

EC results are presented graphically in **Figure 4.7**. A descriptive statistical summary of EC within the Survey Area 2 and Survey Area 9 receiving systems are presented in **Table 4.5** and **Table 4.6**, respectively.

EC within the Survey Area 2 receiving system was well below the relevant ANZECC (2000) guideline limit and was comparable between sites. No trends in results were discernable with respect to location within the Survey Area 2 receiving system (i.e. upstream or downstream the proposed discharge point).

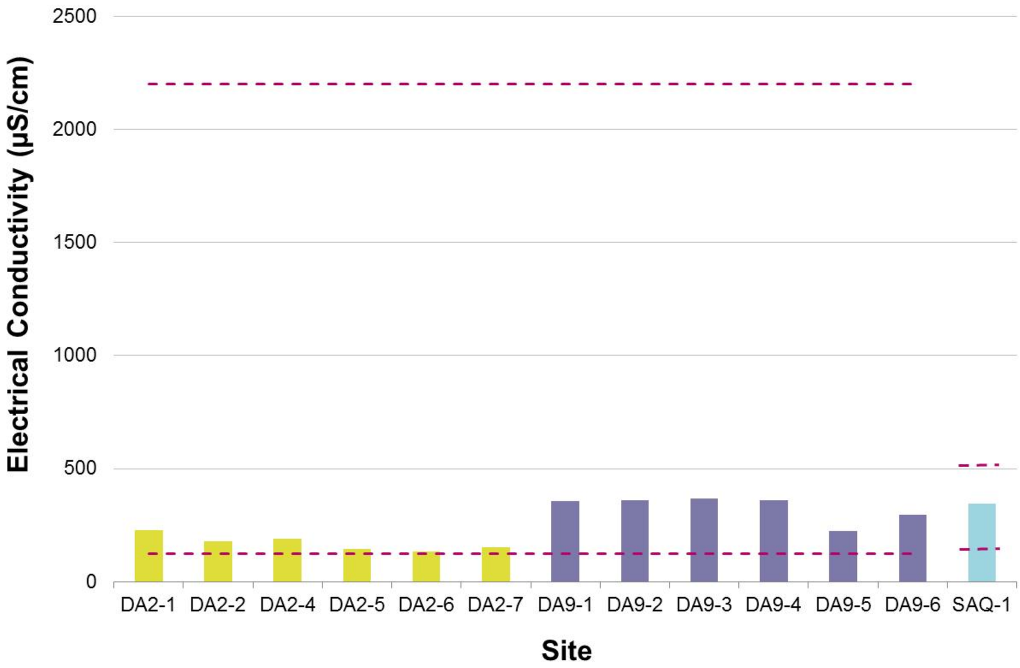

Figure 4.7 Electrical Conductivity of SREIS Survey Sites

Note: Green colouring indicates site situated within the Survey Area 2 receiving system; **purple** colouring indicates site situated within the Survey Area 9 receiving system; **blue** colouring indicates site situated within the Dawson Catchment; **purple** dashed horizontal lines indicate relevant water quality guideline limits applicable to the site (**Section 3.4.5**).

EC levels throughout the Survey Area 9 receiving system were well below the relevant ANZECC (2000) guideline limit and were comparable across all sites, with the values indicating freshwater conditions. No trends in results were discernable with respect to location within the Survey Area 9 receiving system (i.e. upstream or downstream the proposed discharge point).

The level of EC recorded at site SAQ-1 was below the relevant QWQG (2009) guideline limit.

Dissolved Oxygen (DO)

DO results are presented graphically in **Figure 4.8**. A descriptive statistical summary of DO levels within the Survey Area 2 and Survey Area 9 receiving systems is presented in **Table 4.5** and **Table 4.6**, respectively.

DO levels varied widely throughout both the Survey Area 2 and Survey Area 9 receiving systems, with levels below the minimum ANZECC (2000) guideline value at all sites. No trends in results were discernable with respect to location within the Survey Area 2 or Survey Area 9 receiving systems (i.e. upstream or downstream the proposed discharge points), although in Survey Area 9 it was noted that sites situated on Crawlers Creek (DA9-21 and DA9-22) tended to have lower DO levels than those on the Condamine River (DA9-1–DA9-4).

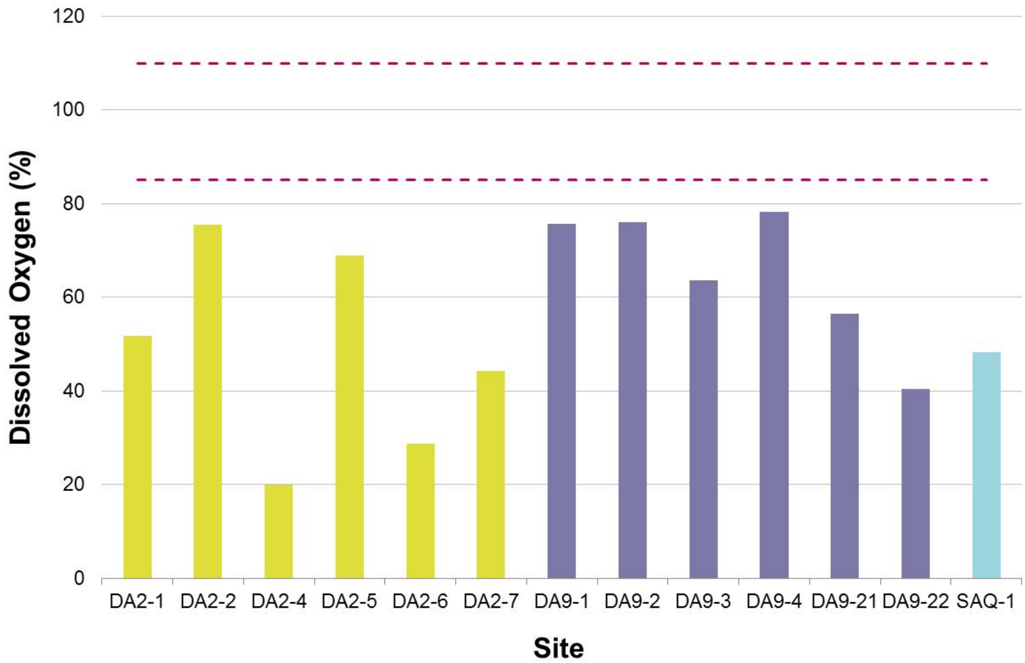

Figure 4.8 Dissolved Oxygen of SREIS Survey Sites

Note: Green colouring indicates site situated within the Survey Area 2 receiving system; **purple** colouring indicates site situated within the Survey Area 9 receiving system; **blue** colouring indicates site situated within the Dawson Catchment; **purple** dashed horizontal lines indicate relevant water quality guideline limits applicable to the site (**Section 3.4.5**).

The DO level recorded at site SAQ-1 was also notably below the lower ANZECC (2000) guideline limit.

DO levels fluctuate naturally throughout the diurnal cycle, the scale of which is dependent upon a range of factors; most notably the amount of aquatic vegetation and the level of organic loading.

Turbidity

Turbidity results are presented graphically in **Figure 4.9**. A descriptive statistical summary of turbidity levels within the Survey Area 2 and Survey Area 9 receiving systems is presented in **Table 4.5** and **Table 4.6**, respectively.

Turbidity levels exceeded the relevant ANZECC (2000) guideline limit at all sites within the Survey Area 2 network. A trend of increased turbidity with distance downstream is apparent between sites DA2-1 and DA2-6. Although site DA2-5 is situated on Dogwood Creek upstream of the confluence of Bottle Tree Creek (the direct receiving system for Survey Area 2), turbidity levels at this site were also elevated. The large increase in turbidity occurring between site DA2-4 (situated on Bottle Tree Creek) and DA2-6 (situated on Dogwood Creek immediately below the confluence with Bottle Tree Creek) is likely linked to a source occurring upstream of DA2-5. Turbidity levels measured at site DA2-7 indicated a reversing of this trend, but remained highly elevated.

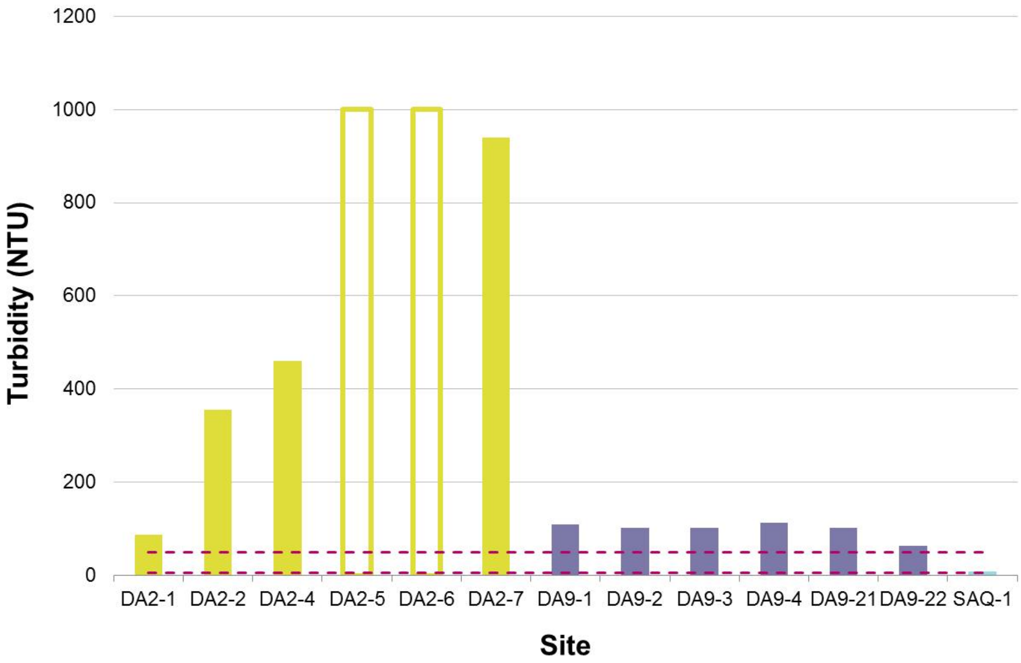

Figure 4.9 Turbidity of SREIS Survey Sites

Note: Green colouring indicates site situated within the Survey Area 2 receiving system; hollow green bars indicate value exceeded upper limit of instrument measurement range; **purple** colouring indicates site situated within the Survey Area 9 receiving system; **blue** colouring indicates site situated within the Dawson Catchment; **purple** dashed horizontal lines indicate relevant water quality guideline limits applicable to the site (**Section 3.4.5**).

The turbidity of water within ephemeral systems is highly variable with respect to prevailing hydrological conditions, recent rainfall levels and local characteristics of the waterway (particularly substrate type and local land-use). The range of values observed throughout the Survey Area 2 receiving system is consistent with conditions commonly occurring within ephemeral systems during periods of high flow (such as that experienced during SREIS surveys – **Figure 3.4**).

Turbidity levels exceeded the relevant ANZECC (2000) guideline limit at all sites within the Survey Area 9 receiving system. No trends in results were discernable with respect to location within the Survey Area 9 receiving system (i.e. upstream or downstream the proposed discharge point).

The turbidity recorded at site SAQ-1 was below the upper ANZECC (2000) guideline limit.

Table 4.5 Descriptive Statistical Summary of In-situ Water Quality within the Survey Area 2 Receiving System

Parameter	Units	Minimum	Maximum	Mean	Standard Deviation	Standard Error	ANZECC (2000)*
Temperature	ºC	22.50	26.90	24.89	1.64	0.62	NA
pH	pH units	6.08	7.05	6.52	0.31	0.12	6.5–8.0
EC	µS/cm	133.00	345.00	196.29	73.23	27.68	125–2200
DO	% sat.	19.90	75.52	48.20	19.96	7.55	90–110
Turbidity	NTU	9.40	1000.00^	550.49	429.87	162.48	6–50

Notes:
* Default guideline values for 'south-east Australia' 'slightly to moderately disturbed' 'lowland streams' adopted.
^ Actual measurement exceeded this value but could not be recorded due to instrumentation calibration limit.
NA Denotes absence of ANZECC (2000) guidelines for this parameter.

Table 4.6 Descriptive Statistical Summary of In-situ Water Quality within the Survey Area 9 Receiving System

Parameter	Units	Minimum	Maximum	Mean	Standard Deviation	Standard Error	ANZECC (2000)*
Temperature	ºC	22.50	24.60	23.15	0.77	0.29	NA
pH	pH units	6.47	7.61	7.09	0.42	0.16	6.5–8.0
EC	µS/cm	224.00	366.00	327.50	56.88	21.50	125–2200
DO	% sat.	40.40	78.20	65.05	14.77	5.58	90–110
Turbidity	NTU	62.80	113.00	98.80	18.15	6.86	6–50

Notes:
* Default guideline values for 'south-east Australia' 'slightly to moderately disturbed' 'lowland streams' adopted.
^ Actual measurement exceeded this value but could not be recorded due to instrumentation calibration limit.
NA Denotes absence of ANZECC (2000) guidelines for this parameter.

4.2.4 Aquatic Flora

A summary of macrophyte taxa recorded during the field surveys is presented in **Table 4.7**.

Six macrophyte species were recorded within the Survey Area 2 receiving system, with diversity ranging from two to five species per site. All species were of the emergent growth form and were native. None of these species were of conservation significance.

The absence of submerged and floating macrophyte species and the low diversity of emergent macrophyte species within the Survey Area 2 receiving system are attributable to the ephemeral nature of Bottle Tree Creek and Dogwood Creek. Ephemeral waterways typically provide poor habitat for macrophytes due to the high degree of spatial and temporal habitat variability and often 'harsh' growing conditions. Consequently, macrophyte assemblages in ephemeral waterways usually consist of a small number of relatively tolerant, emergent macrophyte species, which are common throughout a wide geographical region.

Table 4.7 Summary of Macrophyte Taxa Recorded during SREIS Surveys

Species Name	Common Name	Site												
		DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA9-1	DA9-2	DA9-3	DA9-4	DA9-21	DA9-22	SAQ-1
Emergent Growth-Form														
*Cyperus eragrostis**	umbrella sedge											✓		
Cyperus spp.`	Sedge		✓		✓	✓	✓			✓	✓			
Eleocharis spacelata	tall spike-rush											✓		
Juncus usitatus	Common rush	✓	✓	✓	✓	✓	✓	✓	✓				✓	
Lomandra longfolia	spiny-headed mat-rush	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
*Marsilea mutica****	shiny nardoo											✓		
Persicaria decipiens	slender knotweed				✓	✓	✓	✓	✓	✓	✓		✓	
Philydrum langinosum	frogsmouth	✓	✓											
Phragmites australis	common reed	✓	✓				✓	✓	✓	✓	✓		✓	
Submerged Growth-Form														
None														
Floating Growth-Form														
None														

Notes:
* Introduced species.
*** ACA Priority species.
✓ Taxa present.

Eight macrophyte species were recorded within the Survey Area 9 receiving system, with species diversity ranging from three to five species per site. Species of note include shiny nardoo (*Marsilea mutica*), which is listed as an ACA Priority species within the Condamine sub-basin and the umbrella sedge (*Cyperus eragrostis*), which is an exotic/introduced species. All species were of the emergent growth form.

When considering the pattern of macrophyte results observed throughout Survey Area 9 receiving system, however, it is important to remember that two high flow events occurred within the preceding two months (**Figure 3.4**). As macrophyte assemblages are susceptible to high flow events (due to high velocity flows which scour stream banks and channel), it is possible that the results collected during the field surveys provided an underestimate of typical diversity levels. This is of more relevance to the Condamine River (sites DA9-1 to DA9-4) than Crawlers Creek (DA9-21 and DA9-22), due to the notable difference in stream orders.

Despite the semi-permanent nature of the Condamine River across the Survey Area 9 receiving system (including the presence of large permanent pools upstream of Cecil Plains weir), environmental conditions are generally not conducive for macrophytes of submerged and floating growth forms. High water turbidity and fluctuating water levels (such as those observed at surveys sites) typically prevent the establishment of such species. The diversity of emergent macrophytes species is also likely restricted to some extent by the moderate - extensive rates of bank erosion and access of stock throughout the riparian zone observed throughout the Survey Area 9 Study Area.

The only macrophyte species recorded at site SAQ-1 was lomandra (*Lomandra longifolia*).

4.2.5 Fish

A summary of fish survey results is presented in **Table 4.8**. Site based assessments of fish abundance and species diversity are presented graphically in **Figure 4.10**. The relative abundance of fish species occurring within the Survey Area 2 and Survey Area 9 site networks is also displayed graphically in **Figure 4.11** and **Figure 4.12**, respectively.

Species diversity within the Survey Area 2 receiving system was 14 species. Only 12 species are listed in **Table 4.8** due to the grouping of the *Hypseleotris* species complex (carp gudgeons); of which, three species were positively identified during the SREIS surveys; western carp gudgeon (*Hypseleotris klunzingeri*), Midgely's carp gudgeon (*Hypseleotris species 1*) and Murray-Darling carp gudgeon (*Hypseleotris species 4*). All of the species collected throughout the Survey Area 2 receiving system are potadromous (spend entire life cycle in freshwater).

Two species of conservation significance were collected from the Survey Area 2 receiving system, including: Murray Cod (*Maccullochella peelii peelii*), which is listed as 'vulnerable' under the EPBC Act; and, Agassiz's glassfish (*Ambassis agassizii*), which is listed as an ACA Priority species within the Condamine-Balonne Basin (refer to species dossier presented in **Attachment 2**). The Murray Cod was collected exclusively from site DA2-5, with only a single individual being captured. Site DA2-5 is situated on Dogwood Creek upstream of the Bottle Tree Creek confluence and thus would not receive treated or untreated coal seam gas water. Agassiz's glassfish was collected in low abundance from sites DA2-4 and DA2-7.

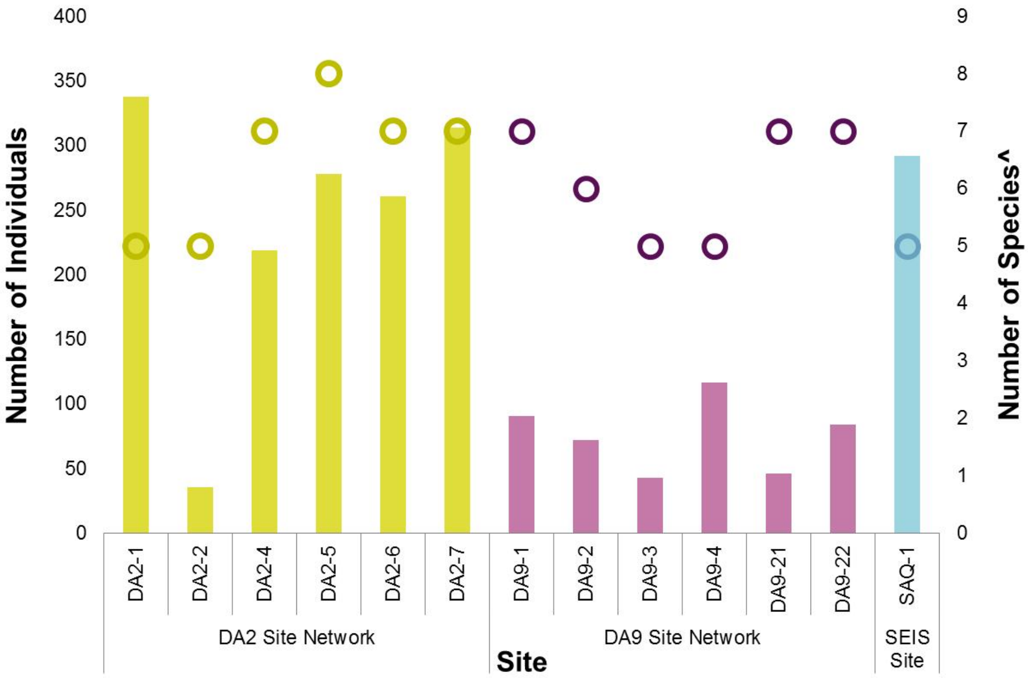

Figure 4.10 Fish Abundance and Species Diversity of SREIS Survey Sites

Note: **Green** colouring indicates site situated within the Survey Area 2 receiving system; **purple** colouring indicates site situated within Survey Area 9 site network; **blue** colouring indicates site situated within the Dawson Catchment; solid bar column denotes number of individuals, hollow circle denotes number of species; ^ presents all species belonging to the *Hypseleotris* genus as a single species complex.

A detailed synopsis of the ecology, distribution, habitat requirements and existing threats is presented in **Attachment 2** for the Murray Cod and Agassiz's glassfish. Suitable habitat for both of these species is generally present throughout the Survey Area 2 receiving system. Concomitantly, irrespective of the relatively low abundance of these species during the SREIS surveys, on the basis of desktop studies, historic records and field surveys, both species are generally expected to occur throughout the Survey Area 2 receiving system.

Three exotic/introduced species (the latter two species being classified as 'noxious' under the *Fisheries Act 1994*) were recorded within the Survey Area 2 receiving system: goldfish (*Carassius auratus*), European carp (*Cyprinus carpio*) and mosquitofish (*Gambusia holbrooki*). Whilst the first two of these species were present in relatively low abundance, the latter was the most dominant fish collected throughout the Survey Area 2 receiving system.

Other common fish species included the *Hypseleotris* species complex and to a lesser extent spangled perch (*Leipotherapon unicolor*), bony bream (*Nematalosa erebi*), Murray River rainbowfish (*Melanotaenia fluviatilus*) and Australian smelt (*Retopinna semoni*). Hyrtl's tandan (*Neosilurus hyrtlii*) and golden perch (*Macquaria ambigua*) were present in low abundance.

Species diversity within the Survey Area 2 receiving system ranged from five to eight species per site (**Figure 4.11**). Sites DA2-1 and DA2-2 (two most upstream sites) consistently supported the lowest species diversity within the Survey Area 2 receiving system, whilst site DA2-5 supported the highest. No consistent patterns were apparent between fish species diversity and corresponding abiotic (physical habitat, water quality) and biotic (fish, macrophytes and reptiles) data-sets. It is of note, however, that substrate complexity at site DA2-5 was the highest within the Survey Area 2 receiving system; with five types (bedrock, cobble, pebble, sand and silt/clay) recorded.

Total abundance within the Survey Area 2 receiving system ranged from approximately 40 to 340 individuals per site. The highest abundance was recorded at site DA2-1, whilst the lowest was recorded at site DA2-2. Individuals of the *Hypseleotris* species complex and the mosquitofish accounted for the majority of total abundance throughout the Survey Area 2 receiving system as a whole (**Figure 4.12**), as well as on a site by site basis. Of the six sites surveyed, the *Hypseleotris* species complex was the most abundant taxon at three sites, whilst mosquitofish was the most abundant species at the other three sites (**Table 4.8**).

Taxonomic diversity within the Survey Area 9 receiving system was 12 species. Only 11 are listed in **Table 4.8** due to the grouping of the *Hypseleotris* complex; of which, two species were positively identified during surveys; western carp gudgeon and Murray-Darling carp gudgeon. All of the species collected throughout the Survey Area 9 receiving system are potadromous.

Two species of conservation significance were collected from the Survey Area 9 receiving system, including: Murray Cod (*Maccullochella peelii peelii*), which is listed as 'vulnerable' under the EPBC Act; and, eel-tailed catfish (*Tandanus tandanus*), which is listed as an ACA Priority species within the Condamine-Balonne Basin (refer to species dossier presented in **Attachment 2**). Murray Cod was the only fish species of national conservation significance collected from the Survey Area 9 receiving system. Murray Cod were collected in low abundance from sites DA9-1 and DA1-2 and a single specimen of eel-tailed catfish (*Tandanus tandanus*) was recorded at site DA9-2. Irrespective of the relatively low abundance of this species during surveys, suitable habitat does exist in the Condamine River throughout the Survey Area 9 receiving system. Accordingly, the section of the Condamine River within the Survey Area 9 Study Area should generally be considered to support this species. Due to its ephemeral nature and comparatively small size, suitable habitat for the Murray Cod is not generally expected in Crawlers Creek.

Two exotic/introduced species (classified as 'noxious' under the *Fisheries Act 1994*) were recorded within the Survey Area 9 receiving system; European carp and mosquitofish. Both species were widespread throughout the Survey Area 9 receiving system at moderate to low abundance.

Bony bream was the most dominant species recorded within the Survey Area 9 receiving system. Other common fish species included the *Hypseleotris* species complex and to a lesser extent spangled perch and golden perch. Murray River rainbowfish, Australian smelt, Hyrtl's tandan and eel-tailed catfish (*Tandanus tandanus*) were present in low abundance.

Taxonomic diversity within the Survey Area 9 receiving system ranged from five to seven species. No consistent patterns were apparent between fish species diversity and corresponding abiotic (physical habitat, water quality) and biotic (fish, macrophytes and reptiles) data-sets. Species richness levels consistently decreased, albeit slightly, between sites DA9-1 and DA9-3 and was constant between sites DA9-3 and DA9-4. This finding of declining species richness is, generally, negatively associated with increasing proximity to the Cecil Plains weir.

Table 4.8 Summary of Fish Species Data Collected during SREIS Surveys

Species Name	Common Name	Site												
		DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA9-1	DA9-2	DA9-3	DA9-4	DA9-21	DA9-22	SAQ-1
Potadromous														
*Ambassis agassizii****	Agassiz's glassfish			10			1							6
*Carassius auratus**	Goldfish	2				1								
*Cyprinus carpio**	European carp				1			4	10	6	3	19	15	
*Gambusia holbrooki**	Mosquitofish	57	2	60	206	206	265			1	1	2	15	
Hypseleotris spp.^	Carp gudgeons	263	20	137	59	36	36	20	29	8	12	2	29	121
Leiopotherapon unicolor	Spangled perch	15	9	1	4	4	4					8	20	160
Maccullochella peelii	Murray Cod				1			1	2					
Macquaria ambigua	Golden perch						2	3	9	5	2	1	2	
Melanotaenia fluviatilus	Murray River rainbowfish	1	2		4	9	5		1					
Melanotaenia splendida	Eastern rainbowfish													2
Nematalosa erebi	Bony bream			6	2	1	1	61	21	23	99	12	2	
Neosilurus hyrtlii	Hyrtl's tandan			2								2	1	
Retropinna semoni	Australian smelt		3	3	1	4		1						
*Tandanus tandanus****	Eel-tailed catfish							1						3
Catadromous														
None														
Anadromous														
None														

Notes:
^ Hypseleotris species complex (consisting of several species belonging to the Hypseleotris Genus).
* Introduced species.
*** ACA priority species Bold text denotes species as listed as 'vulnerable' under the EPBC Act.

Table 4.8 Summary of Fish Species Data Collected during SREIS Surveys

Species Name	Common Name	Site												
		DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA9-1	DA9-2	DA9-3	DA9-4	DA9-21	DA9-22	SAQ-1
Potadromous														
*Ambassis agassizii****	Agassiz's glassfish			10			1							6
*Carassius auratus**	Goldfish	2				1								
*Cyprinus carpio**	European carp				1			4	10	6	3	19	15	
*Gambusia holbrooki**	Mosquitofish	57	2	60	206	206	265			1	1	2	15	
Hypseleotris spp.^	Carp gudgeons	263	20	137	59	36	36	20	29	8	12	2	29	121
Leiopotherapon unicolor	Spangled perch	15	9	1	4	4	4					8	20	160
Maccullochella peelii	Murray Cod				1			1	2					
Macquaria ambigua	Golden perch						2	3	9	5	2	1	2	
Melanotaenia fluviatilus	Murray River rainbowfish	1	2		4	9	5		1					
Melanotaenia splendida	Eastern rainbowfish													2
Nematalosa erebi	Bony bream			6	2	1	1	61	21	23	99	12	2	
Neosilurus hyrtlii	Hyrtl's tandan			2								2	1	
Retropinna semoni	Australian smelt		3	3	1	4		1						
*Tandanus tandanus****	Eel-tailed catfish							1						3
Catadromous														
None														
Anadromous														
None														

Notes:
^ Hypseleotris species complex (consisting of several species belonging to the Hypseleotris Genus).
* Introduced species.
*** ACA priority species Bold text denotes species as listed as 'vulnerable' under the EPBC Act.

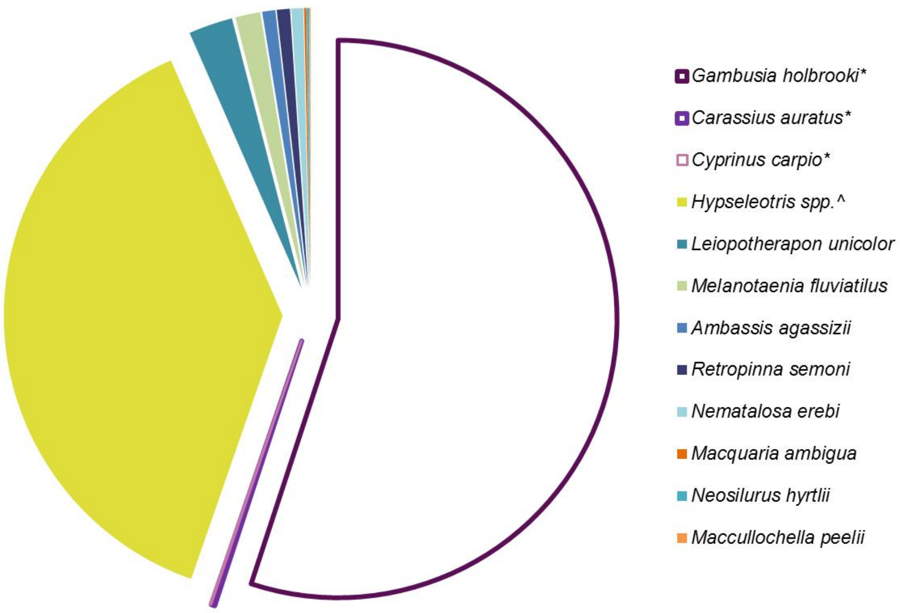

Figure 4.11 Relative Abundance of Fish Collected from the Survey Area 2 Receiving System

Notes:
* Denotes introduced species.
^ Denotes *Hypseleotris* species complex).

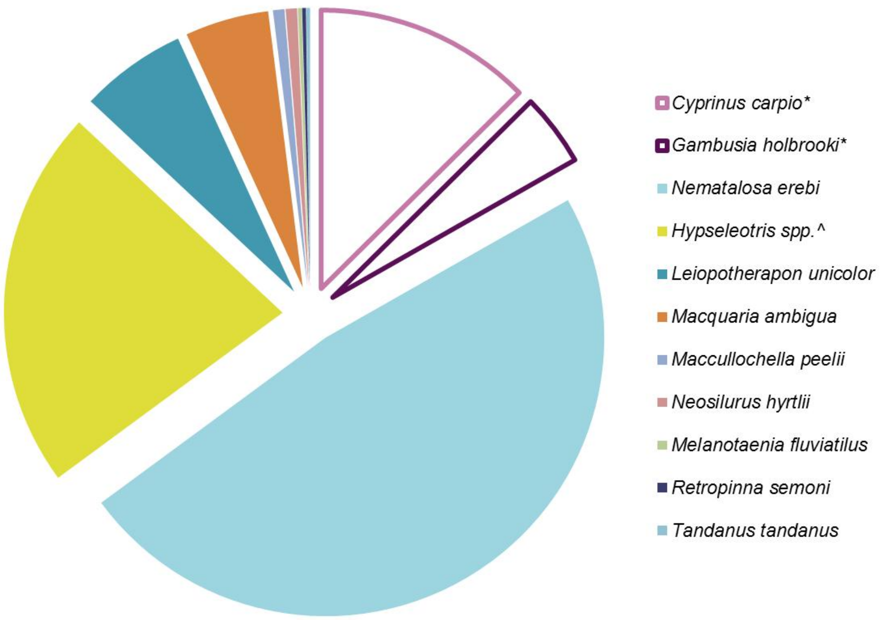

Figure 4.12 Relative Abundance of Fish Collected from the Survey Area 9 Receiving System

Notes:
* Denotes introduced species.
^ Denotes *Hypseleotris* species complex.

Total abundance within the Survey Area 9 receiving system ranged from 43 to 117 individuals per site. The lowest abundance was recorded at site DA9-3, the highest at site DA9-4. Within the Condamine River, individuals of bony bream and the *Hypseleotris* species complex accounted for the majority of total abundance. European carp was the most abundant species recorded at site DA9-21, whilst the Hypseleotris species complex was the most abundant 'species' recorded at site DA9-22.

Five fish species were collected from site SAQ-1. Spangled perch was recorded in the highest abundance, with slightly fewer individuals of the *Hypseleotris* species complex recorded. Agassiz's glassfish, eel-tailed catfish and eastern rainbowfish (*Melanotaenia splendida*) were recorded in low abundance. None of the species collected are of conservation significance within the Dawson River sub-basin. All of these species are native and potadromous.

4.2.6 Turtles

A summary of turtle species captured during SREIS surveys is presented in **Table 4.9**.

Two species of turtle were collected from the Survey Area 2 receiving system; the broad-shelled turtle (*Chelodina expansa*) and the eastern long-necked turtle (*Chelodina longicollis*). Of these, the broad-shelled turtle is classified as an ACA Priority species within the Condamine sub-basin of the Condamine-Balonne Basin.

Suitable habitat for the broad-shelled turtle is generally present throughout the section of the Condamine River occurring within the Survey Area 9 Study Area. Concomitantly, the broad-shelled turtle is generally expected to be present within this same area.

The Murray River turtle (*Emydura macquarii macquarii*) was the only species of turtle collected from the Survey Area 9 receiving system. This species is not of conservation significance, and is generally expected to be common throughout the Condamine sub-basin.

The eastern long-necked turtle was the only species of turtle collected at site SAQ-1.

Table 4.9 Summary of Turtle Species Collected during SREIS Surveys

Species Name	Common Name	Site												
		DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA9-1	DA9-2	DA9-3	DA9-4	DA9-21	DA9-22	SAQ-1
Emydura macquarii macquarii	Murray River turtle							✓	✓	✓	✓			
*Chelodina expansa****	Broad-shelled turtle		✓											
Chelodina longicollis	Eastern long-necked turtle		✓				✓							✓

Notes:
✓ Species present.
*** ACA Priority species.

4.3 Existing Environment Summary

4.3.1 Survey Area 2

The waterways present within the Survey Area 2 receiving system, Bottle Tree Creek and Dogwood Creek, are small and ephemeral. For the majority of the hydrological cycle, surface water does not persist. The potential for a small number of remnant waterholes cannot be completely excluded at the current time, but is considered unlikely based on observations made during the surveys. Stream-flow occurs for a brief period of time following heavy and sustained precipitation, which typically occurs during the wet season. For the majority of time during which surface water does persist, aquatic habitat within these systems is characterised by a series of disconnected and semi-connected recessional waterholes. The far downstream reaches of Dogwood Creek are regulated by the presence of Gil weir.

The prevailing hydrologic conditions throughout the Survey Area 2 receiving system have naturally shaped assemblages of aquatic flora and fauna that are typically low in diversity and temporally (seasonally) variable. Most species recorded during the SREIS surveys have broad habitat requirements and are generally tolerant to a wide range of (hydrological, water quality and physical habitat) naturally occurring conditions.

Three species of conservation significance were recorded within the Survey Area 2 receiving system during surveys:

- Murray River cod, which is listed as ‘vulnerable’ under the EPBC Act;
- Agassiz’s glassfish, which is listed as an ACA Priority species within the Condamine sub-basin; and
- Broad-shelled turtle, also listed as an ACA Priority species within the Condamine sub-basin.

These species are generally expected to use aquatic habitat throughout the entire Survey Area 2 receiving system.

Three noxious fish species (as per *Fisheries Act 1994*) were recorded, including mosquitofish, goldfish and European carp; the former of which, being recorded as widespread and abundant throughout the Survey Area 2 receiving system.

4.3.2 Survey Area 9

The Condamine River is the major waterway present within the Survey Area 9 receiving system. Within the Survey Area 9 receiving system, the Condamine River is semi-permanent and contains permanent pools as a result of the presence of the Cecil Plains weir. The proposed area of Survey Area 9 discharge is situated upstream of the Cecil Plains weir, within the zone of impoundment. Water levels within the impoundment would fluctuate throughout the course of the hydrological cycle.

Crawlers Creek is the other key waterway present within Survey Area 9 receiving system. Crawlers Creek is a small, ephemeral, first order tributary of Condamine River. Stream flow occurs for a brief period of time following heavy and sustained precipitation, which typically occurs during the wet season. For a short period of time immediately following periods of stream flow, surface water persists as a series of semi-connected and disconnected pools, separated by areas of dry stream bed. For the majority of the hydrological cycle, however, surface water does not persist. Under certain hydrological conditions (high precipitation), water from the Condamine River could possibly backup into Crawlers Creek.

Assemblages of aquatic flora and fauna within the Survey Area 9 receiving system are low in diversity. Despite the comparatively increased permanence of water in the Condamine River, the uniformity of aquatic habitat is not conducive to diverse assemblages. In Crawlers Creek the prevailing hydrologic conditions generally restrict assemblage composition to a low number of ‘generalist’ species possessing broad set of habitat requirements.

Seasonal variability in assemblages of aquatic flora and fauna within the Survey Area 9 receiving system would likely be higher within Crawlers Creek than Condamine River, due to varying degrees of water permanence.

Murray Cod, which is listed as ‘vulnerable’ under the EPBC Act, was the only fish species of national conservation significance recorded within the Survey Area 9 receiving system. A species specific dossier outlining ecology, habitat requirements, distribution and threats is presented in **Attachment 2**. This species is generally expected to use aquatic habitat throughout the entire Survey Area 9 receiving system, although it is more likely within the Condamine River.

Shiny nardoo was present within the Survey Area 9 receiving system. This emergent macrophyte species is listed as an ACA Priority species within the Condamine sub-basin.

Two noxious fish species (as per *Fisheries Act 1994*), mosquitofish and European carp, were widespread and abundant throughout the Survey Area 9 receiving system.

4.3.3 SAQ-1

SAQ-1 was situated upon a small semi-permanent waterway, Weringa Creek, occurring within the Dawson River sub-basin. For the majority of the hydrological cycle surface water persists as a series of semi-connected and disconnected pools, separated by areas of dry stream bed. Stream flow occurs for a brief period of time following heavy and sustained precipitation, which typically occurs during the wet season

The prevailing hydrologic conditions at site SAQ-1 have naturally shaped assemblages of aquatic flora and fauna that are typically low in diversity and temporally (seasonally) variable. Most species recorded during surveys have broad habitat requirements and are generally tolerant to a wide range of (hydrological, water quality and physical habitat) naturally occurring conditions

No species of conservation significance were recorded at site SAQ-1 during the surveys. All species recorded were native.

Overall, aquatic habitat (hydrological conditions, water quality, physical characteristics and macro and microhabitat availability), flora (macrophytes) and fauna (fish, turtles, mammals) at site SAQ-1 were assessed as being representative of local and regional conditions characteristic of aquatic ecosystems occurring within the Dawson sub-basin.

4.4 Sensitivity of Environmental Values

Based on desktop investigations and field surveys, the sensitivity values derived for Bottle Tree/Dogwood Creeks (Survey Area 2) and the Condamine River (Survey Area 9) from the classifications outlined in **Tables 3.10 and 3.12** which are assessed in **Table 4.10**. Overall, Bottle Tree/Dogwood Creek at and downstream of Survey Area 2, and the Condamine River at and downstream of Survey Area 9, have been assessed as a moderate sensitivity rating.

Table 4.10 Sensitivity of Aquatic Communities within the Survey Area 2 and Survey Area 9 Receiving Systems

Sensitivity	Survey Area 2 Receiving System	Survey Area 9 Receiving System
Conservation status	**Moderate** *Waterway not listed under state, national or international significance. One EPBC listed species (Murray Cod) is known to occur. Contains moderate/marginal fishery values and is of state and local eco-tourism destination.*	**Moderate** *Waterway not listed under state, national or international significance. One EPBC listed species (Murray Cod) is known to occur. Contains moderate/marginal fishery values and is of state and local eco-tourism destination.*
Intactness	**High** *A largely undisturbed ephemeral aquatic system but with naturally limited passage of aquatic fauna and spawning/nursery opportunities.*	**Moderate** *A moderately disturbed aquatic system. An important movement corridor with nursery and spawning habitat potential.*
Uniqueness	**Low** *Not unique on a regional, national or international scale in terms of biota, communities or processes.*	**Low** *Not unique on a regional, national or international scale in terms of biota, communities or processes.*
Resistance to change	**Moderate** *Moderately tolerant and adaptive aquatic communities.*	**Moderate** *Moderately tolerant and adaptive aquatic communities.*

Sensitivity	Survey Area 2 Receiving System	Survey Area 9 Receiving System
Replacement potential	**Moderate** *Communities likely to exhibit moderate to good recovery following disturbance.*	**Moderate** *Communities likely to exhibit moderate to good recovery following disturbance.*

4.5 AQUATIC VALUES SITE INSPECTION

The information presented in this section provides a summary of results for sites associated with the establishment of CGPF7 and CGPF8, and a temporary workers accommodation facility (TWAF F). These results have been presented separately (in this section) as general ‘aquatic values assessments’, as detailed sampling of specific aquatic indicators was not completed.

4.5.1 Central Gas Processing Facility 7

The site for the proposed CGPF7 is situated on Wilkie Creek about 25 km west of the town of Dalby. A literature review identified a single significant aquatic species, Murray Cod, as potentially occurring.

The point at which Wilkie Creek intersects the properties for the proposed CGPF7 were surveyed and described in the EIS (site D, Aquateco 2011). Adjacent to Wilkie Creek (in the central portion of the site) are several billabongs. Inspection of submerged and floating aquatic flora species suggests it is likely that these billabongs are semi-permanent in nature and therefore likely to support aquatic ecosystems of some importance. Following high rainfall events these waterways would be heavily inundated (Alluvium 2013a). Two smaller streams intersected the western portion of the site and while they contained water at the time of the inspection are likely to be highly ephemeral and are considered to have a low sensitivity (section 4.4 Aquateco 2011).

4.5.2 Central Gas Processing Facility 8

The site for the proposed CGPF8 is situated approximately 26 km south/south-west of the town of Dalby. A literature review identified a single significant aquatic species, Murray Cod, as potentially occurring.

Examination of aerial photography identified that the western section of the proposed CGPF8 site was situated in the catchment above Lake Broadwater, while the central and eastern portions drain into the Wilkie Creek catchment. Even after recent periods of high rainfall there was little standing water observed across the site and no direct evidence of any aquatic values of significance. Longswamp which is a wetland situated in the eastern portion of the property may be frequented by migratory bird species but is unlikely to contain ecosystems of notable value due to the intermittency of water. However, with part of the site situated in the catchment above Lake Broadwater (listed as significant under the EPBC Act) it is considered highly sensitive and imperative that best practices are deployed to prevent soil erosion and runoff to minimise any downstream impacts.

4.5.3 TWAF F

The proposed site for the temporary workers accommodation facility, TWAF F, is situated approximately 35 km south/south-west of the town of Dalby and approximately 10 km south of CGPF8, within the Wilkie Creek sub-catchment. A literature review identified a single significant aquatic species, Murray Cod, as potentially occurring.

Two small creeks intersect the property. The larger creek runs parallel to the western boundary of TWAF F. The smaller creek passes across the south eastern corner, forming a confluence with a drainage line coming from the direction of TWAF F, at the corner of the property. While at the time of the site inspection both creeks contained water it is likely that they remain dry for much of the year with the possibility of a few remnant pools remaining and are considered to have a low sensitivity (section 4.4 Aquateco 2011).

5. POTENTIAL IMPACTS

The following section identifies the activities and potential impacts resulting from changes to the project description (refer to **Section 1.3**). The sensitivity value for each aquatic ecosystem is described in **Section 4.2**. The mitigation controls for each potential impact and residual impacts assessment are detailed in **Sections 6** and **7**, respectively.

5.1 Overview

5.1.1 Additional Survey Sites and Change of Project Description for Establishment of Gas Processing Facilities/Temporary Workers Accommodation Facility

The baseline impact assessment for a range of activities is described in the EIS, including:

- Site clearing;
- Construction of access tracks;
- Use of vehicles and machinery near waterways;
- Waste management;
- Gathering line and pipeline trenching;
- Pipeline/access road creek crossings;
- Drilling operations;
- Altered hydrology (in relation to emergency water releases);
- Operation and maintenance; and
- Maintenance of access tracks and overhead power-line easements.

The EIS included an assessment of potentially threatening processes and impacts associated with these activities. The report also detailed measures to mitigate these impacts during the construction, operation, maintenance and decommissioning phases of the project and residual impacts. Consequently, these have not been discussed in detail in the current report.

The proposed activities relating to the two additional survey sites (SAQ-1 and SAQ-2), the construction, operation and decommissioning of CGPF's (CGPF7 and CGPF8), and the establishment of a temporary workers accommodation facility (TWAF F), are covered by the list of activities described above. The results from surveys do not warrant a change to the description of potential impacts and proposed mitigation measures presented in the EIS.

5.1.2 Change of Project Description for Discharge of Coal Seam Gas Water

The revised Project Description includes the provision for discharge of treated and untreated coal seam gas water from Water Treatment Facility 1 to Bottle Tree Creek (Survey Area 2) and from Water Treatment Facility 2 to the Condamine River or Crawlers Creek (Survey Area 9). A summary of potential impacts on aquatic ecosystems associated with these changes to the Project Description is provided in **Table 5.1**.

Table 5.1 Activities identified in the changed Project Description with potential for significant impacts

Activity	Issues Identified
Discharge of treated and untreated coal seam gas water into streams	Changes in the volume and timing of surface water flows
	Changes in the water chemistry and physical properties
	Changes in geomorphological processes
	Potentially facilitate the establishment and spread of non-indigenous or invasive species and expansion of invasive species already present

5.1.3 Transfer of Water between Water Treatment Facilities

The transfer of water between water treatment facilities could potentially result in the spread of non-indigenous or invasive species if appropriate precautions are not taken.

5.2 Release of Coal Seam Gas Water

5.2.1 Description of Project Activity

One of the options for managing coal seam gas water is to potentially discharge from Survey Area 9 into the Condamine River (or Crawlers Creek immediately above the confluence with the Condamine River) near Cecil Plains and from Survey Area 2 into Bottle Tree Creek north of Miles (refer to **Figure 3.2 and Figure 3.3**). It is assumed that there will be variations in the amount of water that will be released throughout the year, proportional to the wet and dry seasons. Potential impacts associated with this activity are restricted to operational (during and/or between releases) and decommissioning phases (return of the systems to pre-existing flow conditions) of the project.

5.2.2 Sensitivity of the Aquatic Receiving System

Sensitivity ratings for each of the proposed discharge sites under each criterion detailed in **Section 3.5** are presented in **Table 4.10**.

Overall the sensitivity values for the aquatic ecosystems at each site were derived as:

- Bottle Tree and Dogwood Creeks (at and below Survey Area 2) - moderate
- Condamine River (at and below Survey Area 9) - moderate

5.2.3 Description of Potential Impacts

Discharge of coal seam gas water into the Survey Area 2 and Survey Area 9 receiving systems could have a number of potential impacts on aquatic ecosystems, including:

- Changes in the composition of aquatic assemblages as a result of changes in the volumes and frequencies of discharges
- Changes in the aquatic community composition as a result of the altered water chemistry and physical characteristics (e.g. turbidity, pH, tannic acids, temperature, dissolved oxygen, ionic composition and macro/micro nutrients)
- Changes in the geomorphological processes that create, or assist in the formation of, habitat that aquatic assemblages inhabit; particularly those supporting species of conservation significance (e.g. deep pools and undercut banks)

- Creation of conditions that could facilitate the spread and the establishment of pest species (e.g. the establishment of higher base flows in other regions of the Murray-Darling is thought to have provided favourable conditions for carp over native fish species).

Potential impacts on aquatic ecosystems will be determined by the scale of the change in flow conditions and characteristics of each of the two receiving environments. Consequently, this assessment will consider the potential impacts on aquatic ecosystems of the discharges under two broad scenarios:

- Low flow conditions
- High flow events.

According to Alluvium (2013b), the annual flow regime can be divided into two flow seasons:

- a ***low flow season***: generally extended periods of low flows driven mostly by base flow– or periods of no flow, called cease-to-flow periods – with infrequent shorter periods of high flow – freshes – caused by small localised rainfall events. For the Condamine River this occurs from March to October and from March to November for Dogwood Creek.
- a ***high flow season***: higher base flow with frequent, sometimes extended, periods of higher flows from larger and more widespread storms. For the Condamine River this occurs from November to February and from December to February for Dogwood Creek.

For the purposes of this assessment low flow conditions are considered to include (Alluvium 2013b):

- Cease to flow: Zero flow
- Base flow: Flow that is exceeded on 80% of days during the low flow season
- Low flow fresh: Flow that is exceeded on 20% of days during the low flow season.

In the context of the project area this includes flows less than 244 ML/day (including cease to flow days) for the Condamine River at Survey Area 9 and flows less than 20 ML/day (including cease to flow days) at Bottle Tree Creek at Survey Area 2 (based on the flow gauge at Gil weir downstream).

For the purpose of this assessment, a high flow event includes high freshes and bankfull flows. Definitions of these flow components are presented in Alluvium 2013b and outlined below:

- High flow fresh: Flow that is exceeded on 20% of days during the high flow season
- High flow fresh: Flow that is exceeded on 5% of days during the high flow season
- Bankfull flow: 2 year ARI (Average Occurrence Interval) flow.

In the context of the project area high flow events are those which exceed 425 ML/day for the Condamine River and 83 ML/day for Dogwood Creek (Alluvium 2013b).

As discussed in **Section 4.2.1**, flow conditions were highly variable within and between the two receiving systems. However, it is noted that both receiving systems were dominated by extended periods of cease to flow or low flow with intermittent high flow fresh events and bankfull flows (Alluvium 2013a, 2013b).

The potential risks to aquatic ecosystems of un-mitigated impacts vary in magnitude in relation to the volume and duration of releases. They include both direct and indirect risks such as;

- Mobilisation of bed and bank material inducing erosion and increased turbidity
- Sudden drawdown of water levels inducing bank slumping of saturated banks potentially causing erosion, increased turbidity and loss of riparian habitat
- Altered riparian vegetation communities as a result of changes in bank saturation potentially altering functional attributes and geomorphic controls
- Altered riparian vegetation communities aquatic vegetation favouring some native and/or exotic species potentially altering ecosystem process and sediment balance
- Changes in the composition of all aquatic communities from primary producers (such as phytoplankton) through to higher order vertebrates (such as fish, turtles and mammals) as a result of habitat modification and water quality
- Changes in the fundamental aquatic ecosystem processes that are dependent on a natural flow regime (including impacts on life history strategies such as spawning cues)
- Potential to facilitate the colonisation and/ or expansion of opportunistic species, particularly carp (*Cyprinus carpio*).

5.2.4 Magnitude of Potential Impacts

The magnitude rating of potential impacts for both of the proposed discharge sites under each criterion detailed in the EIS is presented in **Table 5.2**. High flow events would have a greater capacity to dilute water discharged into the receiving environment. For the purposes of this assessment it has been assumed that water discharged to the receiving environment would not alter the chemistry of the water downstream of the discharge point. Further information is needed on the water quality being discharged and dilution modelling must be completed to accurately assess the potential impacts on the receiving environments.

Impact ratings for each of the specific magnitude of impact criteria were amalgamated to provide an overall assessment for each receiving system under both high flow events and low flow conditions. The results are as follows:

- Discharge at Survey Area 2 at high flow - low
- Discharge into Survey Area 2 at low flow - high
- Discharge into Survey Area 9 at high flow - low
- Discharge into Survey Area 9 at low flow - high.

Table 5.2 Magnitude of impacts at Survey Area 2 and Survey Area 9 receiving systems during high flow and low flow conditions

Magnitude	Survey Area 2		Survey Area 9	
	Discharge at high flow	**Discharge at low flow**	**Discharge at high flow**	**Discharge at low flow**
Geographic extent of impact	**Low** *Appropriate dilution during high natural flows could mask the extent of releases at the scale specified*	**High** *As a highly ephemeral system, any discharge could extend at least as far as Gil weir approximately 30 km downstream*	**Low** *Appropriate dilution during high natural flows could mask the extent of releases at the scale specified*	**High** *As the Condamine River is a semi-permanent system, any discharge could potentially extend downstream beyond 20 km*
Duration of impact	**Low** *Proportional to the periods of high flow, are likely to be up to several weeks for a given flow period*	**High** *Initial impact period is for the operational life of the project (35 years). The secondary impact will occur when discharges cease and the ecosystem re-equilibrates (the time frame is indeterminable)*	**Low** *Proportional to the periods of high flow, are likely to be up to several weeks for a given flow period*	**High** *Initial impact period is for the operational life of the project (35 years). The secondary impact will occur when discharges cease and the ecosystem re-equilibrates (the time frame is indeterminable)*
Severity	**Low** *Potential for minor, short-term impairment of aquatic communities*	**High** *Changes in flow regime and water chemistry are likely to have a significant impact on aquatic community abundance and diversity*	**Low** *Potential for minor, short-term impairment of aquatic communities*	**High** *Changes in flow regime and water chemistry are likely to have a significant impact on aquatic community abundance and diversity*

5.2.5 Assessment of (Un-mitigated) Impact

The significance of un-mitigated impact assessment for discharges at Survey Area 2 and Survey Area 9 are provided in **Table 5.3** for both high flow events and low flow conditions. (Refer to **Section 3.5** for impact assessment matrix).

Table 5.3 Pre-mitigation assessment of significance of impacts of water discharges to Survey Area 2 and Survey Area 9 receiving systems

	Sensitivity	Magnitude	Impact
Survey Area 2 discharge at high flow	Moderate	Low	Low
Survey Area 2 discharge at low flow	Moderate	High	High
Survey Area 9 discharge at high flow	Moderate	Low	Low
Survey Area 9 discharge at low flow	Moderate	High	High

5.3 Transfer of Water between Sites

5.3.1 Description of Project Activity:

The updated Project Description provides the conceptual layout of the two water treatment facilities and includes the creation of four water storage facilities at these sites; untreated coal seam gas water, treated coal seam gas water and two brine waste dams.

While it is unlikely that the waste brine dams could support aquatic communities of any significance, there is the potential for the untreated coal seam gas water dams and particularly the treated coal seam gas water dam to support aquatic organisms, including native and non-indigenous and/or invasive aquatic species.

5.3.2 Sensitivity of Aquatic Receiving System

Sensitivity ratings for each of the proposed discharge sites under each criterion detailed in **Section 3.5** are presented in **Table 4.10**.

The overall sensitivity values for each receiving system were assessed as:

- Survey Area 2 (Bottle Tree and Dogwood Creeks) - moderate
- Survey Area 9 (Condamine River) - moderate.

5.3.3 Description of Potential impacts

In the event that a non-indigenous or invasive species was able to colonise one of the water storages, then they could be transferred with the water between sites. While the presence of a non-endemic or invasive species in the water storages is likely to be somewhat contained, the introduction of non-indigenous or invasive species with discharges to the Survey Area 2 or Survey Area 9 receiving systems may result in high or major impacts to the health of these aquatic ecosystems.

Potential impacts associated with this activity could occur during the operational phase and persist past the decommissioning phase of the project if a non-indigenous or invasive species becomes established.

5.3.4 Magnitude of Potential Impacts

The magnitude of potential impact ratings for the two proposed discharge sites under each criterion detailed in **Section 3.5** is presented in **Table 5.4**.

Based on the specific magnitude criteria the overall magnitude of impact values at each site were assessed as:

- Survey Area 2 (Bottle Tree/ Dogwood Creeks) - high
- Survey Area 9 (Condamine River) - high.

5.3.5 Assessment of (Un-mitigated) Impact

The un-mitigated impact assessment for water transfers between locations with discharge at either Survey Area 2 and Survey Area 9 are provided in **Table 5.5.** (Refer to **Section 3.5** for impact assessment matrix).

Table 5.4 Magnitude of impacts at Survey Area 2 and Survey Area 9 Receiving Systems

Magnitude Category	Survey Area 2	Survey Area 9
Geographic extent of impact	**High** *Potential for non-endemic or invasive species to become established in the receiving environments and to extend throughout the Murray-Darling catchment.*	**High** *Potential for non-endemic or invasive species to become established in the receiving environments and to extend throughout the Murray-Darling catchment.*
Duration of impact	**High** *Potential for non-endemic or invasive species to become established which impact could be permanent.*	**High** *Potential for non-endemic or invasive species to become established which impact could be permanent.*
Severity	**High** *Depending on the nature of particularly invasive species the impacts on aquatic ecosystems could be high and permanent.*	**High** *Depending on the nature of particularly invasive species the impacts on aquatic ecosystems could be high and permanent.*

Table 5.5 Pre-mitigation impact assessment of water transfer for the Survey Area 2 and Survey Area 9 receiving systems

	Sensitivity	Magnitude	Impact
Survey Area 2	Moderate	High	High
Survey Area 9	Moderate	High	High

6. MITIGATION AND MANAGEMENT MEASURES

Proposed mitigation and management measures are detailed in the following sections.

6.1 Release of Coal Seam Gas Water

6.1.1 Discharge during High Flow

The impacts of discharging at high flow are considered to be low; notwithstanding potential impacts associated with water quality or geomorphological processes. Therefore no mitigation measures are proposed.

6.1.2 Discharge during Low Flow

Several mitigation options are provided for discharging water during periods of low flow to allow for a range of potential discharge options, each will have a different impact magnitude and thus residual impact outcome. While the conceptual approaches for the below mitigation measures applies to both receiving systems, the suitability for implementation for each will vary and requires further investigation.

Options B, C and D do not consider possible impacts from either water quality or geomorphological processes.

6.1.2.1 Option A – No Low Flow Discharges

If there are no discharges during periods of low flow then the magnitude would not be applicable and therefore there would be no residual impact.

Should this option be adopted, further investigation would be required to reliably determine low flow conditions and thresholds. Such an investigation could potentially include analysis of historical hydrological data, additional field measurements and detailed literature review.

6.1.2.2 Option B – Occasional Discharges

This option would allow for discharges that mimic periods of higher than usual high flow events (several years to decades). To determine the appropriate period of zero flow between such releases requires further investigation into the long term hydrological cycles of the receiving environments. Considerations that should be taken into account when assessing the nature of such releases include investigation of natural flows and the timing of such releases including the ecology and life cycle traits (particularly reproductive cycles) of MNES, NC Act and priority species; including the fundamental ecosystem processes upon which these species rely.

Under this option the geographic extent and duration of the impact would mimic natural conditions reducing the scale of the impact to a **low** magnitude rating.

6.1.2.3 Option C – Discharges Based on a 20% Deviation from Natural Flows

The preliminary environmental flows assessment established guidelines for the adaptive management of discharges to the Condamine River and Bottle Tree Creek.

The assessment indicated that discharges that increase flows by up to 20% of the natural flows, but still allow for extended periods of sustained low flow (a large component of which is “cease to flow” for both receiving systems) to allow natural ecological processes to occur would reduce the potential for adverse effects on aquatic ecology.

The interim guidelines provided to assist the development of an operational strategy for the long-term discharge of coal seam gas water (Alluvium 2013b) are based on limited information and it is acknowledged that the extent and the timing of the periods of no discharge requires further investigation.

Current empirical understanding of the critical requirements of aquatic ecosystems and their response to water management regimes across the study area range from rudimentary to non-existent (McGregor et al. 2011). A key component of the adaptive management strategy will be the design and implementation of an aquatic ecology monitoring program to provide the empirical data necessary to assess the potential impacts and inform the discharge strategy. This would be supported by a detailed environmental flows assessment which would include consideration of the flow requirements for aquatic plants, fish assemblages and macroinvertebrates of the watercourses.

Natural (current and pre-European) flow regimes, the timing of discharge, the ecology and life history (particularly reproductive cycles) of priority species and key ecological processes need to be considered during this process.

A detailed understanding of environmental flows in the two watercourses, along with empirical data from the recommended monitoring program should inform the discharge strategy which should establish an operating regime that protects geomorphic values and aquatic ecosystems. On this basis and having regard to the ephemeral and semi-permanent nature of these watercourses, potential impacts would receive a **moderate** magnitude rating.

6.1.2.4 Option D – Continual Discharges with Volumes Varied on a Seasonal Basis

This option would allow for continual releases throughout the year. In this scenario the mitigation would be to attempt to mimic natural flows of permanently flowing streams. With respect to discharges to the Condamine River (Survey Area 9 receiving system), however, there are no permanently flowing streams within the Condamine-Balonne sub-basin. Accordingly, flow patterns in large streams from other locations within the Murray-Darling Basin would be most appropriate. As such systems are likely to occur at more southern latitudes, it is of note that they could potentially support different aquatic assemblages than those currently found in the receiving systems. Should this option be adopted further investigation would be required to ascertain differences in aquatic assemblages and hydrological regimes between the Survey Area 2/Survey Area 9 receiving systems and those which are being mimicked.

The major impacts of this option would be twofold; aquatic assemblages would significantly change over the project life (approximately 35 years), followed by a disturbance event of similar magnitude following decommissioning of the project. Such changes could potentially include the loss of MNES species in this section of the catchment. However, further studies are needed to further understand likely impacts to aquatic assemblages. The extent and timeframe in which the aquatic ecosystems could return to current conditions, assuming that this is at all possible (which it may not be), is indeterminable. Furthermore, changes in flow in streams from ephemeral to perennial have been known to facilitate the establishment and expansion of invasive species such as carp.

Under this option the geographic extent and duration of the impact would alter natural conditions and the severity of the impact would not be reduced. Accordingly, the impact magnitude rating would remain at **high**.

6.2 Transfer of Water between Treatment Sites

The potential impacts of spreading ‘noxious’, ‘non-indigenous’ or invasive species with water transfers are high risk. As the water transfer system will incorporate closed pipeline infrastructure, appropriate control measures can be implemented to reduce the residual impact.

A Pest Species Management Plan should be developed and implemented to identify and outline appropriate measures to prevent the spread of aquatic species. This plan should identify potential ‘noxious’, ‘non-indigenous’ or invasive species of concern (including those that currently are known to exist in the area as well as those with the potential to invade); including a range of organisms such as plants (both terrestrial and aquatic), algae, zooplankton, macroinvertebrates and fish.

Appropriate prevention measures should include a combination of engineering and process solutions, such as:

- Screens of appropriate mesh size filters to prevent passage into and out of pipes
- Electric barriers at the intakes to repel motile organisms (such as fish)
- Overflow systems designed on the dams to ensure that non-indigenous or invasive species which may survive transfers do not escape into nearby waterbodies.

A key component of the Pest Species Management Plan should be ongoing monitoring of the storage dams and receiving systems throughout the operational phase of the Project. Additionally, appropriate steps for dealing with the establishment of non-indigenous or invasive species should be clearly articulated.

Development and implementation of an appropriate management plan would reduce the magnitude of the impact to **low**.

7. RESIDUAL IMPACT ASSESSMENT

The following section provides an assessment of the residual impacts. The sensitivity value for each of the receiving systems is described in **Section 4.4**. The un-mitigated impact assessment and mitigation measures are detailed in **Sections 5** and **6**, respectively.

7.1 Release of Coal Seam Gas Water

The residual impact for the discharge of treated or untreated coal seam gas water into the receiving systems at Survey Area 2 and Survey Area 9 has been assessed following the application of all four mitigation options proposed in **Section 6.1.2** (**Table 7.1**).

Table 7.1 Residual impact assessment of water discharges at sites Survey Area 2 and Survey Area 9 for high flow and several options for low flow

	Sensitivity	Magnitude	Impact
Survey Area 2 high flow discharge	Moderate	Low	Low
Survey Area 2 low flow discharge			
Option A	Moderate	N/A	N/A
Option B	Moderate	Low	Low
Option C	Moderate	Moderate	Moderate
Option D	Moderate	High	High
Survey Area 9 high flow discharge	Moderate	Low	Low
Survey Area 9 low flow discharge			
Option A	Moderate	N/A	N/A
Option B	Moderate	Low	Low
Option C	Moderate	Moderate	Moderate
Option D	Moderate	High	High

7.2 Transfer of Water between Treatment Sites

The residual impact for the transfer of water between treatment and holding sites has been assessed following the application of the mitigation strategies (**Table 7.2**).

Table 7.2 Residual impact assessment of water transfer to Survey Area 2 and Survey Area 9 receiving systems

	Sensitivity	Magnitude	Impact
Survey Area 2	Moderate	Low	Low
Survey Area 9	Moderate	Low	Low

8. CUMULATIVE IMPACTS ASSESSMENT

The EIS identified five distinct components of industries most likely to potentially cumulatively impact on the Project Development Area:

- Coal seam gas projects (including discharge of coal seam gas water by proponents other than Arrow)
- Resource development projects
- Infrastructure and energy projects
- Transport infrastructure projects
- Agricultural activities.

There is currently limited publically available information on the location and extent of activities being undertaken by other coal seam gas proponents throughout the Surat Basin. It is acknowledged that while there will be cumulative impacts of coal seam gas water discharges in watercourses there is insufficient available information to make an assessment at this point in time.

9. RECOMMENDATIONS

The following recommendations have been proposed:

1. Completion of pre-wet season surveys during October – December, 2013

   Such surveys would greatly increase the understanding of seasonal variability in aquatic assemblages and habitat present within aquatic ecosystems potentially impacted by the Project. Additionally, the completion of dual season sampling is a typical expectation by regulatory authorities (such as DEHP).

2. For the proposed discharge of coal seam gas water Option C is likely the most feasible option. However, to adequately inform the discharge strategy into the Survey Area 2 and Survey Area 9 receiving systems it is recommended to;

   - *Examine natural modelled flow data from an Integrated Quality Quantity Model (IQQM)*
   - *Review the spells analysis using the IQQM modelled flows*
   - *Implement a suitable aquatic ecology monitoring program.*

3. Further investigation of baseline water quality within the Survey Area 2 and Survey Area 9 receiving systems

   Through the examination of historical hydrological data, additional field measurements and detailed literature review, such an investigation would enable a comprehensive understanding of the water quality in the receiving systems. Coupled with dilution modelling results, this data could be used to assess the volume of water that could be discharged and the longitudinal extent of mixing required, to minimise potential impacts to aquatic ecosystems.

4. A comprehensive literature review of life history strategies and ecological requirements of aquatic species recorded, known or likely to occur within the Survey Area 2 and Survey Area 9 receiving systems, following completion of recommendation 2

   Such an investigation would enable a more comprehensive understanding of potential impacts resulting from Project operations.

5. Preparation of a Project specific 'Aquatic Pest Species Management Plan'

   This plan should identify potential pest species, outline monitoring requirements, and appropriate measures to contain or prevent the spread of aquatic species throughout the Project Development Area. This is required to reduce the residual impact of Project activities to a 'low' impact rating.

6. Completion of ongoing seasonal monitoring within the Survey Area 2 and Survey Area 9 receiving systems if discharges are to occur

   This would verify the suitability of any environmental flow release strategy by providing an accurate understanding of Project impacts within the Survey Area 2 and Survey Area 9 receiving systems. Importantly, such an exercise would validate assessments made throughout the EIS and SEIS processes, providing transparency and increasing Arrow Energy's reputation and standing within the community.

10. CONCLUSION

This assessment of aquatic ecosystems has addressed the changes to the Project description and has provided further information in the following areas:

- Update the desktop review to reflect sites relating to the changes in the project description
- Incorporate additional sites to characterise aquatic communities in waterways located within the Dawson River catchment (Fitzroy Basin) and Weir River catchment (Murray-Darling Basin) and assess potential impacts
- Undertake aquatic surveys at the two proposed discharge locations and assess potential impacts
- Conduct site inspections of the proposed processing facilities that will not discharge water
- Supply dossiers for aquatic species of conservation significance.

Desktop Review Update

There have been few changes to the relevant legislation and listed species since the submission of the Surat Gas Project EIS. The key changes are summarised below.

In December 2012 the Queensland government approved the Coal Seam Gas Water Management Policy 2012. This policy encourages coal seam gas operators to consider the feasibility of using coal seam gas water to meet these obligations as part of developing their coal seam gas water management strategies and plans. The policy provides a hierarchy for managing coal seam gas water and saline waste. Relevant to this report is the management of coal seam gas water to be used for purposes beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries. After feasible beneficial use options have been considered, treating and disposing coal seam gas water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

There have been reports released since the submission of the EIS technical study that outline species of conservation significance under the ACA and Back On Track. These highlighted several new species of local significance.

Additional EIS Sites

Only one of the additional sites was assessed in the current report due to weather constraints. Site SAQ-1 was located within the Dawson catchment (Fitzroy Basin) in the far northern portion of the Project Development Area.

Aquatic ecosystems at site SAQ-1 were assessed as being representative of local and regional conditions characteristic of aquatic ecosystems occurring within the Dawson sub-basin.

The Fitzroy River Turtle was identified in Commonwealth and State database searches (as recognised in Aquateco 2011) as potentially occurring at SAQ-1. Records of confirmed presence show that Fitzroy River Turtles have not been recorded in this area of the tenement, but have been recorded further downstream.

The proposed activities relating to the SAQ-1 are covered by the list of activities described in the EIS. The results from SREIS surveys do not warrant a change to the description of potential impacts and proposed mitigation measures presented in the EIS.

Surveys for SAQ-2 were undertaken in May 2013 with the results presented as an addendum to this report.

Proposed Discharge Locations

Aquatic ecology assessments were undertaken at sites located both upstream and downstream of the potential discharge location for both Survey Area 2 (on Bottle Tree/Dogwood Creeks) and Survey Area 9 (Crawlers Creek and Condamine River). Both sites were assessed as being moderately sensitive. This assessment supports that initially made by the EIS.

Whilst surface water does persist at sites within the Survey Area 2 sampling site network, aquatic habitat within these systems is characterised by a series of disconnected and semi-connected recessional waterholes. One species of national significance (Murray Cod) was identified in desktop reviews as potentially occurring and was recorded within the Survey Area 2 receiving system during the surveys.

A section of the Condamine River upstream of the Cecil Plains weir, within Survey Area 9, is dominated by a large weir pool which permanently contains water. Downstream of the Cecil Plains weir, the Condamine River contains a series of large permanent waterholes. Crawlers Creek intersects Survey Area 9 and is a low order ephemeral stream. Assemblages of aquatic flora and fauna within the Survey Area 9 receiving system are low in diversity.

The prevalence of large, uniform, pool habitat within the portion of the Condamine River surveyed is not conducive to diverse assemblages. In Crawlers Creek, the prevailing hydrologic conditions generally restrict assemblage composition to a low number of ‘generalist’ species; possessing a broad set of habitat requirements. One species of national significance (Murray cod) was identified in desktop reviews as potentially occurring and was recorded within the Survey Area 9 receiving system during the surveys.

The potential impact on aquatic ecosystems of discharging water at these sites was considered to be low during periods of high flow and high during periods of low flow. A range of options for discharging at low flow is presented for mitigation with the residual impact varying from low to high. A panel of geomorphology, water quality and aquatic ecology experts developed preliminary guidelines for acceptable discharges based on a 20% deviation from natural flows on the basis of limited data/ information.

Site Inspections of Non-discharge Locations

Site inspections were undertaken at sites CGPF7 and CGPF8 and TWAF F.

At the proposed site for CGPF7, Wilkie Creek was identified as having aquatic values which are discussed in detail in the EIS. Billabongs adjacent to Wilkie Creek were noted as likely to support permanent/semi-permanent aquatic ecosystems. Two smaller ephemeral streams were identified in the western portion of the site and are considered to contain ecosystems of low sensitivity under the assessment undertaken by the EIS.

There were no streams noted at the proposed site for CGPF8, and as such no direct evidence of any aquatic values of significance. However, the proximity to Lake Broadwater and positioning of a portion of the site covering the catchment above Lake

Broadwater highlighted the importance of ensuring that any activities that take place on this site follow best practices to ensure downstream impacts are minimised. Longswamp was a wetland identified on the property which may provide habitat for migratory birds but sustain a low aquatic ecology value.

Two small ephemeral streams were noted at TWAF F; however both were located on the margins of the site and are considered to contain ecosystems of low sensitivity under the assessment undertaken by the EIS.

Species Dossiers

Species dossiers have been written for all MNES and locally significant species identified, known to or with the potential to occur across the Project Development Area.

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ATTACHMENT 1 – SUMMARY OF EPBC ACT PROTECTED MATTERS SEARCH TOOL AND WILDLIFE ONLINE SEARCH RESULTS

Site/Section	EPBC Search Results	EPBC Act Status	WildNet Search Results	NC Act Classification
SAQ-2	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Mosquitofish (*Gambusia holbrooki*)	Exotic
SAQ-1	Fitzroy River Turtle (*Rheodytes leukops*)	Vulnerable	No relevant aquatic records	
TWAF F	Narran lake nature reserve	Upstream from RAMSAR	Murray turtle (*Emydura macquarii macquarii*)	Least Concern
	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Eastern snake-necked turtle (*Chelodina longicollis)*	Least Concern
			Eastern water dragon (*Intellagama lesueurii)*	Least Concern
CGPF2	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Golden perch (*Macquaria ambigua)*	Least Concern
	Salvinia (*Salvinia molesta*)	Weeds of National Significance (WoNS)		
CGPF7	Narran lake nature reserve	Upstream from RAMSAR	Murray turtle (*Emydura macquarii macquarii*)	Least Concern
	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Agassiz's glassfish *(Ambassis agassizii)*	Not listed
			Flyspecked hardyhead *(Craterocephalus stercusmuscarum)*	Not listed
			Goldfish *(Carassius auratus)*	Exotic
			Western Carp Gudgeon *(Hypseleotris klunzingeri)*	Not listed
			Eel-tailed catfish *(Tandanus tandanus)*	Not listed
			Mosquitofish *(Gambusia holbrooki)*	Exotic
			Australian smelt *(Retropinna semoni)*	Not listed
			Spangled perch *(Leiopotherapon unicolor)*	Not listed
CGPF8	Narran lake nature reserve	Upstream from RAMSAR	Murray turtle (*Emydura macquarii macquarii*)	Least concern
	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Eastern snake-necked turtle (*Chelodina longicollis)*	Least concern
			Broad shelled turtle (*Chelodina expansa)*	Least concern
			Agassiz's glassfish *(Ambassis agassizii)*	Not listed
			Bony bream (*Nematalosa erebi*)	Not listed
			European carp (*Cyprinus*	Exotic

Site/Section	EPBC Search Results	EPBC Act Status	WildNet Search Results	NC Act Classification
			carpio)	
			Flyspecked hardyhead *(Craterocephalus stercusmuscarum)*	Not listed
			Goldfish *(Carassius auratus)*	Exotic
			Midgley's carp gudgeon (*Hypseleotris species 1*)	Not listed
			Golden perch (*Macquaria ambigua)*	Not listed
			Western Carp Gudgeon *(Hypseleotris klunzingeri)*	Not listed
			Firetail gudgeon (*Hypseleotris galii)*	Not listed
			Eel-tailed catfish *(Tandanus tandanus)*	Not listed
			Mosquitofish *(Gambusia holbrooki)*	Exotic
			Australian smelt *(Retropinna semoni)*	Not listed
			Spangled perch *(Leiopotherapon unicolor)*	Not listed
CGPF9	Narran lake nature reserve	Upstream from RAMSAR	Agassiz's glassfish *(Ambassis agassizii)*	Not listed
	Murray Cod (*Maccullochella peelii peelii)*	Vulnerable	Flyspecked hardyhead *(Craterocephalus stercusmuscarum)*	Not listed
	Salvinia (*Salvinia molesta*)	WoNS	Goldfish *(Carassius auratus)*	Exotic
			Western Carp Gudgeon *(Hypseleotris klunzingeri)*	Not listed
			Eel-tailed catfish *(Tandanus tandanus)*	Not listed
			Mosquitofish *(Gambusia holbrooki)*	Exotic
			Australian smelt *(Retropinna semoni)*	Not listed
			Spangled perch *(Leiopotherapon unicolor)*	Not listed
			Murray turtle (*Emydura macquarii macquarii*)	Least Concern
			Midgley's carp gudgeon (*Hypseleotris species 1)*	Not listed
			Lake's carp gudgeon (*Hypseleotris species 2)*	Not listed
			Flathead gudgeon (*Philypnodon grandiceps)*	Not listed

Site/Section	Points Searched		
	Latitude	Longitude	Buffer (km)
SAQ-2	-28.40194	150.48736	10
	-28.40194	150.48736	10
SAQ-1	-26.10291	150.02507	10
TWAF F	-27.492186	151.129285	10
CGPF2	-26.48441	150.23477	10
	-26.49488	150.23686	10
	-26.51439	150.23285	10
	-26.54638	150.25521	10
	-26.56288	150.24082	10
	-26.57458	150.21276	10
	-26.60928	150.20547	10
	-26.71304	150.18097	10
CGPF7	-27.160106	151.012307	10
CGPF8	-27.418798	151.134992	10
CGPF9	-27.3673	151.24321	10
	-27.45331	151.25021	10
	-27.52393	151.20495	10
	-27.55872	151.13642	10
	-27.58955	151.19472	10

ATTACHMENT 2 – AQUATIC FAUNA SPECIES PROFILES

OVERVIEW

Species dossiers have been prepared for all Matters of National Environmental Significance (MNES) and locally significant species identified, known to or with the potential to occur within the Project Development Area, including:

- Fitzroy River Turtle (*Rheodytes leukops*) – MNES as this species is listed as 'vulnerable' under the Environment Protection and Biodiversity Conservation (EPBC) Act
- Murray Cod (*Maccullochella peelii peelii*) – MNES as this species is listed as 'vulnerable' under the EPBC Act
- Eel-tailed Catfish (*Tandanus tandanus*) – Aquatic Conservation Assessments (ACA) Priority species
- Mountain Galaxias (*Galaxias olidus*) – ACA Priority species
- Purple Spotted Gudgeon (*Mogurnda adspersa*) – ACA Priority species
- Rendahl's Tandan (*Porochilus rendahli*) – ACA Priority species
- River Blackfish (*Gadopsis marmoratus*) – ACA Priority species
- Silver Perch (*Bidyanus bidyanus*) – ACA Priority Species
- Agassiz's glassfish (*Ambassis agassizii*) – ACA Priority Species
- White Throated Snapping Turtle (*Elseya albagula*) - Back on Track High Priority species and ACA Priority species.

METHODOLOGY

The species dossiers are presented in two parts: (A) background information; and (B) Project relevance. These sections are further divided into relevant subcomponents (i.e. status, sensitivity, etc.). The methodology utilised to determine each subcomponent is described below:

A) **Background information**, including:

i. **Status:** The status of each species was determined based on whether the species was listed under the Nature Conservation (NC) Act, EPBC Act, Back on Track species priority framework or ACA as a priority species.

ii. **Sensitivity:** This was determined based on the *Sensitivity Criteria for Aquatic Ecosystem Values* criteria presented in AMEC (2013) **Section 3.5**.

iii. **Recovery Plan:** Determined from a desktop review of available literature, technical knowledge and previous experience.

iv. **Ecology:** Determined from a desktop review of available literature, technical knowledge and previous experience.

v. **Habitat:** Determined from a desktop review of available literature, technical knowledge and previous experience.

vi. **Distribution:** Determined from a desktop review of available literature, technical knowledge and previous experience.

vii. **Threats:** Determined from a desktop review of available literature, technical knowledge and previous experience.

B) **Project relevance**, including:

i. **Recorded presence within the Project Development Area and surrounds:** Recorded presence was determined from a desktop review of available literature, technical knowledge and previous experience.

ii. **Extent of habitat within the Project Development Area:** Extent of habitat within the Project Development Area was determined from a desktop review of available literature, technical knowledge and previous experience.

iii. **Potential Project related impacts (unmitigated):** Project impacts were determined based on an understanding of the aquatic communities and species present in the project development area and the nature, scale and extent of project activities.

iv. **Significance of Project related impacts (unmitigated):** The significance of potential project impacts was determined based on the sensitivity of each species and the *Magnitude of Impacts* criteria presented in AMEC (2013) **Section 3.5**.

v. **Proposed mitigation measures and management:** Several mitigation options for the potential discharge of coal seam gas water were developed and presented in AMEC (2013) **Section 7**. Following an environmental flows workshop and subsequent preliminary report (Alluvium 2013) Mitigation Option C was considered to be the most appropriate option to assess. This option allows for up to a 20% deviation from natural flows, while maintaining the critical flow components essential for supporting species and ecosystem processes. Mitigation and management measures for the transfer of water between treatment facilities are presented in AMEC (2013) **Section 7**. Mitigation and management measures for all other impacts are discussed in Aquateco (2011).

vi. **Residual impact assessment:** Residual impacts were determined based on the sensitivity of the species and the magnitude of the impact, using the methodology and criteria presented in AMEC (2013) **Section 3.5**. The magnitude of the impact can be reduced through the implementation of different mitigation options, which can also change the overall residual impact.

vii. **Significance of Project impacts under MNES guidelines:** This assessment was completed for MNES species (Fitzroy River Turtle and Murray Cod) and was based on methodology specified in the *MNES Significant Impact Guidelines 1.1* (Commonwealth of Australia, 2009).

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Fitzroy River Turtle (*Rheodytes leukops*)

Plate 1 **Fitzroy River Turtle *(Rheodytes leukops)* (Source: WetlandInfo, 2004)**

A. Background Information

i. Status

NC Act: Vulnerable, **EPBC Act**: Vulnerable, **Back on Track**: high priority, **ACA Priority**: no

ii. Sensitivity

'High'

iii. Recovery Plan

The Fitzroy River Turtle is listed in *The Action Plan for Australian Reptiles* (Cogger et al., 1993).

iv. Ecology

The Fitzroy River Turtle grows to 25 cm (shell length) and the shell has a medium to dark brown colouring, with some dark spots and blotches on the top of the shell (DSEWPC, 2012). On the underside surface, the shell is yellow or cream and the skin is an olive-grey colour (DSEWPC, 2012). The neck of the Fitzroy River Turtle is covered with *'large, pointed conical tubercles'* (DSEWPC, 2012). The turtle also has long forelimbs, each with five claws, and a large cloacal bursae (DSEWPC, 2012).

The Fitzroy River Turtle has adapted to breathe either using its lungs or its cloaca (DSEWPC, 2012). The turtles are known as 'bottom-breathers' as they can respire by drawing water in and expelling it from the cloaca at a rate of 15-60 times per minute (DSEWPC, 2012). This function allows the turtle to walk on the streambed and stay underwater without coming to the surface for days or weeks (Limpus, 2007).

The Fitzroy River Turtle is slow to reach sexual maturity, taking up to 15-20 years before reproduction can occur (DSEWPC, 2012). Nesting takes place between September and October annually, with nests being located in river sandbanks 1-4 m above the water level (DSEWPC, 2012). Females typically lay between 46-59 eggs annually in three to five clutches (DSEWPC, 2012).

The Fitzroy River Turtle has a highly diverse diet consisting of algae, macroinvertebrate larvae, macrophytes (including *Vallisneria spp.*), freshwater sponges, terrestrial insects, as well as terrestrial leaves and bark (DSEWPC, 2012).

The Fitzroy River Turtle is thought to have a limited home range (417-679 m), overlapping riffle zones (DSEWPC, 2012). Turtles have been observed to be active mainly during late afternoon and at night, although they can be largely sedentary staying in the same location for several days (DSEWPC, 2012).

v. Habitat

The Fitzroy River Turtle occurs in rivers with a rock, gravel or sand substrate, with deep pools that are connected by shallow riffle zones (DEHP, 2007; Limpus et al. 2011). Riffle zones are an important habitat for Fitzroy River Turtles due to the high dissolved oxygen levels in these zones and abundant food sources, including benthic macroinvertebrates and algae (Tucker et al. 2001).

During the dry season this species retracts into large slow flowing pools and/or non-flowing permanent pools (DEHP, 2007; Limpus et al., 2011). The species prefers waterways with high water clarity and areas that contain large macrophyte beds, including *Vallisneria* spp.

vi. Distribution

The Fitzroy River Turtle has been identified as occurring in the Fitzroy, Connors, Dawson, Isaac and Mackenzie Rivers, as well as Windah Creek and Develin or Malborough Creek (Limpus et al. 2011 DEHP, 2007; Cogger et al. 1993). Since being described in 1980, the distribution of the Fitzroy River Turtle is not believed to have significantly changed (DEHP, 2007; Limpus et al. 2011).

vii. Threats

The Fitzroy River Turtle is threatened by two key factors: excessive loss of eggs and habitat modification (Limpus et al. 2011).

Loss of eggs is related to predation and trampling of the banks by cattle (Limpus et al. 2011). Feral pigs, foxes, dogs, goannas and water rats can disturb the nests and destroy many clutches of eggs (DEHP, 2007; DSEWPC, 2012). Similarly, the trampling by cattle of the sandy/loamy riverbanks where eggs are laid can cause the destruction of many nests (DEHP, 2007; DSEWPC, 2012). Habitat modification through the installation of barrages and weirs has reduced the availability of riffle habitat through flow regulation (DSEWPC, 2012). These structures also act as a physical barrier that restricts the movement of the Fitzroy River Turtle and access to food and nesting areas (DEHP, 2007; DSEWPC, 2012).

Declines in water quality, including increased turbidity levels, has also been associated with increasing agricultural and mining land uses (Venz, 2002). Higher turbidity levels may impact on cloacal respiration and the availability of food resources, which can cause declines in turtle populations (Cann, 1998).

B. Project Relevance

i. Recorded Presence within the Project Development Area and Surrounds

The Fitzroy River Turtle is only known to occur within the Fitzroy Basin, not the Murray-Darling Basin (within which the vast majority of the Project Development Area is situated). A small portion of the Project Development Area falls within the Dawson River catchment of the Fitzroy Basin.

No specimen of Fitzroy River Turtle has been recorded within the Project Development Area. However, database search results returned the species as ‘possibly’ occurring within the small portion of the Project Development Area occurring within the Dawson River catchment.

Targeted Fitzroy River Turtle surveys (including nesting bank inspection during the breeding season) were not completed for this Project and no individuals were collected by routine turtle sampling methodologies employed.

The Fitzroy River Turtle has previously been recorded within the Dawson River below theOrange Creek Weir (Limpus et al. 2007); which is situated approximately 175 km downstream of the Project Development Area.

ii. Extent of Habitat within the Project Development Area

The small portion of the Project Development Area occurring within the Dawson River catchment (Fitzroy Basin) is not expected to support suitable habitat for the Fitzroy River Turtle.

The portion of the Project Development Area occurring within the Murray-Darling Basin is outside of the known range of the Fitzroy River Turtle. Accordingly, no assessment of the suitability of habitat within this area has been completed.

iii. Potential Project Related Impacts (Unmitigated)

Unmitigated Project impacts upon the Fitzroy River Turtle potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment.

The magnitude of project impacts is considered to be ‘low’.

iv. Significance of Project Related Impacts (Unmitigated)

‘Moderate’

v. Proposed Mitigation Measures and Management

General mitigation measures adopted include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area are considered to be ‘moderate’.

vii. Significance of Project Impact under MNES Referral Guidelines

An evaluation of the significance of potential Project impacts upon the Fitzroy River Turtle in accordance with the MNES referral guidelines is presented in the **Table 1** below. This assessment has been completed assuming that the above specified mitigation measures will be implemented (AMEC [2013] **Section 7**). Additionally, it is assumed that the SREIS survey site situated within the Dawson River catchment (SAQ-1) is representative of aquatic habitat occurring throughout the portion of the Project Development Area occurring within the Dawson River catchment.

Table 1 Evaluation of Project Impact to the Fitzroy River Turtle (*Rheodytes leukops*) under MNES Guidelines

Criteria	Evaluation
Criteria 1 Lead to a long-term decrease in the size of an important population*	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 2 Reduce the area of occupancy of an important population*	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 3 Fragment an existing important population*	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 4 Adversely affect habitat critical to the survival of the species	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 5 Disrupt the breeding cycle of an important population*	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 6 Modify, destroy, remove, isolate or decrease habitat leading to the decline of the species.	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 7 Result in the establishment of a harmful invasive species.	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 8 Introduce a disease that may cause the species to decline.	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.
Criteria 9 Interfere with the recovery of the species.	**No** This species is not known to inhabit the Project Development Area, or waterways downstream that will be impacted by the Project. Furthermore, there is a complete lack of suitable habitat to support this species within waterways to be impacted by the Project.

NOTES:

* MNES Guidelines (DEWHA 2009, p.11) define an 'important population' as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

1. Key source populations either for breeding or dispersal
2. Populations that are necessary for maintaining genetic diversity, and/or
3. Populations that are near the limit of the species range

References

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Murray Cod (*Maccullochella peelii peelii*)

Plate 2 **Murray Cod (*Maccullochella peelii peelii*) (Specimen collected from the Condamine River at Survey Area 9, source: Camille Percival)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: Vulnerable, **Back on Track**: critical priority, **ACA Priority**: no

ii. Sensitivity

'High'

iii. Recovery Plan

The National Recovery Plan for Murray Cod (*Maccullochella peelii peelii*) was prepared by the National Murray Cod Recovery Team (2010).

iv. Ecology

Murray Cod can grow up to 1.8 m long and weigh up to 113.5 kg, making it the largest freshwater fish found in Australia (Allen et al. 2003; DSEWPC, 2012; Butcher, 2007). Typically, Murray Cod range from 50 cm to 70 cm in length and weighs less than 10 kg (Allen et al. 2003). The species can live up to 60 years and typically resides within a 10 km stretch of river over their lifetime (Allen et al. 2003).

When compared to other species, Murray Cod has relatively low fertility (DSEWPC, 2012). The species reaches sexual maturing within four to five years of age and females produce around 10,000 eggs to 90,000 eggs depending on the weight of the fish (DSEWPC, 2012). Spawning occurs from late spring to early summer, with breeding taking place just before annual high flow and flood events (Allen et al., 2003; DSEWPC, 2012).

Murray Cod are carnivorous and feed on other fish, turtles, frogs, crustaceans and molluscs, but also have been known to eat terrestrial animals including snakes, birds, mice, and water dragons (Allen et al. 2003; DSEWPC, 2012).

Murray Cod are known to migrate approximately 40 to 120 km upstream to spawn, following a flood event (Butcher, 2007; DSEWPC, 2012). The species then moves downstream to the same territory where they occupied prior to spawning (DSEWPC, 2012).

v. Habitat

Murray Cod occurs in a wide range of warm water habitats including slow flowing, turbid waters of lowland rivers and billabongs and upland streams with rocky substrates and high flowing, clear waters (Allen et al., 2003). The species prefers waterways which are up to 5 m deep, with submerged logs and boulders, undercut banks and overhanging vegetation (Allen et al., 2003). Consequently, it is often found in the main river channel and larger tributaries rather than floodplain channels (Butcher, 2007; DSEWPC, 2012).

vi. Distribution

Murray Cod occurs within the waterways of the Murray-Darling Basin (MDB) within Queensland, New South Wales, Victoria and South Australia. Within Queensland it is found in the south western boarder lakes and rivers (Butcher, 2007; DAFF, 2012). There have been attempts to translocate the species outside its normal range. Within Queensland it has been previously introduced into the Cooper Creek and Burnett and Fitzroy River systems (DSEWPC, 2012).

vii. Threats

The number of Murray Cod has steadily declined since European settlement (DSEWPC, 2012). Current threats to the species include: flow regulation and barriers to fish movement, habitat degradation, water quality declines, commercial, recreational and illegal fishing, disease and loss of genetic diversity associated with alien species and fish stocking, and climate change.

To improve water security and river navigation, over 3,600 dams and weirs have been constructed throughout the MDB (DSEWPC, 2012). These barriers have altered the natural flow regime in these waterways and have created barriers to fish and water movement (DSEWPC, 2012; Butcher, 2007). The regulation of flow has also reduced the number of flood events required for triggering spawning and the habitat available to the Murray Cod (DSEWPC, 2012; Butcher, 2007).

The MDB was historically used for navigation by boat and the removal of snags (i.e. trees or branches found in rivers) occurred throughout waterways (DSEWPC, 2012; Butcher, 2007). Snags provide essential habitat for Murray Cod throughout its lifecycle, from spawning to adulthood (DSEWPC, 2012; Butcher, 2007). The removal of snags has fragmented habitat and populations of Murray Cod (DSEWPC, 2012). Recovery of this habitat continues to be a slow process throughout the MDB.

Water quality has been impacted throughout the MDB in association with the introduction of dams and weirs, as well as urban and agricultural land uses (DSEWPC, 2012; Butcher, 2007). Dams release cold water which can lower overall water temperatures by 15^{o}C and influence water temperatures up to 100 to 150 km downstream (DSEWPC, 2012; Butcher, 2007). These impacts on water temperature can significantly reduce the growth rates in juvenile Murray Cod (DSEWPC, 2012). Similarly, irrigation associated with agriculture along the MDB has resulted in increased nutrient runoff and higher salinity levels through the raising of the water table (DSEWPC, 2012). Juvenile fish are more sensitive to higher salinity levels and this could impact on their life expectancy (DSEWPC, 2012).

Commercial, recreational and illegal fishing has had an impact on the numbers of mature fish (greater than 50 cm) (DSEWPC, 2012; Butcher, 2007). The removal of fish at the beginning of their breeding age (50 cm) has an impact on population structure and sustainability, which has been observed in regards to Murray Cod with declines in catch numbers over the last century (DSEWPC, 2012).

The MDB contains 11 species of exotic fish including, Carp (*Cyprinus carpio*), Redfin (*Perca fluviatilis*) and Eastern Gambusia (*Gambusia holbrooki*). The introduction of these species has affected the Murray Cod through exposure to new diseases and parasites, including Epizootic Haematopoietic Necrosis (EHN) virus and Asian fish tapeworm (*Bothriocephalus acheilognathis*) (DSEWPC, 2012). Similarly, the introduction of hatchery bred fish has caused a loss of genetic diversity of wild populations of Murray Cod (DSEWPC, 2012). This loss of genetic diversity could make the species more vulnerable to disease, increasing their chance of extinction.

Climate change is anticipated to have a potential impact on the MDB through the reduction of rainfall levels (DSEWPC, 2012). Flow regulation has already reduced natural flows throughout the basin, restricting habitat available to the Murray Cod. With decline in rainfall, it is anticipated that a higher number of fish kills will occur during drought periods and there will be less opportunities for spawning (DSEWPC, 2012). These impacts will ultimately reduce the sustainability of populations.

B. Project Relevance

i. Recorded Presence within the Project Development Area and Surrounds

Murray Cod is known to occur within the portion of the Project Development Area within the Murray-Darling Basin (Allen et al. 2003; Pusey et al. 2004). The population is known to be endemic, although there is population supplementation from stocking groups. The species was recorded within the Survey Area 2 and Survey Area 9 receiving systems during baseline surveys completed specifically for the Project. This population of Murray Cod is considered an 'important population', as per the definition provided by the EPBC Significant Impact Guidelines, as it forms a portion of the interconnected population of the broader Murray-Darling Basin which is recognised under the Environment Protection and Biodiversity Conservation Act 1999 as 'vulnerable'. This legislation recognises the importance of this population as necessary for a species' long-term survival and recovery.

ii. Extent of Habitat within the Project Development Area

The portion of the Project Development Area occurring within the Murray-Darling Basin is generally expected to support suitable habitat for Murray Cod.

iii. Potential Project Related Impacts (Unmitigated)

Unmitigated Project impacts upon the Murray Cod potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes in water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water
- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

iv. Significance of Project Related Impacts (Unmitigated)

'Moderate' to 'Major'.

v. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be 'moderate'.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be 'moderate'.

vii. Significance of Project Impact under MNES Referral Guidelines

An evaluation of the significance of potential Project impacts on Murray Cod in accordance with the MNES referral guidelines is presented in **Table 1** and **Table 2** below. **Table 1** considers the significance of impacts with a 'moderate' residual impact including; general impacts not related to discharges into streams. **Table 2** considers the significance of impacts with a 'moderate' residual impact which relates to the mitigation for the scenario where discharges mimic, but deviate up to 20% from natural flows. For more detailed information see AMEC (2013) **Section 6.1** and the assumptions and limitations outlined in AMEC (2013) **Section 1.4**.

Table 3 Evaluation of Project Impacts to the Murray Cod (*Maccullochella peelii peelii*) under MNES Guidelines for activities assessed as having 'moderate' residual impacts (excluding discharge of coal seam gas water)

Criteria	Evaluation
Criteria 1 Lead to a long-term decrease in the size of an important population*	**No** These activities are not considered likely to have a significant impact on Murray Cod and therefore not lead to a long-term decrease in the size of the population.
Criteria 2 Reduce the area of occupancy of an important population*	**No** These activities are not considered likely to have a significant impact on Murray Cod and therefore not lead to a reduction in the area of occupancy for the population.
Criteria 3 Fragment an existing important population*	**No** These activities are not considered likely to create barriers that would impinge on the movement of Murray Cod and hence not fragment the population.
Criteria 4 Adversely affect habitat critical to the survival of the species	**No** These activities are not considered likely to affect habitat critical to the survival of Murray Cod.
Criteria 5 Disrupt the breeding cycle of an important population*	**No** These activities are not considered likely to have a significant impact on the timing and magnitude of flows which are of critical importance to the reproduction of Murray Cod and the ecosystem processes on which they are dependent.
Criteria 6 Modify, destroy, remove, isolate or decrease habitat leading to the decline of the species.	**No** These activities are not considered likely to have a significant impact on the existing habitat.
Criteria 7 Result in the establishment of a harmful invasive species.	**No** With the appropriate mitigation steps taken to minimise impacts on the transfer of aquatic species between locations these activities are unlikely to facilitate the establishment of harmful invasive species.
Criteria 8 Introduce a disease that may cause the species to decline.	**No** With the appropriate mitigation steps taken to minimise impacts on the transfer of aquatic species between locations these activities are unlikely to introduce a disease that may cause the decline of Murray Cod.
Criteria 9 Interfere with the recovery of the species.	**No** Murray Cod currently exist within vicinity of the project development area. From current knowledge, this population has declined from pre-settlement times but is in a state of recovery from prior disturbance. The activities identified as having a 'low' residual impact are unlikely to interfere with this recovery.

NOTES:

* MNES Guidelines (DEWHA 2009, p.11) define an 'important population' as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

1. Key source populations either for breeding or dispersal
2. Populations that are necessary for maintaining genetic diversity, and/or
3. Populations that are near the limit of the species range

Table 4 Evaluation of Project Residual Impact to the Murray Cod (*Maccullochella peelii peelii*) under MNES Guidelines for the discharge of coal seam gas water (assessed as having 'moderate' residual impacts)

Criteria	Evaluation
Criteria 1 Lead to a long-term decrease in the size of an important population*	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water (with appropriate consideration given to breeding requirements) is not considered likely to have a significant impact on Murray Cod reproduction and survivability and therefore not expected to lead to a long-term decrease in the size of the population.
Criteria 2 Reduce the area of occupancy of an important population*	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water is not considered likely to have a significant impact on the area of occupancy for the Murray Cod population.
Criteria 3 Fragment an existing important population*	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water is not considered likely to create barriers that would impinge on the movement of Murray Cod and hence not fragment the population.
Criteria 4 Adversely affect habitat critical to the survival of the species	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water is not considered likely to affect habitat critical to the survival of Murray Cod.
Criteria 5 Disrupt the breeding cycle of an important population*	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water (with appropriate consideration given to breeding requirements) is not considered likely to have a significant impact on the timing and magnitude of flows which are of critical importance to the reproduction of Murray Cod.
Criteria 6 Modify, destroy, remove, isolate or decrease habitat leading to the decline of the species.	**No** Increasing the frequency of high flow events through the discharge of coal seam gas water (with appropriate geomorphological considerations taken into account) is not considered likely to have a significant impact on the habitat of Murray Cod.
Criteria 7 Result in the establishment of a harmful invasive species.	**Yes** Increasing the frequency of high flow events through the discharge of coal seam gas water has the potential to facilitate the establishment of harmful invasive species.
Criteria 8 Introduce a disease that may cause the species to decline.	**No** With the appropriate mitigation steps taken to minimise impacts on the transfer of aquatic species with water between locations these activities are unlikely to introduce a disease that may cause the decline of Murray Cod.

Criteria	Evaluation
Criteria 9 Interfere with the recovery of the species.	**Yes** Murray Cod currently exist within vicinity of the project development area. From current knowledge, this population has declined from pre-settlement times but is in a state of recovery from prior disturbance. The activities identified as having a 'moderate' residual impact have the potential to interfere with this recovery.

NOTES:

* MNES Guidelines (DEWHA 2009, p.11) define an 'important population' as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

1. Key source populations either for breeding or dispersal
2. Populations that are necessary for maintaining genetic diversity, and/or
3. Populations that are near the limit of the species range

Conclusions

Based on the preceding information, the potential impact to Murray Cod inhabiting the Project Development Area depends upon the type of Project activity.

Under MNES criteria, activities with a 'moderate' residual impact (those related to the soil disturbance activities and water transfers) are considered to be of 'low' significance for Murray Cod with none of criteria registering any impacts.

Under MNES criteria, activities with a 'moderate' residual impact (those related to the discharges that mimic, but deviate up to 20% from natural flows) are considered to be of 'moderate' significance for Murray Cod with the majority of criteria not registering any impacts. However, under Criteria 7 there is the potential for facilitating the establishment of harmful invasive species and consequently under Criteria 9 to interfere with the recovery of Murray Cod.

There is potential for cumulative impacts from similar activities undertaken by other proponents (discharge of coal seam gas water) to further exacerbate these impacts.

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Eel-tailed Catfish (*Tandanus tandanus*)

Plate 3 **Eel-tailed catfish *(Tandanus tandanus)* (Source: Timothy Howell)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

An Eel-tailed catfish (*Tandanus tandanus)* Recovery Plan was prepared by the Victorian Department of Natural Resources and Environment (Clunie & Koehn, 2001).

iv. Ecology

Eel-tailed catfish are grey, brown, reddish-brown, purplish or olive-green colour with a white dorsal surface (Allen et al. 2003). The average size of the species is 45 cm, but they can grow up to 90 cm (Allen et al. 2003).

The species is a bottom feeder and its diet largely consists of zooplankton, small fish, crustaceans, insects and snails (Allen et al. 2003; NSW DPI 2013).

The species spawns between spring and mid-summer, when water temperatures reach 20^o-25^{o}C (Allen et al. 2003). Spawning is believed to be temperature and water level dependent, with the eel-tailed catfish building nests in areas of still water to breed (NSW DPI 2013). This species is potadromous and does not migrate to spawn (NSW DPI 2013).

v. Habitat

The species prefers slow flowing streams, lakes and pools with overhanging vegetation, woody debris and sand or gravel substrates (Allen et al. 2003; Butcher, 2007).

vi. Distribution

Eel-tailed catfish are widely distributed in the MDB and along the east coast of Australia, found from Cape Tribulation to the south of the Manning River in central-northern New South Wales (Allen et al. 2003; Butcher, 2007). The species is commonly found in the Macquarie, Namoi, Gwydir and Border River catchments (NSW DPI 2013). The species was previously abundant in the MDB, but the introduction of carp is suspected to be associated with the decline of the species in this system (Allen et al. 2003).

vii. Threats

Eel-tailed catfish are currently threatened by five key factors: exotic species, thermal pollution, flow regulation, agricultural runoff and destruction of the riparian zone (Butcher, 2007; NSW DPI 2013).

Introductions of carp have degraded breeding habitats and directly impacted on food resources for eel-tailed catfish (Allen et al. 2003). Carp also damage nests and consume the eggs and larvae of the species (Butcher, 2007).

Thermal pollution from water released from dams and flow regulation, has also potentially impacted on water temperatures and disrupted the breeding cycles of the eel-tailed catfish (NSW DPI 2013).

Agricultural runoff, associated with riparian vegetation clearing has increased the siltation of waterway and reduced the coverage of aquatic vegetation of the MDB (Butcher, 2007). This has impacted on the habitat available for the eel tailed catfish and water quality conditions, resulting in localised population declines (Butcher, 2007).

B. Project Relevance

i. Recorded Presence within the Project Development Area

Eel-tailed catfish was recorded within the Project Development Area during baseline surveys completed specifically for the Project, in both the Fitzroy Basin (at site SAQ-1) and Murray-Darling Basin (Condamine River – Survey Area 9). Eel-tailed catfish were recorded in low abundance at three sites within the Murray Darling Basin (2 sites on the Condamine River and from Westbrook Creek) for the EIS surveys (Aquateco 2010). Database search results suggest eel-tailed catfish are generally present throughout the wider Project Development Area.

ii. Extent of Habitat within the Project Development Area

Habitat suitable for the eel-tailed catfish occurs generally throughout the Project Development Area.

iii. Potential Project Related Impacts (Unmitigated)

Unmitigated Project impacts on eel-tailed catfish potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water
- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water to watercourses
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

iv. Significance of Project Related Impacts (Unmitigated)

'Low to High'

v. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Summary Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be 'low'.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from, natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be 'moderate'.

References

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Mountain Galaxias (*Galaxias olidus*)

Plate 4 **Mountain Galaxias *(Galaxias olidus)* (Source: Robert McCormack)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

Mountain galaxias are included in the Action Plan for South Australian Freshwater Fishes (Hammer et al. 2009).

iv. Ecology

Mountain galaxias are variable in appearance, with stripes, blotches or no marks present on the body (Lintermans, 2007; Allen et al. 2003). The body is yellowish-green to brown, with the ventral surface white or olive in colouring (Lintermans, 2007; Allen et al. 2003).

Mountain galaxias diet largely consists of aquatic invertebrates and terrestrial invertebrates sourced from overhanging riparian vegetation (Butcher, 2007).

The species is sexually mature at the age of one and live for around four years (Butcher, 2007). Spawning is temperature dependent, taking place from August to late October when water temperatures range from 8 to 10^{o}C (Butcher, 2007). Adults move upstream to spawn and lay their eggs in shallow riffle zones and pools on the underside of stones (Lintermans, 2007; Allen et al. 2003).

v. Habitat

Mountain galaxias are tolerant of a wide range of habitats, found in clear pools and flowing streams and in upland tarns above the snowline, fed by ice-melts (Allen et al. 2003). The species also prefers waterways with rocky substrates and structural woody habitat (Allen et al. 2003).

vi. Distribution

Mountain galaxias occur in upland streams draining on both sides of the Great Dividing Range, from southern Queensland to South Australia, including Kangaroo Island (Allen et al. 2003). Unlike other galaxiids, the species is found at elevations from sea level to 1,800 m (Allen et al. 2003).

The introduction of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) has greatly impacted on mountain galaxias numbers, effectively eliminating the species from upland streams and significantly reducing numbers in lowland areas (Lintermans, 2007).

vii. Threats

The greatest threat to the survival of mountain galaxias is predation from exotic species including, rainbow trout and brown trout (Lintermans, 2007). The introduction of exotic species has also exposed mountain galaxias to the alien parasitic copepod (*Lernaea spp.*) (Lintermans, 2007).

Barriers, including dams and weirs, may have also impacted on spawning migrations of the species and resulted in localised declines in the population (Lintermans, 2007). Riparian vegetation clearing associated with agricultural and urban land uses could have potentially resulted in lower availability of suitable habitat and food supplies (Lintermans, 2007).

B. Project Relevance

i. Recorded Presence within the Project Development Area

No specimens of mountain galaxias were recorded during baseline surveys for the Project (Aquateco, 2011; AMEC, 2013). This was not unexpected as mountain galaxias are largely restricted to the higher altitude upper reaches of the Condamine catchment (Lintermans 2007). While there is a possibility of juveniles moving downstream, they are unlikely to move downstream into the Project Development Area due to thermal barriers exceeding their temperature tolerances.

ii. Extent of Habitat within the Project Development Area

Habitat suitable to support the mountain galaxias does not occur within aquatic ecosystems situated directly downstream of areas potentially impacted by the Project.

iii. Potential Project Related Impacts

None.

iv. Significance of Project Related Impacts (Unmitigated)

'Low'

v. Proposed Mitigation Measures and Management

No specific mitigation measures are proposed. General mitigation measures adopted should be those presented in Aquateco (2011) and in AMEC (2013) **Section 7**.

vi. Summary Residual Impact Assessment

'Low'

References

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Purple Spotted Gudgeon (*Mogurnda adspersa*)

Plate 5 **Purple-spotted gudgeon *(Mogurnda adspersa)* (Specimen collected at Westbrook Creek December 2009, source: Timothy Howell)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

Purple-spotted gudgeon are included in the Action Plan for Australian Freshwater Fishes (Wagner & Jackson, 1993).

iv. Ecology

Purple-spotted gudgeon are a purplish-brown to light blue colour, with a white belly and scattered red and white spots on the sides (Allen et al. 2003). They grow up to a maximum size of 14 cm (Pusey et al. 2004).

Purple-spotted gudgeon are benthic ambush predators, consuming small fish, aquatic macroinvertebrates, molluscs and terrestrial insects (Lintermans, 2007). The species lives up to four years of age and is sexually mature at 12 months (Butcher, 2007).

Purple-spotted gudgeon form breeding pairs and spawn during the wet season (November to April) (Lintermans, 2007). Females produce several batches of eggs, which are deposited and attached to rocks, woody debris and aquatic vegetation and protected by the male until they hatch, three to nine days later (Allen et al. 2003).

v. Habitat

The species prefers slow moving or still waters of creeks, rivers and billabongs over cobbles or rocks with aquatic vegetation (Butcher, 2007; Lintermans, 2007). Purple-spotted gudgeon are found in shallow (10 to 60 cm) and deep water habitats (>60 cm) (Butcher, 2007; Lintermans, 2007). They are tolerant of a wide range of water quality conditions, including low levels of dissolved oxygen (0.6 to 12.8 mg/L) and a wide range of turbidity (0.2 to 200 NTU) and salinity levels (Lintermans, 2007).

vi. Distribution

Purple-spotted gudgeon distribution previously extended from eastern coastal streams from central Cape York, south to the Clarence River in northern NSW, west to the MDB and some coastal streams of South Australia (Lintermans, 2007). However, in the MDB, it is now largely restricted to the upper Condamine River and the Boarder Rivers, Moonie River and Condamine-Balonne system in QLD (Lintermans, 2007).

vii. Threats

The decline of the purple-spotted gudgeon is largely unknown, but has been correlated with the introduction of exotic species (especially Eastern Gambusia and Redfin), instream barriers and flow regulation (Butcher, 2007; Lintermans, 2007).

The species may compete with exotic species for food resources and habitat (Butcher, 2007; Lintermans, 2007). Instream barriers may restrict migration of the purple-spotted gudgeon and alter natural flow levels which are important for reproduction and recruitment (Butcher, 2007).

B. Project Relevance

i. Recorded Presence within the Project Development Area

Purple spotted gudgeon are known to occur throughout the Project Development Area (Lintermans, 2007; Allen et al. 2003; Pusey et al. 2004). Database search results also suggest the species to occur generally within the Project Development Area.

A single specimen was collected during baseline surveys completed for the Project (Aquateco, 2011). This specimen was collected from upstream and outside of the Project Development Area.

ii. Extent of Habitat within the Project Development Area

Habitat suitable for purple-spotted gudgeon occurs throughout the Project Development Area.

iii. Potential Project Related Impacts (Un-mitigated)

Unmitigated Project impacts upon the purple-spotted gudgeon potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water

- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

iv. Significance of Project Related Impacts (Unmitigated)

'Low to High'

v. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Summary Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be 'low'.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from, natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be 'moderate'.

References

Allen, G., Midgley, S. and Allen, M. (2003). *Field guide to the Freshwater Fishes of Australia*, CSIRO Publishing, Collingwood, VIC.

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Rendahl's Tandan (*Porochilus rendahli*)

Plate 6 **Rendahl's Tandan *(Porochilus rendahli)* (Specimen collected at Louden Weir May 2010, source: Timothy Howell)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

Rendahl's Tandan is included in the Action Plan for Australian Freshwater Fishes (Wagner & Jackson, 1993).

iv. Ecology

Rendahl's Tandan are mottled dark grey to a yellowish-brown colour, and grow to a maximum size of 24 cm (Allen et al. 2003).

Rendahl's Tandan is a benthic species, which feeds on insect larvae, microcrustaceans and detritus (Lintermans, 2007). The species becomes sexually mature at around 100 mm to 110 mm in length (Lintermans, 2007).

There is limited information available on the ecology of this species (Pusey et al. 2004). However, it is known that adults migrate to flooded lowland swamps and lagoons during the early wet season

(December-January) to breed (Allen et al. 2003). Around 900 eggs are produced by females during this period (Lintermans, 2007). Adults and juveniles migrate back upstream into refuge creeks during the onset of the dry season (Allen et al. 2003).

v. Habitat

This benthic species has been recorded from a variety of habitats, including the main channel, ephemeral tributary streams and floodplain lagoons (Pusey et al. 2004). Rendahl's Tandan prefers slow flowing habitats, with muddy substrates and submerged aquatic macrophytes (Pusey et al. 2004).

vi. Distribution

Rendahl's Tandan has a patchy distribution across northern Australia (Pusey et al. 2004). The species has been recorded from the Kimberley Region in Western Australia, coastal rivers of the Northern Territory, Cape York, the Burdekin, and the Condamine-Balonne system in QLD (Pusey et al. 2004; Lintermans, 2007).

vii. Threats

Due to the limited information available on the ecology of this species it is difficult to determine specific threats to the Rendahl's Tandan (Pusey et al. 2004; Lintermans, 2007). However, loss of wetlands and the introduction of exotic species may be threatening factors for this species (Lintermans, 2007).

B. Project Relevance

i. Recorded Presence within the Project Development Area

Rendahl's Tandan are known to occur throughout the Project Development Area (Lintermans 2007; Allen et al. 2003; Pusey et al. 2004). Database search results also suggest the species to occur generally within the Project Development Area.

This species has only recently been recorded in the Murray-Darling Basin from Charley's Creek, Dogwood Creek (both of which are within the project development area) and the Balonne Catchment near St. George (Lintermans 2007).

Two individuals were collected within the Project Development Area from the Condamine River at Loudens Weir during baseline surveys completed for the Project (Aquateco, 2011).

ii. Extent of Habitat within the Project Development Area

Habitat suitable for the Rendahl's Tandan occurs generally throughout the Project Development Area.

iii. Potential Project Related Impacts (Un-mitigated)

Unmitigated Project impacts upon the Rendahl's Tandan potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water

- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water to watercourses
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

iv. Significance of Project Related Impacts (Unmitigated)

'Low to High'

v. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Summary Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be 'low'.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from, natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be 'moderate'.

References

Allen, G., Midgley, S. and Allen, M. (2003). *Field guide to the Freshwater Fishes of Australia*, CSIRO Publishing, Collingwood, VIC.

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River Blackfish (*Gadopsis marmoratus*)

Plate 7 **River blackfish *(Gadopsis marmoratus)* (Juvenile specimen collected at Westbrook Creek December 2009, source: Timothy Howell)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

River blackfish are included in the Action Plan for South Australian Freshwater Fishes (Hammer et al. 2009).

iv. Ecology

River blackfish are pale olive-green, brown or almost black in colouring and grow to a maximum size of 35 cm (Lintermans 2007).

River blackfish are nocturnal, opportunistic carnivores feeding on insect larvae, crustaceans, terrestrial insects and occasionally other fish (Butcher 2007; Lintermans 2007). Movements of adults are largely restricted to small home ranges typically less than 20 m (Khan et al. 2004).

The species reaches sexual maturity at two years of age and has an average lifespan of six years (Butcher 2007). Spawning for the river blackfish is temperature dependent and occurs between

October to January when water temperatures rise above 16°C (Lintermans 2007). The females lay eggs inside hollow logs, under undercut banks and on rocks, while the males guard and fan the eggs until they hatch (Lintermans 2007).

v. Habitat

River blackfish prefer habitats with good instream cover such as structural woody habitat, aquatic vegetation or boulders (Lintermans 2007). The species has been commonly observed in slow flowing pools, with a depth of 20 cm to 60 cm (Butcher 2007).

vi. Distribution

River blackfish are widespread and common throughout Victoria, northern coastal drainages of Tasmania and southern sections of the MDB (Allen et al. 2003). There is an undescribed species complex within river blackfish consisting of two species (northern and southern) with only the northern form occurring in the Murray-Darling Basin (Lintermans 2007). Populations exist in several high altitude streams along the eastern side of the Murray-Darling Basin, with locally abundant populations in the Upper Condamine catchment representing the northern-most extent of the species' range (Lintermans 2007).

vii. Threats

Key threats to the species include the smothering of eggs and spawning habitats with sediment and predation and competition for food with exotic species, including Trout and Redfin (Lintermans 2007). Other threats may include impacts to breeding cycles from altered flow regimes and cold-water pollution from dams, as well as loss of habitat associated with historical desnagging of rivers (Lintermans 2007).

B. Project Relevance

i. Recorded Presence within the Project Development Area

River blackfish is not known to occur within the Project Development Area. No records of the species within the Project Development Area were returned during database searches.

A single specimen of river blackfish was recorded from Westbrook Creek during baseline surveys completed for the Project (Aquateco, 2011). This site is situated well outside the Project Development Area. It is likely that the artificial flows through Westbrook Creek (resulting from treated sewerage releases) facilitated the movement of the juvenile river blackfish recorded outside what might be considered its natural range.

ii. Extent of Habitat within the Project Development Area

Although suitable habitat for river blackfish occurs within the Project Development Area, the species is not expected to utilise this habitat as it is situated outside of the natural distribution.

iii. Potential Project Related Impacts (Un-mitigated)

Unmitigated Project impacts upon the river blackfish potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes in water quality as a result of soil disturbance activities that occur across the catchment.

The magnitude of project impacts is considered to be ‘low’.

iv. Significance of Project Related Impacts (Unmitigated)

‘Low’

v. Proposed Mitigation Measures and Management

No specific mitigation measures are proposed. General mitigation measures adopted should include those proposed by Aquateco (2011) and AMCE (2013) Section 7 to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Summary Residual Impact Assessment

‘Low’

References

Allen, G., Midgley, S. and Allen, M. (2003). *Field guide to the Freshwater Fishes of Australia*, CSIRO Publishing, Collingwood, VIC.

Butcher, A (2007). *Characteristics of fish fauna of the Macintyre and Dumaresq Rivers and Macintyre Brook*, Department of Primary Industries and Fisheries, viewed 22 February 2013, http://www.qmdc.org.au/publications/download/576/website-pdfs/border-rivers-demonstration-reach/characterisation-of-fish-fauna-full-report.pdf

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Silver Perch (*Bidyanus bidyanus*)

Plate 8 **Silver perch *(Bidyanus bidyanus)* (Source: Timothy Howell)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

Silver Perch NSW Recovery Plan was developed by the NSW DPI (2006).

iv. Ecology

Silver perch are grey in colouring and typically grow to a length of 30 cm and weight of less than 1.5 kg (Butcher 2007; Lintermans 2007). The species can live up to 26 years of age, but typically live less than 16 years (Butcher 2007; Lintermans 2007).

Silver perch feed on a mixture of macrophytes, macroinvertebrates, molluscs and algae (Allen et al. 2003; Lintermans 2007).

Females reach sexual maturity at around five years of age and males reach sexual maturity at around three years of age (Butcher 2007; Lintermans 2007). The species migrates upstream to spawn during spring and summer, when temperatures exceed 23°C (Butcher 2007). Spawning activity is increased following a flood period, due to greater fish passage during these high flows (Butcher 2007; Lintermans 2007).

v. Habitat

The species is found in slow-flowing pools or fast flowing waters (Butcher 2007; Lintermans 2007). They are commonly captured in open water or near areas with woody debris and submerged aquatic macrophytes (Butcher 2007; Lintermans 2007).

vi. Distribution

Silver perch were formerly widespread throughout the MDB; however the introduction of barriers (e.g. weirs and dams) has impacted on migration for spawning (Lintermans 2007). Consequently their distribution has declined with sustainable populations of the species currently persisting in the Border River region in Queensland and the upper Murray River (Butcher 2007). Silver perch have been stocked and translocated outside their natural ranges in Queensland, New South Wales and south-western Western Australia (Allen et al. 2003).

vii. Threats

Threats to silver perch include the introduction of barriers (e.g. dams and weirs) and exotic species (e.g. redfin and carp).

Dams and weirs alter natural flow regimes, water temperature conditions and restrict fish passage, which impact on spawning and recruitment success ultimately leading to localised population declines (Butcher, 2007).

Introductions of carp and redfin have degraded breeding habitats and directly impacted on food resources for the silver perch (Allen et al. 2003). These exotic species also consume the eggs and larvae of silver perch (Butcher, 2007).

B.Project Relevance

i. Recorded Presence within the Project Development Area

Silver perch are known to occur throughout the Project Development Area (Lintermans 2007; Allen et al. 2003; Pusey et al. 2004). Database search results also suggest the species to occur generally within the Project Development Area.

No silver perch were recorded during baseline surveys completed for the Project (Aquateco, 2011; AMEC 2013).

ii. Extent of Habitat within the Project Development Area

Habitat suitable for the silver perch occurs generally throughout the Project Development Area.

iii. Potential Project Related Impacts (Un-mitigated)

Unmitigated Project impacts upon the silver perch potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water

- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water to watercourses
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

iv. Significance of Project Related Impacts (Un-mitigated)

'Low to High'

v. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

vi. Summary Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be 'low'.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from, natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be 'moderate'.

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Agassiz's glassfish (*Ambassis agassizii*)

Plate 9 **Agassiz's glassfish (*Ambassis agassizii*) (Source: Timothy Howell).**

A. Background Information

vii. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: not listed, **ACA Priority**: yes

viii. Sensitivity

'Moderate'

ix. Recovery Plan

No recovery plans currently exist for this species.

x. Ecology

Agassiz's glassfish are a small, oval fish with a laterally compressed body and a semi-transparent to green colouring (Allen et al. 2003; Pusey et al. 2004). The species typically is less than 50 mm in length, but can grow to a maximum size of 76 mm (Allen et al. 2003; Lintermans, 2007).

Agassiz's glassfish are carnivorous and their diet consists of microcrustaceans (copepods and cladocera), aquatic and terrestrial insects and small fish (Lintermans, 2007). The species also appears to be tolerant of a wide range of water quality conditions, including:

- Temperatures ranging from 11.0°C to 33.6°C
- Dissolved oxygen levels ranging from 0.3 mg/L to 19.5 mg/L

- pH ranging from 6.3 to 9.9
- Conductivity ranging from 19.5 µS/cm to 15102.0 µS/cm
- Turbidity ranging from 0.2 NTU to 144.0 NTU.

Agassiz's glassfish live for approximately four years and complete their lifecycle entirely in freshwater (Butcher, 2007). Males and females both become sexually mature at 12 months of age and spawning occurs from October to December (Pusey et al. 2004; Lintermans, 2007). Spawning is believed to be associated with either increasing water temperatures or photoperiods during late winter and early spring (Pusey et al. 2004; Lintermans, 2007). Agassiz's glassfish are serial spawners, with eggs deposited in macrophyte beds, on the substrate or in submerged riparian vegetation (Pusey et al. 2004).

Little information is known about the migration patterns of the Agassiz's glassfish, but the species is believed to migrate upstream following flood events when water velocity is low (Pusey et al. 2004; Butcher, 2007).

xi. Habitat

The species has been recorded from a variety of freshwater habitats, including still or slow flowing sections of upland, lowland and coastal rivers and streams (Pusey et al. 2004). The species is also known to occur in lakes, ponds, swamps, dune systems (Fraser and North Stradbroke islands) and river impoundments (dams and weirs) (Pusey et al. 2004).

The species is pelagic, preferring fine sediment substrates of mud, sand and clay and close to submerged aquatic macrophytes and algae (Butcher, 2007). The species has been most commonly recorded in larger streams with low to moderate riparian cover (less than 40%), in the mid to upper catchments (on average around 90 m above sea level) (Pusey et al. 2004).

xii. Distribution

Agassiz's glassfish were previously found throughout the MDB and coastal catchments of northern NSW and south-east Queensland (McNeil et al. 2008). However, the species has undergone significant decline and is now presumed extinct in South Australia and Victoria (Lintermans, 2007). In inland NSW, the species is also identified as being in *"immediate danger of extinction"* and is classified as an "endangered population" under the NSW Fisheries Management Act (McNeil et al. 2008, p. 9). The species is currently known to occur in the Darling basin upstream of Bourke in NSW, as well as the Border Rivers, Condamine-Balonne, Nebine and Warrego Catchments of QLD (Allen et al. 2003; Lintermans, 2007). In coastal drainages, the species is found from Lake Hiawatha in NSW north to the Mowbray River near Cairns in QLD (Allen et al. 2003; Pusey et al. 2004). Coastal populations are not considered to be threatened (Pusey et al. 2004).

xiii. Threats

Key threats to the Agassiz's glassfish include the introduction of exotic fish species, habitat loss, flow regulation and degraded water quality (Pusey et al. 2004; Butcher, 2007).

Agassiz's glassfish compete with exotic species, including Eastern Gambusia and Redfin, for habitat and food resources (Pusey et al. 2004). Exotic species may also feed on larvae and juveniles (Butcher, 2007).

Degradation of riparian vegetation and aquatic macrophytes from adjacent land uses (agriculture and/or mining) and flood events has resulted in habitat loss for the Agassiz's glassfish (Pusey et al. 2004). Loss of vegetative cover also increases the risk of predation from avian and instream predators as the Agassiz's glassfish are unable to find protection (Pusey et al. 2004).

Spawning for the Agassiz's glassfish is believed to be triggered by increasing water temperatures. Cold water released from dams may significantly impact on water temperatures in waterways downstream (Pusey et al. 2004). These releases may also cause rapid changes in water levels which could expose fish eggs (Pusey et al. 2004). Consequently, these releases may impact on key spawning cues; reduce egg survivability and larvae recruitment levels of the Agassiz's glassfish.

Dams, weirs and culverts can also create barriers to fish movement, which can affect the migration and spawning of Agassiz's glassfish following flood events (Pusey et al. 2004).

B. Project Relevance

xiv. Recorded Presence within the Project Development Area

Agassiz's glassfish are known to occur throughout the Project Development Area (Allen et al. 2003; Pusey et al. 2004; Lintermans 2007). Database search results also suggest the species occurs generally within the Project Development Area.

A total of 11 individuals were collected within the Project Development Area from Bottle Tree Creek (10 individuals) and Dogwood Creek (one individual) during baseline surveys completed for the Project during February 2013.

xv. Extent of Habitat within the Project Development Area

Habitat suitable for the Agassiz's glassfish occurs generally throughout the wider Project Development Area.

xvi. Potential Project Related Impacts (Un-mitigated)

Unmitigated Project impacts upon the Agassiz's glassfish potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment and discharge of coal seam gas water
- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of coal seam gas water to watercourses
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of coal seam gas water.

The magnitude of the project impacts from the continuous releases of coal seam gas water into receiving waterways is considered to be 'high'. The magnitude of all other project impacts is considered to be 'low'.

xvii. Significance of Project Related Impacts (Unmitigated)

‘Low to High’

xviii. Proposed Mitigation Measures and Management

Specific mitigation measures from the discharge of coal seam gas water and the transfer of water between treatment facilities include those proposed in AMEC (2013) **Section 6** (Mitigation and Management Measures) and **Section 9** (Recommendations). General mitigation measures adopted should also include those proposed by Aquateco (2011) to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

xix. Summary Residual Impact Assessment

The residual impact for the transfer of water between treatment facilities and general activities across the Project Development Area not receiving coal seam gas water are considered to be ‘low’.

The residual impact for the discharge of coal seam gas water under the scenario where discharges mimic, but deviate up to 20% from, natural flows for the Survey Area 2 and Survey Area 9 receiving systems, are considered to be ‘moderate’.

References

Allen, G., Midgley, S. and Allen, M. (2003). *Field guide to the Freshwater Fishes of Australia*, CSIRO Publishing, Collingwood, VIC.

Butcher, A (2007). *Characteristics of fish fauna of the Macintyre and Dumaresq Rivers and Macintyre Brook*, Department of Primary Industries and Fisheries, viewed 22 February 2013, http://www.qmdc.org.au/publications/download/576/website-pdfs/border-rivers-demonstration-reach/characterisation-of-fish-fauna-full-report.pdf

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White-throated snapping turtle (*Elseya albagula*)

Plate 10 **White-throated snapping turtle *(Elseya albagula)* (source: ozanimals.com.au)**

A. Background Information

i. Status

NC Act: not listed, **EPBC Act**: not listed, **Back on Track**: high priority, **ACA Priority**: yes

ii. Sensitivity

'Moderate'

iii. Recovery Plan

No recovery plan currently exists for the white-throated snapping turtle.

iv. Ecology

Limited information exists on the white-throated snapping turtle as the species was only formally described in 2006 (DEHP, 2011).

The white-throated snapping turtle can dive for up to three hours underwater using cloacal ventilation (Hamann et al. 2007; DEHP, 2011). The white-throated snapping turtle feeds mainly on aquatic plants and occasionally feeds on macroinvertebrates and molluscs (DEHP, 2011). The species utilises highly productive riffle zones during the wet season to feed and build energy reserves for reproduction (Hamann et al. 2007). During the dry season this species retracts into large slow flowing pools and/or non-flowing permanent pools (DEHP, 2011).

The white-throated snapping turtle breed and lay one clutch of eggs between autumn and winter, while hatching occurs during spring to summer (Hamann et al. 2007). The species may not breed during periods of low food availability (DEHP, 2011). Populations of white-throated snapping turtle are dominated by adult animals and low juvenile numbers, due to egg predation by feral animals and goannas (Hamann et al. 2007; DEHP, 2011).

v. Habitat

The species prefers waterways with permanent flowing water, with undercut banks, large woody debris, deep pools (6 m deep) and shallow riffle zones (Hamann et al., 2007; DEHP, 2011). The white-throated snapping turtle also has been recorded in streams with a sand-gravel substrate and overhanging riparian vegetation (Hamann et al., 2007).

vi. Distribution

The white-throated snapping turtle are found exclusively in the Burnett, Fitzroy, Raglan and Mary river catchments of south-east Queensland (DEHP, 2011). High densities of the species have been recorded at the Fitzroy Barrage impoundment (Fitzroy River), Ned Churchward weir (Burnett River) and the Eden Bann Weir (Hamann et al. 2007; Limpus et al. 2007).

vii. Threats

Key threats to the white-throated snapping turtle include: egg predation, habitat modification and boat strike (Hamann et al. 2007; DEHP, 2011).

Loss of eggs is related to predation and trampling of the banks by cattle (DEHP, 2011). Feral pigs, foxes, dogs, goannas and water rats can disturb the nests and destroy many clutches of eggs (DEHP, 2011). Similarly, the trampling by cattle of the sandy/loamy riverbanks where eggs are laid can cause the destruction of many nests (DEHP, 2011).

Habitat modification through the installation of barrages and weirs has reduced the availability of riffle habitat through flow regulation (DEHP, 2011). These structures also act as a physical barrier that restricts the movement of the white-throated snapping turtle and access to food and nesting areas (DEHP, 2011).

Injury and mortality due to boat strike is also another key threat to this species in some waterways (DEHP, 2011).

B.Project Relevance

viii. Recorded Presence within the Project Development Area

The white-throated snapping turtle is only known to occur within the Fitzroy Basin, not the Murray-Darling Basin (which the vast majority of the Project Development Area is situated within). A small portion of the Project Development Area falls within the Dawson River catchment of the Fitzroy Basin.

No records of the white-throated snapping turtle exist within the Project Development Area. The species has previously been recorded in the Dawson River approximately 100 km downstream of the Project Development Area (FRC, 2010).

The species was not recorded during baseline surveys completed for the Project (Aquateco, 2011; AMEC 2013). However, database search results returned the species as 'possibly' occurring within the small portion of the Project Development Area within the Dawson River catchment.

ix. Extent of Habitat within the Project Development Area

The small portion of the Project Development Area within the Dawson River catchment (Fitzroy Basin) is not expected to support suitable habitat for the white-throated snapping turtle.

The portion of the Project Development Area within the Murray-Darling Basin is outside of the known range of the white-throated snapping turtle. Accordingly, no assessment of the suitability of habitat within this area has been completed.

x. Potential Project Related Impacts (Unmitigated)

Unmitigated Project impacts upon the white-throated snapping turtle potentially include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment.

The magnitude of project impacts is considered to be 'low'.

xi. Significance of Project Related Impacts (Unmitigated)

'Low'

xii. Proposed Mitigation Measures and Management

No specific mitigation measures are proposed. General mitigation measures adopted should include those proposed by Aquateco (2011) and AMEC (2013) **Section 7** to decrease the potential for increased turbidity resulting from runoff from activities undertaken across the project development area.

xiii. Summary Residual Impact Assessment

'Low'

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ATTACHMENT 3 – SITE PHOTOS

SAQ1 – Weringa Creek (Looking Upstream) **SAQ1 – Weringa Creek (Looking Downstream)**

DA2-1 – Bottle Tree Creek (Looking Upstream) **DA2-1 – Bottle Tree Creek (Looking Downstream)**

DA2-2 – Bottle Tree Creek (Looking Upstream) **DA2-2 – Bottle Tree Creek (Looking Downstream)**

DA2-4 – Bottle Tree Creek (Looking Upstream)

DA2-4 – Bottle Tree Creek (Looking Downstream)

DA2-5 – Dogwood Creek (Looking Upstream)

DA2-5 – Dogwood Creek (Looking Downstream)

DA2-6 – Dogwood Creek (Looking Upstream)

DA2-6 – Dogwood Creek (Looking Downstream)

DA2-7 – Dogwood Creek (Looking Upstream)

DA2-7 – Dogwood Creek (Looking Downstream)

DA9-1 – Condamine River (Looking Upstream)

DA9-1 – Condamine River (Looking Downstream)

DA9-2 – Condamine River (Looking Upstream)

DA9-2 – Condamine River (Looking Downstream)

DA9-3 – Condamine River (Looking Upstream)

DA9-3 – Condamine River (Looking Downstream)

DA9-4 – Condamine River (Looking Upstream)

DA9-4 – Condamine River (Looking Downstream)

DA9-5 – Condamine River (Looking Upstream)

DA9-5 – Condamine River (Looking Downstream)

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DA9-21 – Crawlers Creek (Looking Upstream)

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Coffey Environments

Surat Gas Project

Supplementary Aquatic Ecology Assessment – Addendum

Document No. COF130082-ENV-RPT-001_ADDENDUM_FINAL

June 2013

Revision	Date	Description	Prepared	Reviewed	Approved		
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Item	Page	Section	Comments

** Use after Rev. 0*

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This Report has been prepared for Coffey Environments Australia Pty Ltd (Coffey Environments) by AMEC Environment & Infrastructure Australia Pty Ltd (AMEC), based on assumptions as identified throughout the text and upon information and data supplied by others.

The Report is to be read in the context of the methodology, procedures and techniques used, AMEC's assumptions, and the circumstances and constraints under which the Report was written. The Report is to be read as a whole, and sections or parts thereof should therefore not be read or relied upon out of context.

AMEC has, in preparing the Report, followed methodology and procedures, and exercised due care consistent with the intended level of accuracy, using its professional judgment and reasonable care.

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Attachment 3 – PRIMER Results
Attachment 4 – Site Photos

EXECUTIVE SUMMARY

Background

AMEC Environment and Infrastructure Pty Ltd (AMEC) was engaged to undertake aquatic ecology and water quality studies to address updates to the project description of the Surat Gas Project and provide further characterisation of the aquatic ecology environment. The technical report (this document) is an addendum to the supplementary report to the EIS (SREIS) and is intended to:

- Provide characterisation of macroinvertebrate communities at 19 sites
- Complete aquatic flora, fauna and habitat surveys at three sites (two sites in the DA2 receiving environment and a single site in the Macintyre and Weir Rivers catchment) that could not be sampled during February and March 2013 due to wet weather access.

Methods

Field sampling was undertaken at sites specified in the SREIS document and using the methodologies outlined therein. This included:

- Collection and live picking of macroinvertebrate samples as per the Queensland AUSRIVAS sampling manual (2001)
- Fish surveys using boat and backpack electrofishers, box traps, fyke nets and/or cathedral traps, as dictated by the habitat and species present
- Visual inspection of habitat and aquatic flora.

Data was analysed using a combination of AUSRIVAS models, univariate and multivariate statistics and published biotic indices.

Results and Outcomes

As is commonly experienced in ephemeral systems in southern and central Queensland, the AUSRIVAS macroinvertebrate assessments were inconclusive due to lack of available reference sites for calibration of the models.

SIGNAL2 scores and PET analysis indicated that the invertebrate taxa present were largely comprised of families that are tolerant to a wide range of water quality parameters.

Analysis of functional feeding groups, hydrological preferences, community condition and environmental association supported the assertion that the macroinvertebrate communities are typical of those expected in these types of systems.

Similarity analysis returned groupings that appear to be based largely on physical factors and microhabitat diversity/abundance, rather than water quality or other parameters. There was a clear influence associated with proximity to the Cecil Plains Weir, with communities within the operating head range differing from sites downstream.

No high value aquatic habitat, fish, turtles, flora or other aquatic values of conservation significance were identified during the May 2013 sampling event. One listed aquatic macrophyte pest species (Salvinia) was recorded in the DA2 receiving system.

Conclusion

Whilst pre-wet season surveys are still recommended, the results of the work undertaken to date indicate that no further refinement of the potential impacts or mitigation measures outlined in the SREIS are likely to be required.

ABBREVIATIONS

Abbreviations	Meaning
ACA	Aquatic Conservation Assessments
AMEC	AMEC Environment and Infrastructure Pty Ltd
ANOSIM	Analysis of Similarity
ANZECC	Australian and New Zealand Environment and Conservation Council
Arrow Energy	Arrow Energy Pty Ltd
AUSRIVAS	Australian River Assessment System
Coffey Environments	Coffey Environments Australia Pty Ltd
CPOM	Coarse particulate organic matter
DERM	Department of Environment and Resource Management
DEHP	Department of Environment and Heritage Protection
DNRM	Department of Natural Resources and Mines
DO	Dissolved Oxygen
EC	Electrical Conductivity
EIS	Environmental Impact Statement
FPOM	Fine Particulate Organic Matter
OE	Observed over Expected
PET	Plecoptera, Ephemeroptera, Tricoptera
SREIS	Supplementary report to the EIS
SREISa	Addendum to the Supplementary report to the EIS (this report)
SIGNAL2	A metric of macroinvertebrate community tolerance to chemical pollution

GLOSSARY

Term	Definition
Australian River Assessment System (AUSRIVAS) Physical Assessment Protocol	This protocol is a standardised rapid method for the collection of geomorphological, physical habitat, riparian and basic water quality data. It can be used to assess the physical condition of rivers and streams and to predict the local scale habitat features that should be present at a site. It incorporates aspects of several existing physical assessment methods into a method that can be implemented to construct AUSRIVAS style predictive models (DEHP 2012).
Ephemeral	A waterway that contains surface water flow through all or part of a defined channel, only following heavy and sustained precipitation events (typically during the wet-season/summer).
Exotic	Species living outside its native distributional range, which has arrived there by anthropogenic activities, either deliberate or accidental.
Macrophyte	Aquatic plants growing in or near water that are emergent, submerged or floating.
Perennial	A waterway with a well-defined channel that normally flows throughout the entire hydrological cycle.
pH	The absolute value of the decimal logarithm of the hydrogen-ion concentration (activity), used as an indicator of acidity (pH less than 7) or alkalinity (pH greater than 7) or neutrality (pH 7).
Stream order	A number that designates the relative position of a stream in a drainage basin network, ranked from headwaters to river terminus.
Taxon	(Plural Taxa) Taxonomic group or classification, such as a phylum, order, family, genus, or species.

1. INTRODUCTION

1.1 Background

Arrow Energy Pty Ltd (Arrow Energy) proposes to expand its coal seam gas operations in the Surat Basin (the Project). A voluntary Environmental Impact Statement (EIS) has been prepared for the Project by Coffey Environments Australia Pty Ltd (Coffey Environments), a subsidiary of Coffey International Pty Ltd.

Arrow Energy is required to prepare a supplementary report to the EIS (SREIS) to present information on changes to the Project Description and to provide further consideration and/or information. In order to satisfy these requirements, AMEC Environment and Infrastructure Pty Ltd (AMEC) was contracted by Coffey Environments to undertake the supplementary aquatic ecology assessment for the Project (this assessment).

The SREIS for aquatic ecology (AMEC, 2013) was submitted to Coffey as a draft in April 2013 (finalised in June 2013) based on field surveys undertaken in February and March 2013. Two knowledge gaps in this submission prevented the complete fulfilment of the project scope:

1. Characterisation of macroinvertebrate communities was not possible during the February and March surveys due to the requirement to complete sampling for the ‘autumn’ season between May - July.
2. Sampling of aquatic indicators (habitat, flora or fauna) could not be undertaken at three of the proposed survey sites due to restricted land access resulting from wet weather.

1.2 Scope and Objectives

The overall objective of this assessment (herein referred to as the ‘SREISa’) was to complete the SREIS scope of works for relevant sites. Specifically, the following key tasks were undertaken:

1. Completion of an additional round of field survey, including:
    a. Macroinvertebrate sampling at 19 SREIS survey sites
    b. Sampling of all aquatic indicators (physical habitat, water quality, macrophytes, fish, turtles and other vertebrates) at the three SREIS sites which could not be accessed during earlier field surveys; namely sites DA2-8, DA2-9 and SAQ-2
2. Prepare an updated description of the existing environment
3. Re-assess the potential impacts proposed by the SREIS
4. Re-assess the recommended mitigation measures proposed by the SREIS.

2. ASSESSMENT METHODOLOGY

2.1 Study Area

The Study Area for this assessment is shown in **Figure 2.1**. The focal point of the SREISa relates specifically to aquatic ecosystems within the following:

- Dawson catchment (Fitzroy Basin)
- Macintyre and Weir Rivers catchment (Murray-Darling Basin)
- Drainage area 2 receiving system of coal seam gas water discharge from Water Treatment Facility 1 (Murray-Darling Basin)
- Drainage area 9 receiving system of coal seam gas water discharge from Water Treatment Facility 2 (Murray-Darling Basin).

A detailed description of the Study Area, Project Development Area and Project Footprint is provided in the SREIS.

2.2 Desktop Investigations

A detailed review of literature relevant to the Project excluding macroinvertebrates was completed and reported in the SREIS. Relevant findings from this review are discussed herein. The results of the macroinvertebrate review are presented in **Section 3.1.1**.

2.3 Field Assessment

2.3.1 Site Selection

The rationale underpinning the site selection process is comprehensively described in the SREIS. In summary, sites selected addressed:

1. Providing further characterisation of the aquatic values in the:
   a. Dawson catchment (Fitzroy Basin)
   b. Macintrye and Weir Rivers catchment (Murray-Darling Basin)
2. Updates to the Project Description (reported in the EIS); regarding the option for discharge of treated and/or untreated coal seam gas water at two locations:
   a. Water Treatment Facility 1 receiving system (Bottle Tree Creek and Dogwood Creek) - Drainage Area 2
   b. Water Treatment Facility 2 receiving system (Crawlers Creek or Condamine River) Drainage Area 9.

A total of 19 sites were selected for inclusion in the SREISa. Information regarding the site locations and other specifics is presented in **Table 2.1** and **Figure 2.1**, **2.2** and **2.3**. Site DA9-6 was not surveyed during the SREISa due to restricted land access.

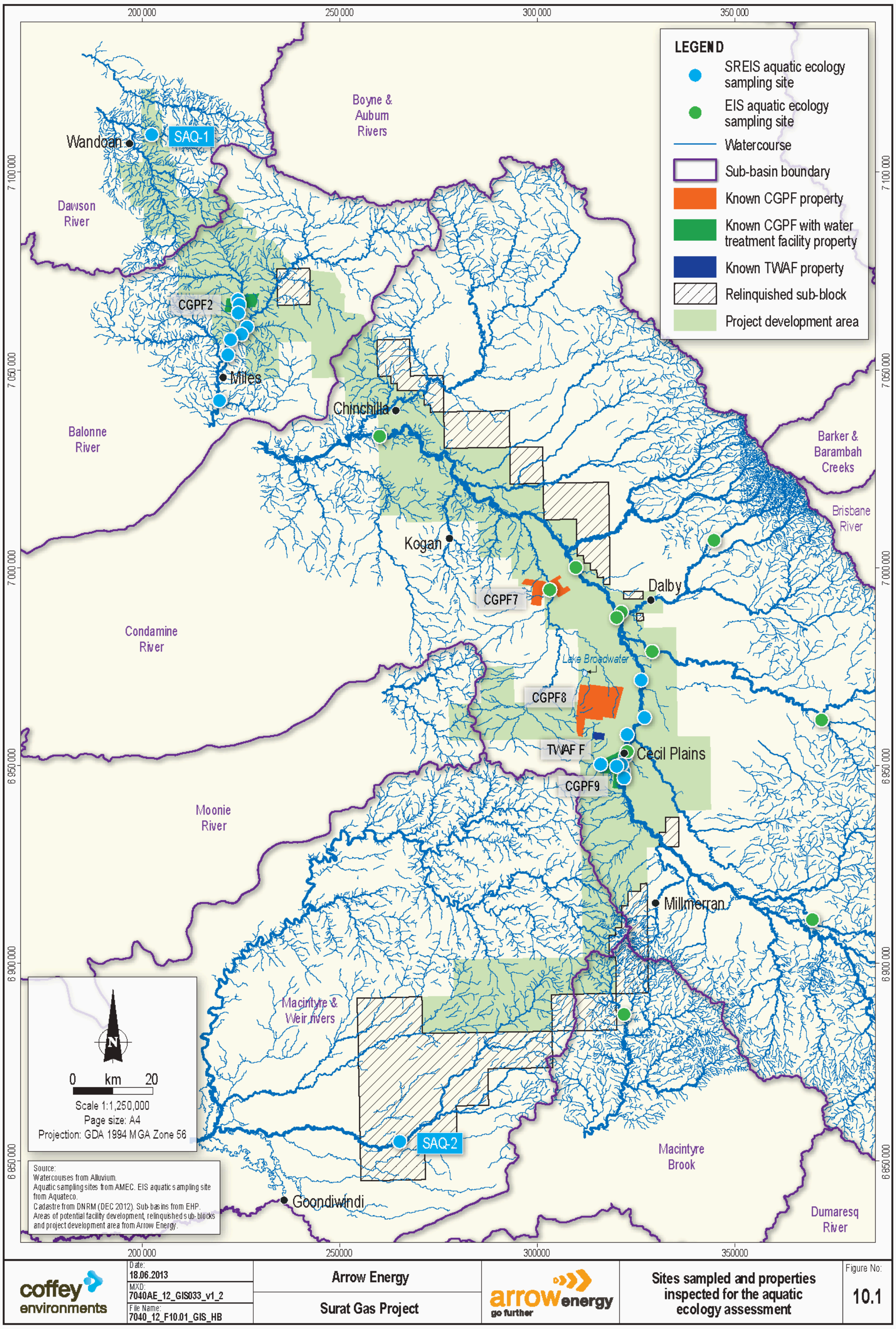

Figure 2.1 Map of SREISa Survey Sites

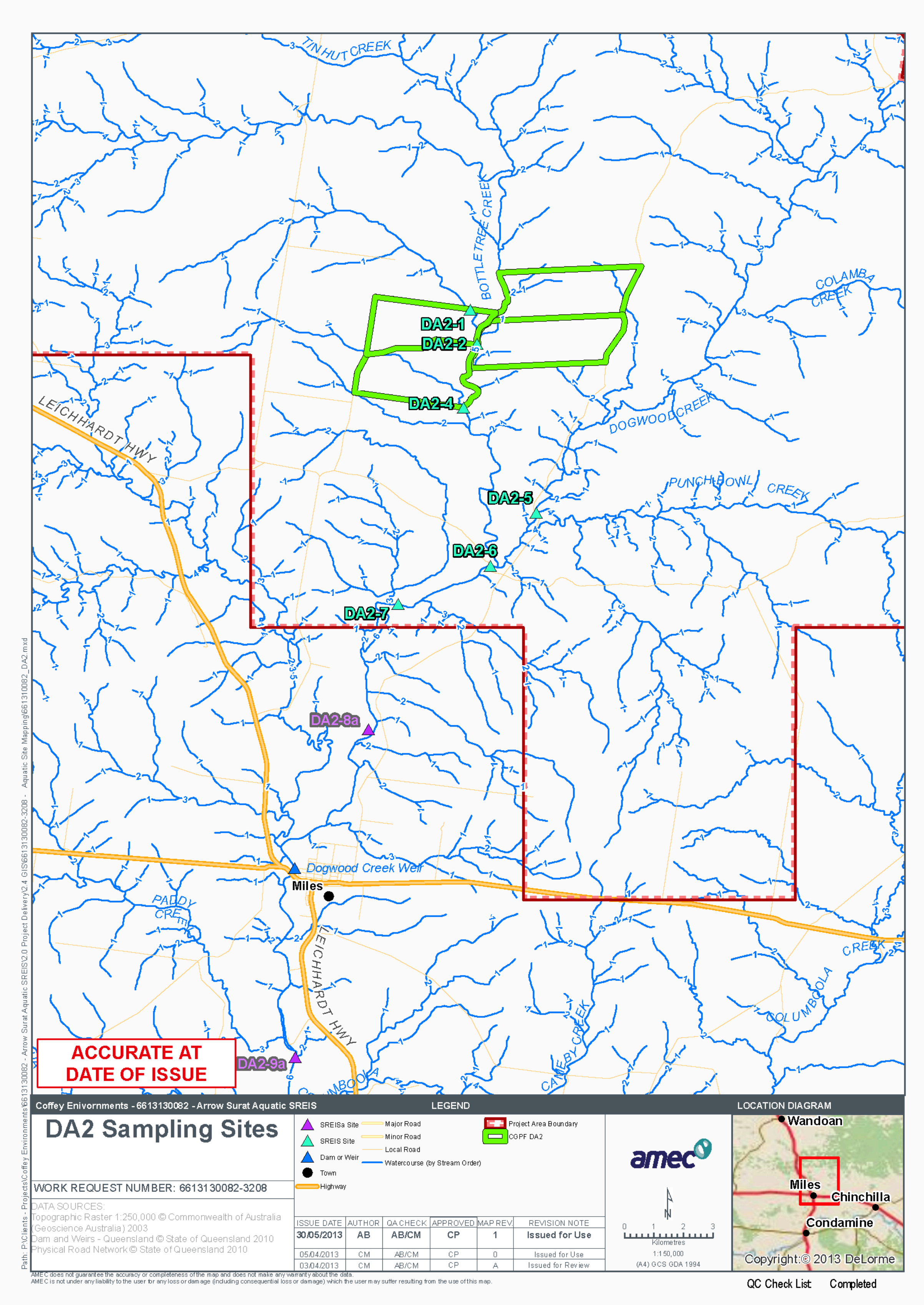

Figure 2.2 SREISa Drainage Area 2 Receiving System Site Network

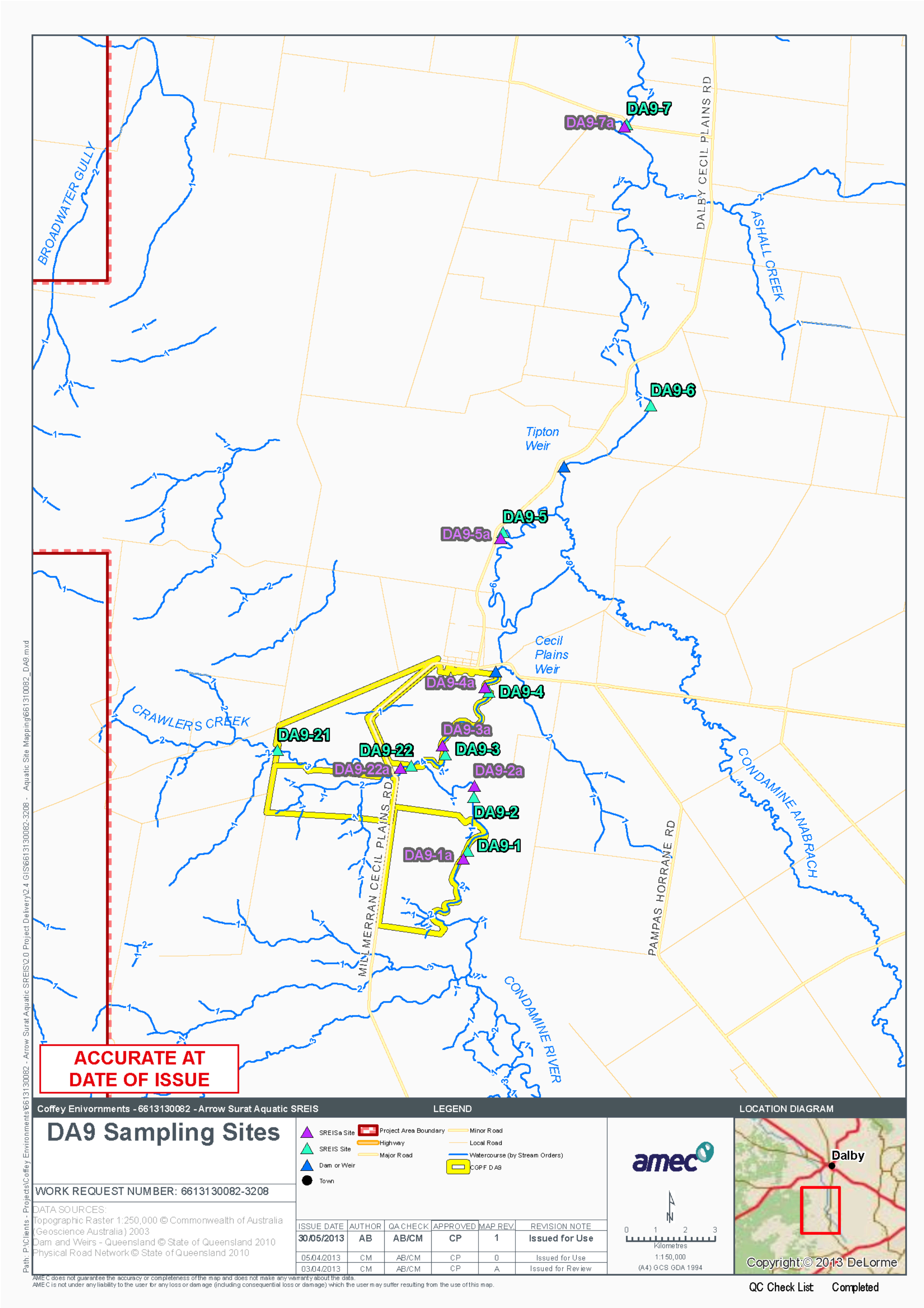

Figure 2.3 SREISa Drainage Area 9 Receiving System Site Network

Table 2.1 Summary of SREISa Survey Site Information

Site Code	Purpose[1]	Basin	Sub-Basin	Catchment	Waterway	Wetland Type[2]	Elevation (m)	GPS Coordinate[3] (UTM WGS 84, Zone 55J)	
								Latitude	Longitude
SAQ-1	1a	Fitzroy	Dawson	Dawson River	Weringa Creek	Riverine	261	-26.10315	150.02512
SAQ-2	1b	Murray-Darling	Condamine-Balonne	Weir River	Commoron Creek	Riverine	245	-28.41009	150.60281
DA2-1	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	318	-26.48431	150.23480
DA2-2	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	317	-26.49485	150.23687
DA2-4	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Bottle Tree Creek	Riverine	314	-26.51435	150.23288
DA2-5	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	310	-26.54654	150.25520
DA2-6	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	310	-26.56294	150.24098
DA2-7	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	307	-26.57455	150.21282
DA2-8	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	305	-26.61275	150.20378
DA2-9	2a	Murray-Darling	Condamine-Balonne	Dogwood Creek	Dogwood Creek	Riverine	298	-26.71309	150.18125
DA9-1^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	362	-27.59188	151.19314
DA9-2^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	361	-27.56957	151.19668
DA9-3^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	360	-27.55710	151.18694
DA9-4^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	359	-27.53928	151.19987
DA9-5^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	355	-27.49377	151.20473
DA9-6	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	353	NA	NA
DA9-7^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Condamine River	Riverine	349	-27.36794	151.24264
DA9-21	2b	Murray-Darling	Condamine-Balonne	Condamine River	Crawlers Creek	Riverine	370	-27.55860	151.13644
DA9-22^	2b	Murray-Darling	Condamine-Balonne	Condamine River	Crawlers Creek	Riverine	360	-27.56414	151.17408

Notes:
1 Described in **Section 2.4.1**.
2 Defined by DEHP (2013).
^ Denotes minor difference in sampling locale to that completed for the SREIS
NA Could not be sampled due to restricted land-access

In some instances, restricted land access during the SREISa surveys precluded sampling at the exact sites utilised during the SREIS surveys including seven sites within the DA9 site network (refer to **Figure 2.1**). Sites utilised during the SREISa were geographically close to and possessed a high degree of similarity in biophysical attributes as per the SREIS sites.

2.3.2 Survey Methodology

A general summary of survey effort completed at each site is provided in **Table 2.2**.

Table 2.2 Summary of SREISa Survey Effort

Site	Water Quality	Aquatic Habitat	Macrophytes	Macroinvertebrates	Fish	Other Vertebrates
SAQ-1	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
SAQ-2	✓[c]	✓[c]	✓[c]	Dry	Dry	Dry
DA2-1	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-2	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-4	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-5	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-6	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-7	✓[a]	✓[a]	✓[a]	✓[c]	✓[a]	✓[a]
DA2-8	✓[c]	✓[c]	✓[c]	✓[c]	✓[c]	✓[c]
DA2-9	✓[c]	✓[c]	✓[c]	✓[c]	✓[c]	✓[c]
DA9-1	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]
DA9-2	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]
DA9-3	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]
DA9-4	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]
DA9-5	✓[c]	✓[b]	✓[c]	✓[c]	x	x
DA9-6	✓[c]	✓[b]	✓[c]	✓[c]	x	x
DA9-7	✓[c]	✓[b]	✓[c]	✓[c]	x	x
DA9-21	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]
DA9-22	✓[b]	✓[b]	✓[b]	✓[c]	✓[b]	✓[b]

Notes:

✓ Survey completed.
X Survey not completed.
Dry Site dry.

a. Survey completed 18–28 February 2013.
b. Survey completed 18–22 March 2013.
c. Survey completed 8–16 May 2013.

A detailed description of methodologies employed for surveying aquatic habitat, water quality, macrophytes, fish and turtles is provided in the SREIS. A description of methodologies employed for the sampling and analysis of macroinvertebrates is provided below, along with a summary of survey effort employed for fish sampling.

Macroinvertebrates

Macroinvertebrate samples were collected at each monitoring location in line with the approach outlined in the Department of Environment and Resource Management (DERM) Monitoring and Sampling Manual 2009; which defaults to those methods adopted by the Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (DNRM 2001). All sampling was completed by accredited Queensland AUSRIVAS operators.

AUSRIVAS sampling protocols require that a ‘habitat’ be sampled if it accounts for more than 10% of a survey location reach. Edge habitats were present and sampled at all sites. Pool bed habitat was present at all sites, although this habitat could not be sampled at sites DA9-1, DA9-2, DA9-3 and DA9-4, due to deep water (>2 m) and steep banks. Riffle habitat was not present at any of the SREISa sites (refer to **Table 2.3**). Site DA9-6 was not assessed in the SREISa due to site access limitations.

Samples from each habitat were live picked in the field, preserved in 70% ethanol and delivered to *Stream Macroinvertebrate Identifications* for sorting, taxonomic identification and enumeration. Organisms were generally identified to family level with the exception of lower phyla (e.g. Porifera, Nematoda), oligiochaetes (freshwater worms), Acarina (mites) and microcrustacea (Ostracoda, Copeopoda and Cladocera). Chironomids were identified to sub-family level, in accordance with standard AUSRIVAS protocols (DNRM 2001).

Fish

Sampling techniques deployed for the May 2013 surveys are outlined in **Table 2.4**. A full description of the sampling methodologies employed is provided in the SREIS.

2.3.3 Survey Timing

Surveys for the SREISa were completed from the 8 – 16 May, 2013. An overview of antecedent stream flow is presented in **Figure 2.4**.

2.3.4 Data Analysis

Data relating to water quality, aquatic habitat, macrophytes, fish and other vertebrates have been presented graphically and in tabular format in **Section 3**, as appropriate.

Both univariate and multivariate data analysis techniques were utilised for the characterisation of macroinvertebrate communities. Each of these styles of analysis provide differing levels of information; with univariate indices assessing the condition or ‘health’ of a community, and multivariate analysis providing comparisons between communities based on overall structure and associated environmental variables.

Table 2.3 SREISa Macroinvertebrate Habitat Sampling Effort Summary

Site	Macro-Habitat Type	
	Edge	Bed (Pool)
SAQ-1	✓	✓
SAQ-2	Dry	Dry
DA2-1	✓	✓
DA2-2	✓	✓
DA2-4	✓	✓
DA2-5	✓	✓
DA2-6	✓	✓
DA2-7	✓	✓
DA2-8	✓	✓
DA2-9	✓	✓
DA9-1	✓	X
DA9-2	✓	X
DA9-3	✓	X
DA9-4	✓	X
DA9-5	✓	✓
DA9-6	NA	NA
DA9-7	✓	✓
DA9-21	✓	✓
DA9-22	✓	✓

Notes:
✓ survey completed
X habitat present but sample could not be collected due to deep water and steep banks
NP habitat absent
NA no site access
Dry site dry / insufficient surface water habitat present to sample

Table 2.4 SREISa Fish Sampling Effort Summary

Site	Fish Sampling Technique				
	Backpack EF	Boat EF	Fyke Netting[1]	Box Trapping[1]	Cathedral Netting[1]
DA2-8	NP	NP	2	10	X
DA2-9	NP	NP	2	10	X
SAQ-2	Dry				

Notes:
1 number of nets set
Dry insufficient surface water habitat present to sample
X sampling method not employed
NP habitat absent

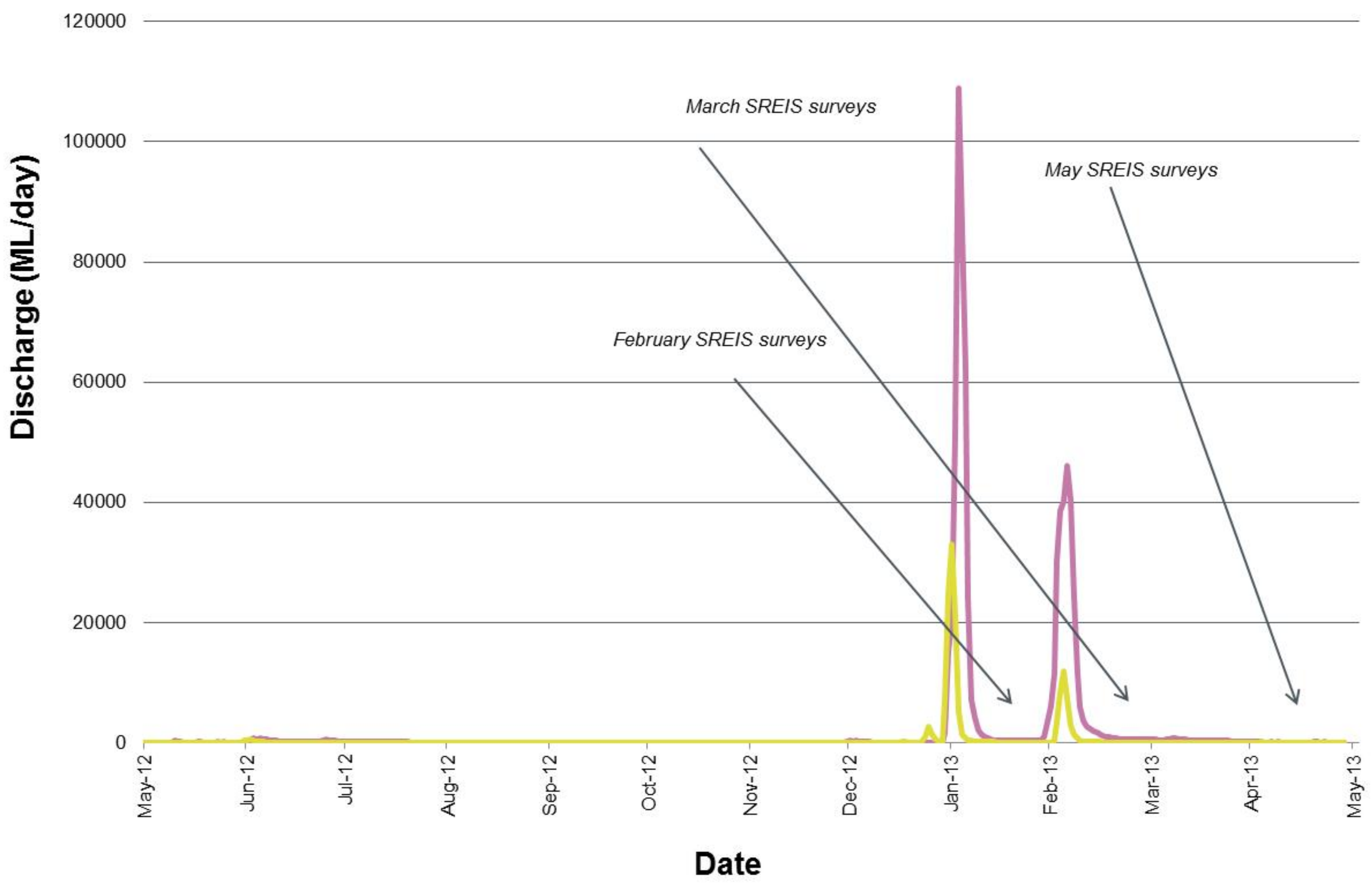

Figure 2.4 Indicative Stream-Flow of Dogwood Creek (Drainage Area 2)^ and Condamine River (Drainage Area 9)* within the Study Area

Notes: Purple line denotes 'Dogwood Creek at Gil Weir' (DERM Station # 422202B) - ^ Data source: DNRM 2013a; Green line denotes 'Condamine River at Cecil Plains Weir' (DERM Station # 422316A) - * Data source: DNRM 2013b. Discharge on the y axis refers to natural stream discharge.

2.3.4.1 Univariate Analysis & Metrics

Taxa Richness

Richness refers to the number of different taxa contained in a sample. Unlike some biological indices a higher number does not always indicate better in-stream conditions. In some cases, higher values of this metric may indicate favourable conditions in terms of food availability and/or the quality of habitat. High richness values can also occur when altered conditions provide habitats that may not occur naturally (e.g. riffle habitats due to altered flow conditions). Each richness value must be assessed individually with a final assessment based upon changes from natural or reference/control condition.

PET Richness

Some groups of aquatic macroinvertebrates are more sensitive to changes in the aquatic environment than others and it is possible to refine the assessment of river health based on the presence or absence of sensitive taxa. It is generally accepted that three groups (orders) of aquatic insects, the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) (PET) are the most sensitive to changed conditions. The total number of PET families can be used to assess changes in habitat condition and water quality (Plafkin et al. 1989). The use of this index is based on the premise that undisturbed sites will have relatively greater diversity of PET than sites in a degraded condition. The use of PET should be limited to regional or preferably in-catchment comparisons as the composition of the fauna varies between regions and river systems, with some systems naturally containing more PET taxa than others. Taxa from the order Plecoptera (stoneflies) occur infrequently throughout undisturbed aquatic ecosystems within Queensland.

SIGNAL2

SIGNAL2 is a biotic index based on pollution sensitivity values (grade numbers) derived from published and unpublished information on macroinvertebrate tolerance to pollutants, such as sewage and nitrification (Chessman 2003). Each taxa in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive). Those taxa for which no grade can be assigned are excluded from the analysis. The SIGNAL2 index is calculated as the average grade number for all taxa present in the sample.

To aid in the interpretation, the SIGNAL 2 index can be plotted against taxa richness to produce a bi-plot. A quadrant diagram is then used to place the results in context (Chessman 2003) (**Figure 2.5**). The bi-plot is divided into four quadrants, the boundaries of which differ between geographic regions due to natural variation in macroinvertebrate assemblages. They also vary according to sampling effort and habitat type.

Chessman (2001) describes the necessity to set the boundaries of the quadrant diagram individually, in order to suit each study region and the local sampling methods. Due to insufficient data specific to this study, the boundaries for all DA2 and DA9 sites were those specified for 'Murray Darling Basin between 200 – 400 m elevation'. For site SAQ-1 'Queensland east of Great Dividing Range' were used (Chessman, 2001). As guideline bi-plot boundary values are only provided for edge and riffle habitat (which were absent from the study area), data from pool bed samples collected during the SREISa could not be analysed using this technique.

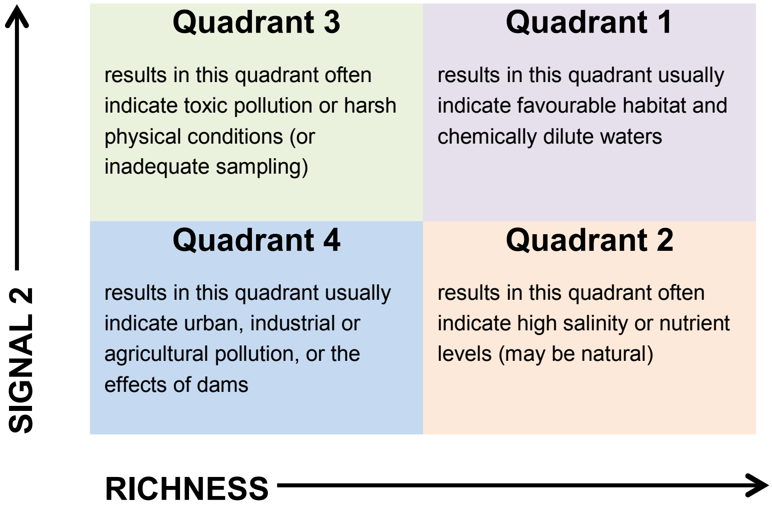

Figure 2.5 SIGNAL2 / Taxa Richness Quadrant Diagram

(Source: Chessman 2003)

AUSRIVAS Modelling

AUSRIVAS (AUStralian RIVer Assessment System) is a macroinvertebrate based tool for assessing the biological health of rivers (DNRM 2001). AUSRIVAS models use site-specific predictions of the expected structure of macroinvertebrate communities based on comparison of habitat data (e.g. altitude) to 'reference' sites (Coysh et al. 2000). Separate models exist for varying States (QLD, NSW, Vic), regions (coastal and western), seasons (spring and autumn) and macrohabitat (edge, pool and riffle/run).

The AUSRIVAS model produces two key outputs (refer to **Table 2.5**):

- *O/E50 score*, which is a ratio of the observed (O) to the expected (E) fauna and can range from zero, when none of the expected taxa are found at a site, to one, when all the expected taxa are found. Values can be greater than one if more families are found at the site than predicted by the model
- *Bands* based on the O/E50 scores are derived from the model. These bandings reflect the general health of the macroinvertebrate community and indicate whether the diversity and makeup of the macroinvertebrate assemblages at a site have deviated from the "normal" or undisturbed state.

The specific AUSRIVAS models used for this assessment were the 'Queensland regional', 'coastal', 'autumn', 'edge' or 'pool' for sites situated in the Fitzroy Basin (SAQ-1), and the 'Queensland regional', 'western', 'autumn', 'edge' or 'pool' models for sites situated in the Murray-Darling Basin.

Climate data required for the predictor variables was sourced from the closest Bureau of Meteorology (BOM) weather gauging stations; Miles (station no. 42112) for temperature and Chinchilla (station no. 41017) for rainfall.

Table 2.5 AUSRIVAS Modelling Banding Scheme Summary

Band Label	Description	O/E Taxa	Model Output interpretation	O/E50 Score Banding *		
				Edge	Pool	Riffle
Band X	More biologically diverse than reference sites	O/E greater than 90th percentile of reference sites used to create the model.	More taxa found than expected. Potential biodiversity hot-spot or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.	Infinity	Infinity	Infinity
Band A	Reference condition	O/E within range of central 80% of reference sites used to create the model	Most/all of the expected families found at 80% of the reference sites. Water quality and/or habitat condition roughly equivalent to reference sites.	1.22	1.22	1.22
Band B	Significantly impaired	O/E below 10th percentile of reference sites used to create the model. Same width as band A	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of families	0.72	0.72	0.72
Band C	Severely impaired	O/E below band B. Same width as band A	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality	0.32	0.32	0.32
Band D	Extremely impaired	O/E below band C down to zero.	Few of the expected families and only the hardy, pollution tolerant families remain. Extremely poor water and/or habitat quality. Highly degraded	0	0	0

Notes:
* ‘Queensland regional’, ‘coastal’, ‘autumn’ model

Attempts to AUSRIVAS model macroinvertebrate data from sites within the Murray Darling Basin (DA2 and DA9 receiving systems) using the ‘Queensland regional’, ‘western’, ‘autumn’, ‘edge’ or ‘pool’ models generated an “outside the experience of the model” error. Subsequent correspondence with the Queensland AUSRIVAS coordinator indicated that insufficient reference sites exist for this portion of the study area (S. Choy, *pers. comm.*). AUSRIVAS results for sites within the DA2 and DA9 receiving systems are therefore not presented.

Functional Feeding Group Analysis

Macroinvertebrates can be associated with different functional feeding groups based on their morphological and behavioural mechanisms for acquiring food resources (Cummins and Klug 1979). Major functional feeding groups are outlined in **Table 2.6**.

The relative proportion of the different functional feeding groups present at a site can provide an indication of broad scale ecosystem health by assessing how the main taxa interact with their environment (Cummins et al. 2005). Specialist feeders, such as shredders and scrapers are presumed to be more sensitive to perturbation, while generalists, such as gatherers and filterers, are more tolerant to pollution that might alter the availability of certain food (Barbour et al. 1996).

The applicability of this classification scheme to Australian macroinvertebrates has been questioned due to the fact that several taxa are generalist feeders (St Clair 1994, Lake 1995) or may change feeding groups throughout their life cycle (Boulton and Brock 1999). Nevertheless, this scheme is still commonly applied and provides a useful additional metric for general characterisation of macroinvertebrate communities.

Table 2.6 Macroinvertebrate Functional Feeding Groups

Feeding Group	Food Resources	Feeding Mode
Shredder	leaf litter (CPOM), green water plants, wood (usually rotted)	chewing, mining
Scraper/Grazer	periphyton and algal biofilms	scraping and browsing
Gatherer/Collector	deposited FPOM, biofilms on rocks/hard surfaces	brushing biofilms, burrowing in soft sediments
Filter-feeder	suspended FPOM	filter-feed using specialised setae, nets or secretions
Predator	animal prey	biting, piercing and engulfing

(Source: Boulton and Brock 1999)

Flow Preference Group Analysis

DEHP (formerly DERM) has developed indices to determine the flow preferences of macroinvertebrate taxa (S. Choy *pers. comm*.). Although these indices currently exist for internal departmental purposes only, a formal publication is being prepared (Marshall and Marshall, *in prep*; as cited in Smythe-McGuiness et al. 2012).

Flow preference groupings are as follows: no flow / low flow; high flow; and, no preference. For any given taxa, the designation of 'preference' is based upon the frequency of collection from such habitats. The reference data-set from which such designations are based is populated by information collected from large, long-term, broad-scale monitoring programmes conducted in Queensland by DEHP (formerly DERM) (S. Choy, *pers. comm*.).

It is important to remember that the designation to a particular flow preference grouping is exactly just that; a ‘preference’. The designation of a given taxon to any given grouping does not preclude its presence in other flow environments. For example, the preference of particular taxa to high flow habitats, does not mean the taxa cannot viably occupy habitats of no flow; simply that it is more commonly collected from high flow habitats.

For the purpose of this assessment, flow preference groupings were designated as per Smythe-McGuiness et al. (2012). Additionally, a few taxa were assigned a grouping based upon professional judgement.

The inclusion of these metrics in the SREISa is intended to aid in the general characterisation of macroinvertebrate communities only. Due to the fact that taxa residing in edge habitat typically possess a broad habitat niche, flow and preference groups were only assigned to those taxa collected from the pool bed habitat. Such taxa are more likely to be influenced by flow regime; the alteration of which, being a key issue of investigation for the SREIS.

2.3.4.2 Multivariate Analysis

Multivariate techniques were employed for sites within the DA2 and DA9 receiving system only, as the scope of works did not warrant this level of assessment for the remaining sites. The multivariate techniques used enabled exploration of patterns between macroinvertebrate communities (Ordination) and identification of the key taxa contributing to such differences (SIMPER).

Taxa that were considered rare (present at only one replicate, at a single site) do not add value to the assessment, but create ‘noise’ which can mask important patterns. They were therefore omitted from the analysis dataset (Clarke and Warwick, 2001). All multivariate analyses were performed using the statistical package PRIMER Version 6.1.6 (PRIMER-E: Plymouth Marine Laboratory, UK). All data were converted to presence/ absence for multivariate analyses.

A summary of each routine is provided below. For a comprehensive description refer to Clarke and Warwick (2001).

Ordination

Ordination provides a graphical representation of the relative similarity of entities (i.e. site samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar sites are to each other, the closer they are located within the ordination space. This procedure is useful to display the samples interrelations on a continuous scale.

ANOSIM (Analysis of Similarities) and SIMPER (Similarity of Percentages)

ANOSIM is a multivariate non-parametric permutation procedure used to test for statistical difference between groups. ANOSIM is not required to adhere to many of the assumptions placed upon other parametric procedures. The SIMPER routine was used to identify taxa that contributed most to the average dissimilarity between site groups identified from the ANOSIM. SIMPER computes the average dissimilarity (Bray-Curtis) between all pairs of inter-group samples (every sample in group 1 with every sample in group 2 etc.) and then breaks this average down into the separate contributions from each taxon. In addition to calculating the average dissimilarity between groups, SIMPER also calculates the average similarity within a group.

2.4 Impact Assessment

The assessment of impacts followed the method detailed in the SREIS. This method quantifies a significance rating of impacts as a function of the sensitivity of freshwater aquatic values and the magnitude of the impact (see AMEC 2013 for specific criteria used and the significance matrix applied).

3. DESCRIPTION OF ENVIRONMENTAL VALUES

3.1 Desktop review

3.1.1 Macroinvertebrate Literature Review

The issue of macroinvertebrate responses to altered low-flow hydrology in Queensland Rivers has recently received significant Government attention (Smythe-McGuinness et al. 2012), as has the ecological health of the Murray Darling headwaters through 'Healthy HeadWaters Coal Seam Gas Water Feasibility Study' (DSITIA, 2012). Some key points have been re-iterated here for the purpose of providing important context regarding potential Project impacts.

According to McGregor et al. (2011) our current empirical understanding of the critical water requirements of Queensland's aquatic ecosystems and their response to water management regimes ranges from rudimentary to non-existent, with few examples of general transferable quantitative relationships between flow alteration and ecological responses in the scientific literature. Consequently, there is still much reliance on broad conceptual relationships and expert opinion.

Aquatic biota inhabiting ephemeral and semi-permanent waterways have developed flexible physiological and lifecycle characteristics that enable them to survive episodic high magnitude flows and extended periods of no-flow (Smythe-McGuinness et al. 2012). These characteristics, which allow biota to survive unpredictable and often harsh conditions, also mean they are sensitive to flow modifications that alter those conditions (Bunn & Arthington 2002). The pattern of drying and wetting in such systems is also a large determinant of species diversity and richness (Boulton and Brock 1999). Accordingly, changes away from natural low or no flow conditions can thus negatively impact ephemeral freshwater ecosystems – either as a reduction in the frequency or duration of low-flows (Smythe-McGuinness et al. 2012). This is especially so where changes exceed thresholds of biotic resistance and resilience (Smythe-McGuinness et al. 2012).

Potential impacts on macroinvertebrate community structure could result from: (1) changes in water quality; (2) changes in physical habitat (both microhabitat and macrohabitat); (3) changes in flow regime (including the magnitude, frequency, duration, timing and rate of change); and, (4) indirectly due to changes in other biotic indicators. In the absence of more specific information outlining how these factors are expected to change as a result of the Project, it is difficult to accurately quantify how macroinvertebrate communities within and downstream of the receiving systems of discharge at DA2 and DA9 will be impacted.

With respect to potential Project impacts that may occur as a result of changes to the hydrological regime, some conceptual understanding is presented in the literature. Marsh et al. (2012) suggest that predictable changes in macroinvertebrate community composition can be expected as hydrological regimes shift between perennial and highly ephemeral flows. Perennial streams are expected to support a wider diversity of more sensitive taxa, whilst ephemeral streams are expected to support a lower diversity of more tolerant taxa (Marsh et al. 2012). It is noted, however, that the premise (and data-sets) upon which Marsh et al. (2012) base this inference, is observations made when flow regimes are altered from perennial to ephemeral, not the other way around. Marsh et al., also note that any changes in hydrological regime will also depend upon a complex association with water quality. The concept of 'thresholds' is also not discussed by Marsh et al. (2012). Thus, although Marsh et al. (2012) provide some important context, it is difficult to understand how this will specifically relate back to the Project.

3.2 Field surveys

The section provides a summary of field survey results for each of the aquatic indicators sampled. Macroinvertebrate results are reported for all sites. Other aquatic indicators (physical habitat, water quality, macrophytes, fish and reptiles) were sampled at sites that had not previously been surveyed (DA2-8, DA2-9 and SAQ-2) and are also briefly presented herein. Biophysical data collected for the purpose of elucidating patterns in macroinvertebrate community data is presented in **Attachment 1** and has been discussed where relevant.

The discussion of results for each aquatic indicator are presented in the following order; Drainage Area 2, Drainage Area 9 and Macintyre and Weir Rivers catchment (SAQ-2 in Commoron Creek).

3.2.1 Hydrological Conditions

Sites DA2-8 and DA2-9 are situated on Dogwood Creek, for which a hydrological description is provided in the SREIS. Two important distinctions should be made with respect to these sites (1) the depth of Dogwood Creek at site DA2-8 suggests this site to be situated in a semi-permanent or possibly permanent pool – although a dry-season survey would be needed to confirm this; and, (2) due to its location almost immediately downstream of Miles Weir, the flow regime at site DA2-9 would be more regulated than other sites on Dogwood Creek.

Site SAQ-2 was situated on Commoron Creek. At the point of survey, Commoron Creek is a small ephemeral waterway, within which surface water would only persist during and immediately following significant rainfall events.

3.2.2 Physical Habitat

An overview and detailed summary of key physical habitat features at sites DA2-8, DA2-9 and SAQ-2 is presented in **Table 3.1** and **Table 3.2**. Details of the physical habitat for all other sites are provided in the SREIS. Physical attributes recorded at all sites surveyed in May 2013 are presented in **Attachment 1**. Note that riparian and instream habitat constituents are determined by percentage coverage of the area and may therefore exceed 100% due to overlapping of various constituents (e.g. shrubs existing under 100% tree coverage). Photos of all sites surveyed in May 2013 are presented in **Attachment 4**.

Reach Habitat

Sites DA2-8 and DA2-9 consisted entirely of sandy pool macrohabitat.

Site SAQ-2 was dry at the time of sampling. This site would support shallow sandy pool habitat (<0.5 m) and shallow run habitat (<10 cm) for a small portion of the year; during the wet season following heavy and sustained precipitation.

Substrate

Substrate at both sites DA2-8 and DA2-9 was dominated by sand (70%), with a low portion of silt-clay (30%).

Substrate at site SAQ-2 was dominated by silt/clay (80%). Low portions of sand (10%), pebbles (5%) and cobbles (5%) were also present.

Riparian Zone

Riparian vegetation at site DA2-8 was dominated equally by tall trees (>10 m) and grass (each at 30%), with shrubs (25%) small trees (<10 m) (15%) and bare ground (10%) also present. Site DA2-9 was also dominated by equally by tall trees and grass (each at 30%), with small trees (20%), shrubs (5%) and bare ground (15%) also present.

Site SAQ-2 was dominated by grass (40%), with tall tress (30%), small trees (30%), shrubs (2%) and bare ground (15%) also present.

Woody Debris

Woody debris at site DA2-8 is estimated on the basis of visible habitat to consist of detritus (15%) with small amounts of sticks (2%) and branches (1%), although visual inspection was hindered by deep water and poor water clarity.

Woody debris at site DA2-9 consisted of a mixture of detritus (20%), sticks (15%), branches (15%) and logs (10%).

Woody debris at site SAQ-2 consisted of a mixture of detritus (15%), sticks (5%), branches (5%) and logs (1%).

Table 3.1 Overview Summary of Key Habitat Characteristics at SREISa Survey Sites

Site ID	Hydrology	Stream Order[3]	Stream Width		Dominant Substrate	Habitat Type			Adjacent Land-Use	Mean Riparian Zone Vegetation width (m)	Bank Erosion	AUSRIVAS Habitat Assessment Rating
			Mean (m)	Max. (m)		Dominant	Other	Micro				
DA2-8	ephemeral	6	7	8	silt-clay / sand	Pool (sandy)	Run[1]	Detritus, structural woody habitat, macrophytes[2], undercut bank, overhanging/trailing vegetation	Natural / light grazing	20+	Limited	62
DA2-9	ephemeral	6	9	20	silt-clay / sand	Pool (sandy)	Run[1]	Detritus, structural woody habitat, macrophytes[2], undercut bank, overhanging/trailing vegetation	Natural / light grazing	20+	Limited	70
SAQ-2	ephemeral	3	2^	7.5	silt-clay	Pool (sandy)	Run[1]	Detritus, structural woody habitat, trailing vegetation	Natural / light grazing	30+	Moderate	41

Notes:

1 Run macrohabitat would only persist during the wet-season; during the drier months this macrohabitat feature would be a shallow sandy pool.

2 Emergent macrophytes that were present within the wetted width of the channel; does not include floating or submerged macrophytes

3 Strahler (1963) method of stream order classification.

^ Site dry at time of survey; the value provided is an estimate of 'wet-season' wetted width

Table 3.2 Detailed Summary of Key Habitat Characteristics at SREISa Survey Sites

Aquatic Habitat ^		Site		
		DA2-8	DA2-9	SAQ-2
Reach Habitat [1]	Dry	0	0	100*
	Pool (sandy)	100	100	0
	Pool (rocky)	0	0	0
	Run	0	0	0
	Riffle	0	0	0
Substrate [2]	Silt/Clay	30	30	80
	Sand	70	70	10
	Gravel	0	0	0
	Pebble	0	0	5
	Cobble	0	0	5
	Boulder	0	0	0
	Bedrock	0	0	0
Riparian Vegetation	Bare Ground	10	15	15
	Grass	30	30	40
	Shrubs	25	5	2
	Trees < 10 m	15	20	30
	Trees > 10 m	35	30	30
Woody Debris	Logs	0	10	1
	Branches	1	10	5
	Sticks	2	15	5
	Detritus	15	20	15

Notes:
1 Sum of all reach habitat categories equals 100%
^ All values presented are percentages (%)
* During the 'wetter months' site would predominantly be sandy pool

3.2.3 Water Quality

A summary of water quality parameters at sites DA2-8, DA2-9, DA9-5, DA9-7 and SAQ-2 is presented in **Table 3.3**. Discussion of the water quality for all other sites are provided in the SREIS, however, water quality data recorded for all sites in May 2013 are presented in **Attachment 1**.

Temperature

Water temperature was 18.3 and 17.2ºC at sites DA2-8 and DA2-9 respectively, and 17.8 and 16.9 ºC at sites DA9-5 and DA9-7 respectively.

pH

A pH value of 6.2 and 6.8 was recorded at sites DA2-8 and DA2-9, respectively. The value recorded at site DA2-8 was slightly below the relevant minimum ANZECC (2000) guideline value of 6.5. A pH value of 7.5 and 7.2 was recorded at sites DA9-5 and DA9-7, respectively. The values recorded at sites within the DA9 receiving system were within the ANZECC (2000) guideline values of 6.5 – 8.5.

Electrical Conductivity (EC)

EC was 138 and 109µS/cm at sites DA2-8 and DA2-9 respectively. The value recorded at site DA2-9 was marginally below the relevant ANZECC (2000) minimum guideline value of 125µS/cm.

Dissolved Oxygen (DO)

DO was 61.0 and 85.2% saturation at sites DA2-8 and DA2-9 respectively. The value recorded at site DA2-9 was marginally below the relevant ANZECC (2000) minimum guideline value of 85% saturation. Dissolved oxygen was not recorded at sites DA9-5 and DA9-7 due to equipment failure.

Turbidity

Turbidity was 78.3 and 51.6 NTU at sites DA2-8 and DA2-9 respectively, and 16.1 and 17.2 at sites DA9-5 and DA9-7 respectively. The values recorded at both sites on the DA2 receiving system exceeded the relevant ANZECC (2000) maximum guideline value of 50 NTU, while the values were below the guidelines at the two sites within the DA9 receiving system.

Table 3.3 Summary of In-situ Water Quality at SREISa Survey Sites

Parameter	Measurement Units	Site				
		DA2-8	DA2-9	DA9-5	DA9-7	SAQ-2
Water Temperature	° C	18.3	17.2	17.8	16.9	Dry
pH	pH Units	6.2	6.8	7.5	7.2	Dry
Electrical Conductivity	µS/cm	138.0	109.0	397	451	Dry
Dissolved Oxygen	% saturation	61.0	85.2	NR	NR	Dry
Turbidity	NTU	78.3	51.6	16.1	17.2	Dry

Notes:
Dry Indicates site to be dry at time of survey
NR Not recorded due to equipment failure

3.2.4 Aquatic Flora

A summary of macrophyte taxa recorded at sites DA2-8, DA2-9, DA9-5, DA9-7 and SAQ-2 during SREISa field surveys is presented in **Table 3.4**.

Macrophyte species diversity was four and six for sites DA2-8 and DA2-9 respectively and three and four at sites DA9-5 and DA9-7 respectively. All of these species were of the emergent growth form, with the exception of Salvinia (*Salvinia molesta)* which is a floating macrophyte. Salvinia is an introduced species and is listed as a 'Class 2 declared pest' under the *Land Protection (Pest and Stock Route Management) Act 2002*. No species of conservation significance were recorded.

Five macrophyte species were recorded at site SAQ-2. Para grass (*Urochloa mutica*) is an introduced species but is not listed as a 'declared pest'. No species of conservation significance were recorded.

Table 3.4 Summary of Macrophyte Taxa recorded during SREISa Surveys

Species Name	Common Name	Site				
		DA2-8	DA2-9	DA9-5	DA9-7	SAQ-2
Emergent Growth-Form						
Cyperus spp.	sedge		●		●	●
Juncus usitatus	common rush	●	●	●	●	●
Lomandra longifolia	spiny-headed mat-rush	●	●			
Persicaria decipiens	slender knotweed	●	●	●	●	
Phragmites australis	common reed		●	●	●	
Carex fascicularis	tassel sedge	●				●
Eleocharis sphacelata	tall spike-rush					●
Urochloa mutica	para grass					●
Submerged Growth-Form						
None						
Floating Growth-Form						
*Salvinia molesta**	salvinia		●			

Notes:

● Taxa present.

* Listed as 'Class 2 declared pest' under *Land Protection (Pest and Stock Route Management) Act 2002*

3.2.5 Macroinvertebrates

3.2.5.1 Overview

A list of macroinvertebrate taxa collected during the SREISa survey is presented in **Table 3.5**. The complete macroinvertebrate data-set is presented in **Attachment 2**.

A total of 54, 49 and 34 taxa (predominantly family) were collected from the DA2 and DA9 receiving systems and from SAQ-1, respectively. At the level of taxonomic resolution applied, none of the taxa collected are considered noteworthy with respect to conservation status at the local, regional or national scales. One exotic family, Physidae (freshwater snail), was collected from a single site within the DA9 receiving system. Although exotic, this family is now considered to have naturalised in Australia.

Macrocrustaceans were widespread and abundant throughout the DA2 and DA9 receiving systems, with three of the four families of Australian freshwater decapod – Atyidae, Palaemonidae and Parasticidae – collected in both receiving systems. Atyidae and Parasticidae were equally widespread throughout the DA2 receiving system, being collected from all sites. Palaemonidae was the most widespread throughout the DA9 receiving system, also being collected from all sites. All three of these taxa are widespread and typically found in waterways such as those surveyed in this assessment.

Table 3.5 Summary of Macroinvertebrate Taxa Collected at SREISa Survey Sites

Taxa		Traits		Site																
Order	Family	SIGNAL2	FFG	DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA2-8	DA2-9	DA9-1	DA9-2	DA9-3	DA9-4	DA9-5	DA9-7	DA9-21	DA9-22	SAQ-1
Acarina	Acarina	6	P	•		•			•	•	•		•	•				•	•	•
Bivalvia	Hyriidae	5	P	•																•
Coleoptera	Dytiscidae	2	P	•	•	•	•	•	•	•	•		•				•	•	•	•
Coleoptera	Gyrinidae	4	P	•		•	•	•	•											•
Coleoptera	Heteroceridae	1	S									•							•	
Coleoptera	Hydraenidae	3	GC			•		•	•		•	•	•	•	•	•	•	•	•	•
Coleoptera	Hydrochidae	4	S	•	•	•	•	•	•	•	•		•				•	•	•	•
Coleoptera	Hydrophilidae	2	P	•			•	•	•	•	•	•				•			•	•
Coleoptera	Noteridae	4	P			•	•	•		•	•	•						•	•	
Coleoptera	Staphylinidae	3	P				•							•				•		
Collembola	Collembola	1	GC			•		•	•			•		•			•	•	•	
Crustacea [4]	Cladocera [3]	^	FF	•	•	•	•	•	•	•	•							•	•	•
Crustacea [4]	Copepoda [2]	^	GC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Crustacea [4]	Ostracoda [1]	^	FF	•	•					•	•	•						•	•	•
Decapoda	Atyidae	3	GC	•	•	•	•	•	•	•	•	•	•	•		•		•	•	•
Decapoda	Palaemonidae	4	GC				•	•	•	•	•	•	•	•	•	•	•	•	•	•
Decapoda	Parastacidae	4	S	•	•	•	•	•	•	•	•					•	•		•	•
Diptera	Ceratopogonidae	4	P	•	•	•	•	•		•	•	•				•	•	•		•
Diptera	Chironominae [5]	3	FF	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Diptera	Culicidae	1	FF	•	•	•	•	•	•	•	•	•				•	•	•	•	
Diptera	Empididae	5	P														•			

Taxa		Traits		Site																
Order	**Family**	**SIGNAL2**	**FFG**	**DA2-1**	**DA2-2**	**DA2-4**	**DA2-5**	**DA2-6**	**DA2-7**	**DA2-8**	**DA2-9**	**DA9-1**	**DA9-2**	**DA9-3**	**DA9-4**	**DA9-5**	**DA9-7**	**DA9-21**	**DA9-22**	**SAQ-1**
Diptera	Ephydridae	2	G															•		
Diptera	Orthocladiinae [5]	4	GC			•		•	•		•	•		•		•	•	•		•
Diptera	Psychodidae	3	GC				•													
Diptera	Simuliidae	5	FF						•		•					•	•			
Diptera	Tabanidae	3	P																	•
Diptera	Tanypodinae [5]	4	P	•	•	•	•	•	•	•							•	•	•	•
Diptera	Tipulidae	5	GC		•				•								•			
Ephemeroptera	Baetidae	5	GC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Ephemeroptera	Caenidae	4	GC	•	•	•		•		•		•	•	•	•	•	•	•	•	•
Ephemeroptera	Leptophlebiidae	8	GC	•	•	•	•	•	•	•			•			•	•			
Gastropoda	Ancylidae	4	G	•	•		•		•		•								•	•
Gastropoda	Lymnaeidae	1	G		•						•									
Gastropoda	Physidae	1	G															•		
Gastropoda	Planorbidae	2	G		•	•				•								•	•	
Hemiptera	Corixidae	2	P	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Hemiptera	Gelastocoridae	5	P				•													
Hemiptera	Gerridae	4	P	•							•		•		•			•		•
Hemiptera	Hydrometridae	3	P			•		•	•									•	•	
Hemiptera	Nepidae	3	P							•						•			•	
Hemiptera	Notonectidae	1	P		•		•	•	•	•	•	•				•	•	•	•	•
Hemiptera	Pleidae	2	P	•		•		•		•	•									•
Hemiptera	Veliidae	3	P		•	•	•	•	•	•	•					•		•	•	•

Taxa		Traits		Site																
Order	**Family**	**SIGNAL2**	**FFG**	**DA2-1**	**DA2-2**	**DA2-4**	**DA2-5**	**DA2-6**	**DA2-7**	**DA2-8**	**DA2-9**	**DA9-1**	**DA9-2**	**DA9-3**	**DA9-4**	**DA9-5**	**DA9-7**	**DA9-21**	**DA9-22**	**SAQ-1**
Hirudinea	Eropdellidae	1	P								●									
Hirudinea	Glossiphoniidae	1	P							●										
Hydrozoa	Hydridae	2	P								●									
Isopoda	Cirolanidae	2	P										●	●	●	●			●	
Lepidoptera	Pyralidae	3	S								●									
Nematoda	Nematoda	3	P	●		●			●						●		●	●	●	●
Odonata	Coenagrionidae	2	P	●	●	●	●	●		●										●
Odonata	Gomphidae	5	P	●		●	●	●	●	●	●							●		●
Odonata	Hemicorduliidae	5	P								●								●	●
Odonata	Isostictidae	3	P				●	●	●	●	●									
Odonata	Libellulidae	4	P	●	●					●									●	
Odonata	Protoneuridae	4	P														●			
Odonata	Synthemistidae	2	P															●	●	
Oligochaeta	Oligochaeta	2	GC	●	●	●	●	●	●	●	●			●		●	●	●	●	●
Trichoptera	Ecnomidae	4	P			●	●	●	●	●	●				●	●				●
Trichoptera	Hydropsychidae	6	GC				●		●		●						●			
Trichoptera	Hydroptilidae	4	S																●	
Trichoptera	Leptoceridae	6	S	●	●	●	●	●	●	●	●	●	●			●	●	●		●

Taxa		Traits		Site																
Order	**Family**	**SIGNAL2**	**FFG**	**DA2-1**	**DA2-2**	**DA2-4**	**DA2-5**	**DA2-6**	**DA2-7**	**DA2-8**	**DA2-9**	**DA9-1**	**DA9-2**	**DA9-3**	**DA9-4**	**DA9-5**	**DA9-7**	**DA9-21**	**DA9-22**	**SAQ-1**
Turbellaria	Temnocephalidae	5	P	●			●		●						●			●	●	●
Turbellaria	Dugesiidae	2	GC								●									
TOTAL				**29**	**25**	**30**	**31**	**31**	**33**	**32**	**36**	**18**	**15**	**14**	**12**	**22**	**25**	**33**	**34**	**34**

Notes:

●	taxa present (either edge and/or bed habitat)
-	taxa not identified to family level
^	no SIGNAL2 score available
1	indicates taxa as class
2	indicates taxa as sub-class
3	indicates taxa as order
4	indicates taxa as sub-phylum
5	indicates taxa as sub-family
FFG	functional feeding group (P = predator, GC = gatherer/collector; FF = filter-feeder; G = grazer/scraper; S = shredder) - refer to **Table 2.4**
green	taxa deemed comparatively sensitive to pollution (PET taxa and others)

3.2.5.2 Diversity of Taxa (Taxa Richness)

Taxa richness of edge communities within the DA2 receiving system ranged from 22 to 32, while bed communities exhibited lower taxa richness ranging from 10-18 taxa (**Figure 3.1** and **Table 3.6**). With the exception of site DA2-2, which contained sparser microhabitat (shallow water with sparse detrital material over a sand/gravel substrate), the diversity of edge communities appears to increase slightly with increasing distance downstream. There was no similar spatial pattern in the diversity of bed communities.

Correlation between these communities and biophysical attributes were generally not obvious and while it is possible that there may be causative factors, it is equally likely that these observations reflect natural system variability.

The taxa richness of edge communities within the DA9 receiving system ranged from 12 to 32, while the bed communities exhibited richness ranging from 7 to 16 taxa (**Figure 3.1** and **Table 3.6**). Note that bed samples could not be obtained for sites DA9-1 to DA9-4 due the depth and associated safety concerns.

The diversity of edge communities inhabiting the Condamine River (sites DA9-1 – DA9-7) was lower than those inhabiting Crawlers Creek (sites DA9-21 and DA9-22). Additionally, the diversity of edge communities within the Condamine River sites varies spatially, with sites within the operating head range of the weir (sites DA2-1 and DA9-4) having lower diversity than those downstream of the weir (DA9-5 and DA9-7). This is likely to reflect hydrological influences as well as habitat quality, with sites downstream having more diverse habitat and sites upstream comprised largely of shallow detrital microhabitat.

Crawlers Creek supports a greater diversity of edge microhabitat than the Condamine River sites, which is likely to have resulted in the comparatively higher taxonomic diversity. The higher taxa richness within Crawlers Creek sites may also be attributable to the concentration of animals within 'refugial' pools, as both of the Crawlers Creek sites consisted entirely of non-flowing pool habitat, with water levels continuing to recede at the time of sampling.

Stream bed communities were generally more diverse in the Condamine system than Crawlers Creek, reflecting the more diverse flow characteristics, substrate and microhabitat of the Condamine River sites. Crawlers Creek sites were non-flowing pool habitat with uniform sand substrate, which limits taxa diversity.

The taxa richness of edge and bed macroinvertebrate communities inhabiting site SAQ-1 was 32 and 19, respectively.

Taxa richness of edge habitat was higher than that of bed habitat at all sites sampled for the SREISa. This is likely attributable to a comparatively higher diversity of edge microhabitat.

Whilst bed habitats throughout the survey area typically consisted of an almost bare sand/gravel or silt bed with a low percentage cover of detritus, edge habitats typically supported a variety of microhabitat features (such as large woody debris, undercut banks, trailing vegetation, macrophytes, tree roots). It is of note that high flows typically experienced during the wet-season would reduce the presence and diversity of bed microhabitat.

3.2.5.3 Diversity of PET Taxa (PET Taxa Richness)

PET richness of edge habitat within the DA2 receiving system ranged from three to five taxa, while edge communities contained two to four taxa (**Figure 3.2** and **Table 3.2**). There were no clear spatial patterns in distribution, and there did not appear to be a correlation between PET richness in bed and edge samples within each site.

Similarly, there did not appear to be a correlation between PET richness and overall taxonomic diversity at sites within the DA2 receiving system. For example, edge habitat at site DA2-9 supported the highest taxa richness but the lowest PET taxa richness. In part it is likely that these results are reflective of the generally low PET richness of these communities, which is a normal feature of these systems but increases the statistical error, as the presence or absence of a single individual PET taxon can skew the analysis.

PET taxa richness within the DA9 receiving system ranged from two to four in edge habitat and from zero to five in bed habitat (**Figure 3.2** and **Table 3.6**).

PET richness for Condamine River sites was lowest at DA9-4 (immediately upstream of the Cecil Plains weir). Sites downstream of Cecil Plains Weir (DA9-5 and DA9-7) displayed a marked increase in PET taxa richness than was recorded at site DA9-4, probably reflecting the uniform detrital habitat and possible lacustrine influences. Factors influencing taxa richness in both edge and bed appear to also drive PET taxa richness within DA9. The reason for the PET richness being lowest upstream of the weir is unclear and may be a result of a single sampling event.

This observation was not mirrored for Crawlers Creek sites or for DA9-5, where a correlation between taxa diversity and PET taxa diversity did not appear to exist.

PET taxa richness was three for both edge and bed habitat at site SAQ-1.

Whilst it was observed that overall taxa diversity was lower in bed samples than edge samples across all sites, the same was not true for PET taxa richness.

3.2.5.4 Pollution Sensitivity (SIGNAL2)

The average SIGNAL2 scores of edge habitat within the DA2 receiving system ranged from 3.2 to 3.7; and from 3.6 to 4.3 for bed samples (**Figure 3.3** and **Table 3.6**). No spatial patterns were observed within equivalent habitats between sites, with all edge and bed SIGNAL2 scores being comparable across sites surveyed.

Evaluation of average SIGNAL2 scores against taxa richness reveals all edge communities within the DA2 receiving system fall within ‘Quadrant 2’ (**Figure 3.5**). According to Chessman (2003), this suggests high salinity or nutrient levels (either natural or anthropogenic). However, caution must be exercised when interpreting these results as the quadrant boundaries of the bi-plot have been calibrated in accordance with generic values relevant to a wide geographic region (i.e. the Murray Darling Basin as a whole), as data relevant to the specific study region are not currently available (refer to **Section 2.4.4.1**). Experience suggests that ephemeral streams, even those in good health, are rarely placed into ‘Quadrant 1’, which indicates that refinement of the quadrat boundaries to meet local conditions is required before these data can be considered reliable.

The average SIGNAL2 scores within the DA9 receiving system ranged from 2.9 to 4.0 for edge habitat and from 3.4 to 4.1 for bed habitat (**Figure 3.3** and **Table 3.6**).

Sites on the Condamine River within the operating head range of Cecil Plains Weir exhibited decreasing SIGNAL2 scores with increasing proximity to the weir, with the exception of site DA9-1. This observation broadly reflects the PET richness and it is considered likely that the same factors (hydrology and low microhabitat diversity) are influencing both of these indicators. SIGNAL2 appeared to increase downstream of the weir.

Sites situated on Crawlers Creek (DA9-21 and DA9-22) were characterized by a lower average SIGNAL2 score than those on Condamine River, with the exception of DA9-1; which was similar to the Condamine River sites.

Comparison of average SIGNAL2 scores against taxa richness reveals half of the edge communities fall within ‘Quadrant 2’ and half within ‘Quadrant 4’ (**Figure 3.5**). According to Chessman (2003), sites within ‘Quadrant 4’ typically indicate urban, industrial or agricultural pollution, as well as the effects of dams. This explains observations at sites DA2-1 – DA9-4, all of which were situated within the operating head range of Cecil Plains Weir. As noted above, the results for sites situated in ‘Quadrant 2’ should be interpreted with caution due to the calibration of the quadrant boundaries.

The average SIGNAL2 scores at site SAQ-1 were 3.5 and 3.8 for edge and bed habitat, respectively.

The average SIGNAL2 score of bed habitat was higher than that of edge habitat at all SREISa sites and was the opposite of that observed for taxa richness levels, which were higher in edge than bed habitat. Simple linear correlation suggests a weak negative correlation (r = -0.557) between SIGNAL2 and taxa richness for communities within the SREISa surveys area (**Figure 3.5**).

3.2.5.5 Community Condition (AUSRIVAS)

Site SAQ-1 received an AUSRIVAS Band X for both edge (O/E50 1.25) and bed (O/E50 1.57) habitat. According to AUSRIVAS modelling band descriptions (refer to **Table 2.5**), this indicates that the site is “more biologically diverse than the reference sites it was evaluated against”.

Data from all other sites were outside of the experience of the AUSRIVAS models, hence no outputs could be generated (see **Section 2.3.4.1**).

Figure 3.1 Taxa Richness of SREISa Macroinvertebrate Communities

Note: Green colouring indicates site situated within the Drainage Area 2 receiving system; **Purple** colouring indicates site situated within the Drainage Area 9 receiving system; **Blue** colouring indicates site situated within the Dawson Catchment; no bed sampled was collected at site DA9-1, DA9-2, DA9-3 and DA9-4

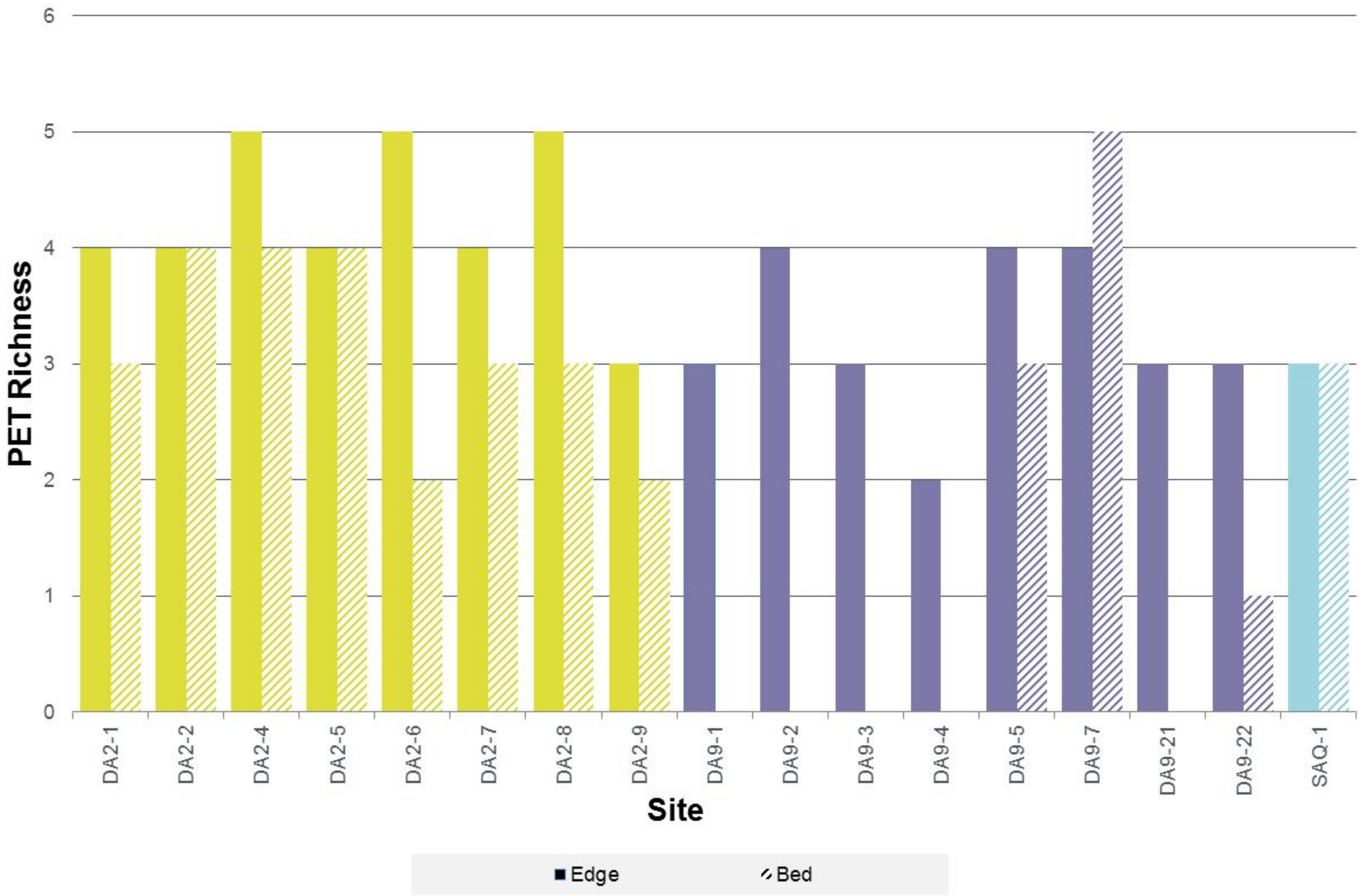

Figure 3.2 PET Richness of SREISa Macroinvertebrate Communities

Note: Green colouring indicates site situated within the Drainage Area 2 receiving system; **Purple** colouring indicates site situated within the Drainage Area 9 receiving system; **Blue** colouring indicates site situated within the Dawson Catchment; no bed sampled was collected at site DA9-1, DA9-2, DA9-3 and DA9-4

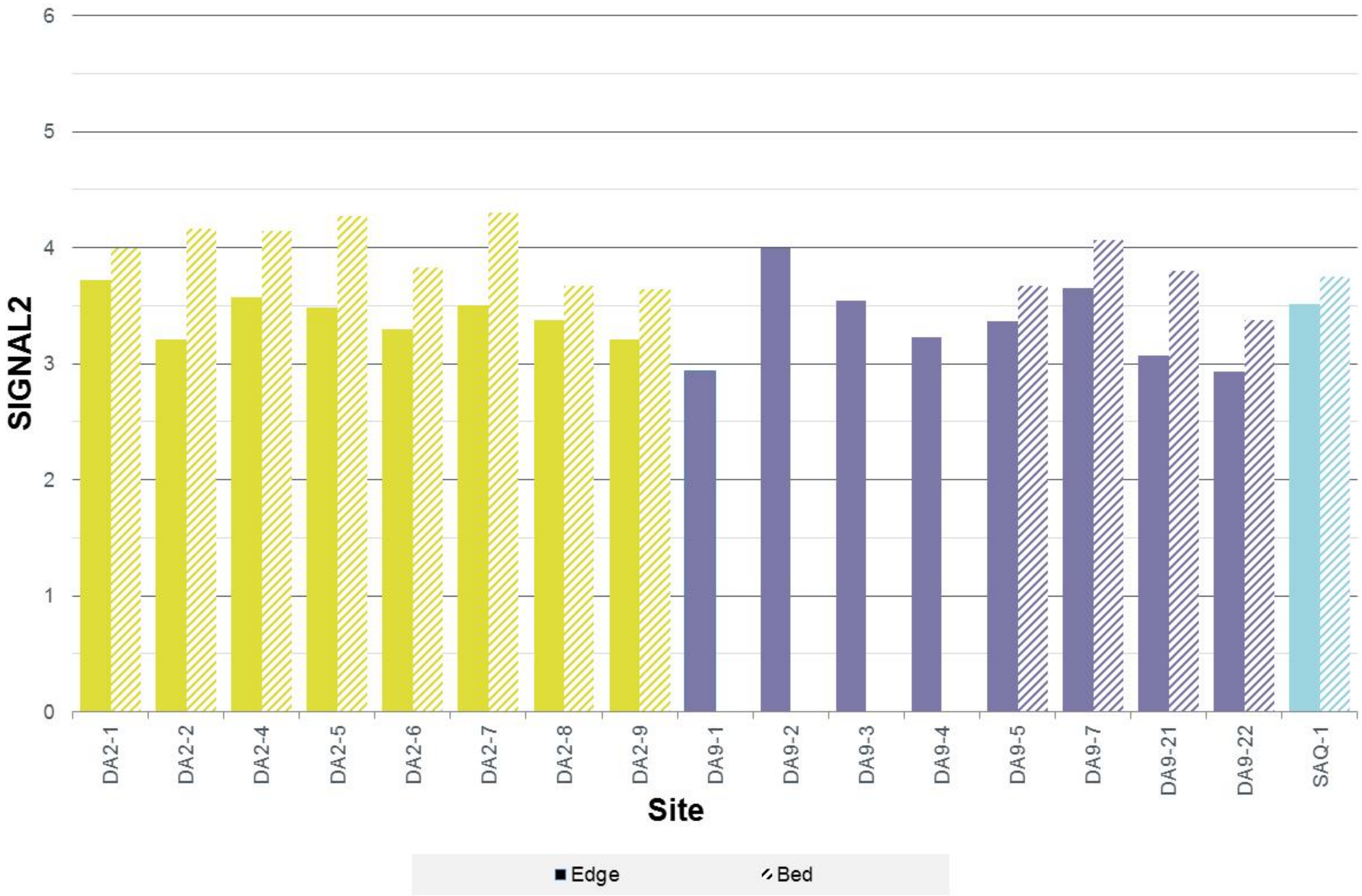

Figure 3.3 Average SIGNAL2 scores of SREISa Macroinvertebrate Communities

Note: Green colouring indicates site situated within the Drainage Area 2 receiving system; **Purple** colouring indicates site situated within the Drainage Area 9 receiving system; **Blue** colouring indicates site situated within the Dawson Catchment; no bed sampled was collected at site DA9-1, DA9-2, DA9-3 and DA9-4

Table 3.6 SREISa Macroinvertebrate Data Univariate Analysis Results Summary

Indices	Habitat	Site																
		DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA2-8	DA2-9	DA9-1	DA9-2	DA9-3	DA9-4	DA9-5	DA9-7	DA9-21	DA9-22	SAQ-1
Taxa Richness	Edge	28	22	28	28	28	30	30	32	18	15	12	14	20	21	31	32	32
	Pool Bed	11	15	16	13	14	10	18	17	-	-	-	-	10	16	7	9	19
PET Richness	Edge	4	4	5	4	5	4	5	3	3	4	3	2	4	4	3	3	3
	Pool Bed	3	4	4	4	2	3	3	2	-	-	-	-	3	5	0	1	3
SIGNAL2	Edge	3.72	3.21	3.58	3.48	3.30	3.50	3.37	3.21	2.94	4.00	3.55	3.23	3.37	3.65	3.07	2.93	3.52
	Pool Bed	4.00	4.17	4.14	4.27	3.83	4.30	3.67	3.64	-	-	-	-	3.67	4.06	3.80	3.38	3.75
AUSRIVAS	Edge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-
	Pool Bed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-

Notes:

\- habitat not sampled (refer to **Section 2.4.2**)

NA AUSRIVAS model could not be run (refer to **Section 2.4.4.1**)

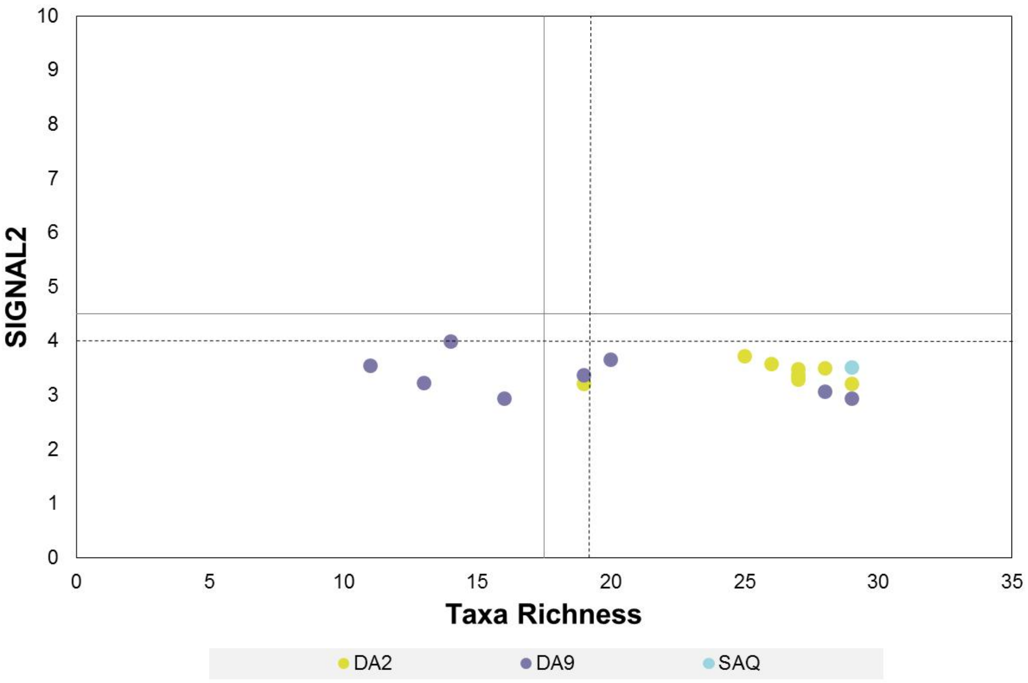

Figure 3.4 **SIGNAL2 / Taxa Richness Bi-plot of SREISa Edge Macroinvertebrate Communities**

Note: solid black line indicates quadrant boundaries for all DA2 and DA9 sites, dashed black line quadrant boundaries for site SAQ-2

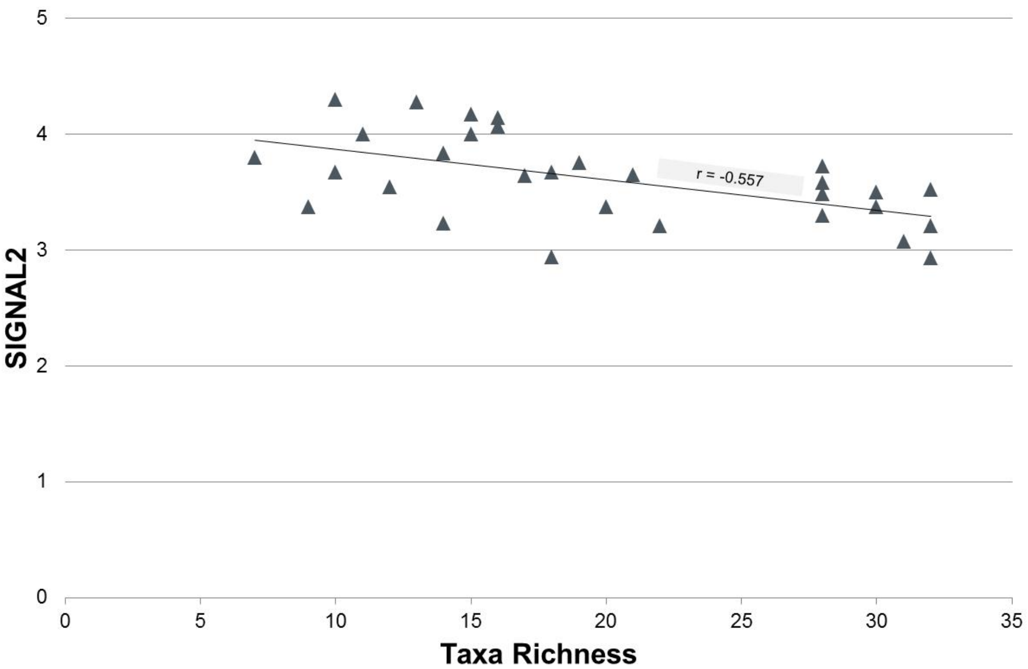

Figure 3.5 **Correlation of SIGNAL2 and Taxa Richness for SREIS Macroinvertebrate Communities**

Note: r indicates the results from a simple linear correlation test

3.2.5.6 Functional Feeding Group Structure

Functional feeding group structure of edge habitat communities was comparable between all sites within the DA2 receiving system (**Figure 3.6**). Similarly, the communities within bed habitats were comparable between all DA2 sites.

Edge sites were dominated by generalists; predominantly predators (approx. 30 - 50%) with notable contributions from gatherer/collectors (approx. 20 - 30%) and a low number of filter-feeders (approx. 10 - 15%). The more specialist groups were present in only low proportions; shredders contributing approximately 10%, whilst grazers ranged between 0 - 9%.

At bed sites, generalists dominated, with gatherer/collectors strongly represented at all sites (approx. 40 – 70%), followed by filter-feeders (approx. 20-30%), with predators the least represented generalist feeding group (approx. 2 - 10%). The specialist feeding groups were not present at all sites, with shredders collected from six sites (approx. 10 - 20%) and grazers at only a single site (8%). Bed communities at sites DA2-5 and DA2-7 did not support any specialist feeding groups.

Functional feeding group structure of edge habitats throughout the DA9 receiving system were dominated by generalists; at some sites these were predominantly predators (approx. 30-60%), and at other sites gatherer/collectors (approx. 20-60%) (**Figure 3.7**). The remaining generalist feeding group, filter-feeders, was also present at all sites (approx. 10-15%). The specialist feeding groups were not present at all sites, with shredders collected from six sites (approx. 5 - 10%) and grazers at only two sites (5-10%). No specialist feeding groups were present at sites DA9-3 and DA9-4.

The relationship between bed and edge communities within the DA9 receiving system mirrored the general pattern of results observed within the DA2 receiving system. All sites were dominated by generalists; largely gatherer/collectors (approx. 50 - 80%), followed by filter-feeders (approx. 10-40%) and lastly predators (2 - 15%). Representation of specialist feeders was sparse, with only a single site (DA9-7) found to support shredders (approx. 10%) and grazers were entirely absent.

No consistent patterns in functional feeding group were apparent with respect to position within either the DA2 or DA9 receiving system, for either edge or bed communities. The relatively low representation of specialist feeders throughout the SREISa surveys area reflects the ephemeral nature of waterways. This is because (1) environmental conditions within ephemeral waterways exhibit a high degree of temporal variability, thus exposing macroinvertebrate communities to high degrees of perturbation, and (2) generally do not support the presence of floating/submerged macrophytes, periphyton and algae, preferred by specialist feeders.

3.2.5.7 Flow Preference Group Structure

Representation of the various flow preference groups within bed communities varied throughout the DA2 receiving system (**Figure 3.8**). Taxa assigned to the ‘no preference’ group dominated at seven sites (approx. 35 - 70%), with notable representation of those assigned to the ‘low/no flow’ group (approx. 20 - 50) which dominated the eight sites. Taxa from the ‘high flow’ grouping were collected from only three sites, in low proportion (approx. 10 - 20%).

Figure 3.6 FFG Composition of SREISa Edge Macroinvertebrate Communities

Note: P = predator, GC = gather/collector, FF = filter-feeder, S = shredder, G = grazer / scraper

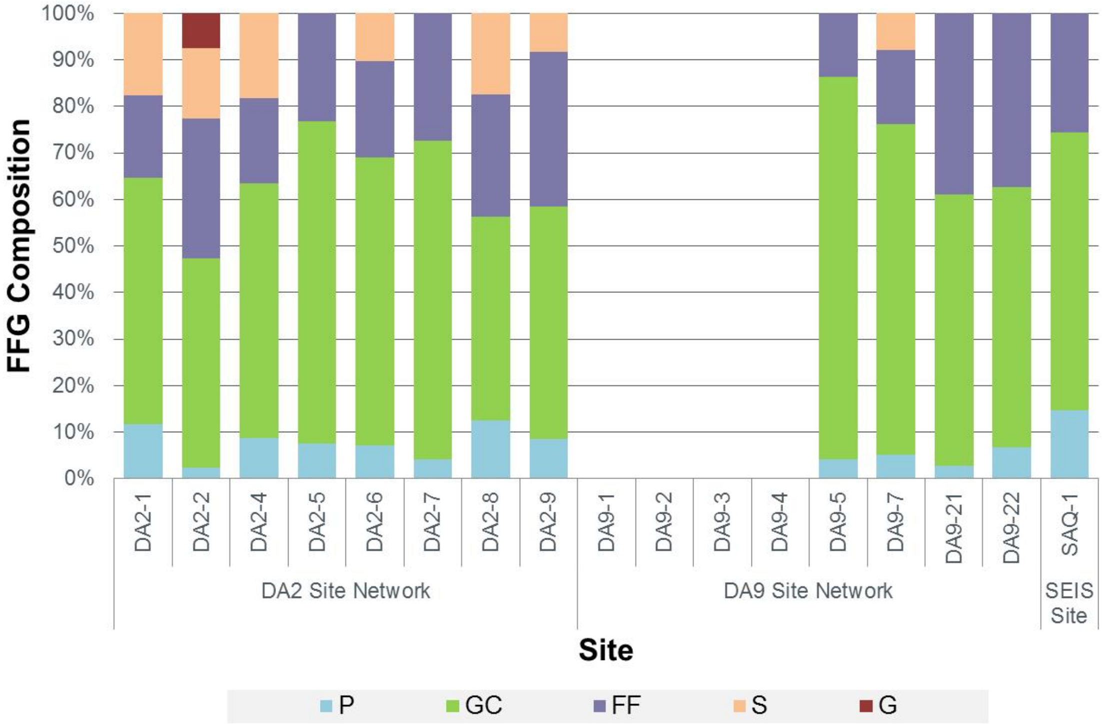

Figure 3.7 FFG Composition of SREISa Bed Macroinvertebrate Communities

Notes: P = predator, GC = gather/collector, FF = filter-feeder, S = shredder, G = grazer / scraper; No bed samples were collected at site DA9-1, DA9-2, DA9-3 and DA9-4 (refer to Section 2.3.2).

A similar pattern of results was observed for bed communities within the DA9 receiving system. Taxa assigned to the 'no preference' group dominated at four sites (approx. 30 - 70%), with notable representation of those assigned to the 'low/no flow' group (approx. 20 - 70) which dominated the fifth site. Taxa from the 'high flow' grouping were collected from only a single site, in low proportion (approx. 10 - 20%).

Site SAQ-1 was dominated by taxa from the 'no preference' group (approx. 60%), with the remaining taxa assigned to the 'low/no flow' group.

No spatial patterns in flow preference group were apparent within either the DA2 or DA9 receiving system and the observed patterns are driven by the ephemeral nature of the waterways surveyed. The high representation of taxa from the 'no preference' and 'low/no flow groupings is attributable to the predominance of pool habitat at the time of sampling. The low representation of taxa from the 'high-flow' group is to be expected as high flows occur on a transitory basis for only a fraction of the year.

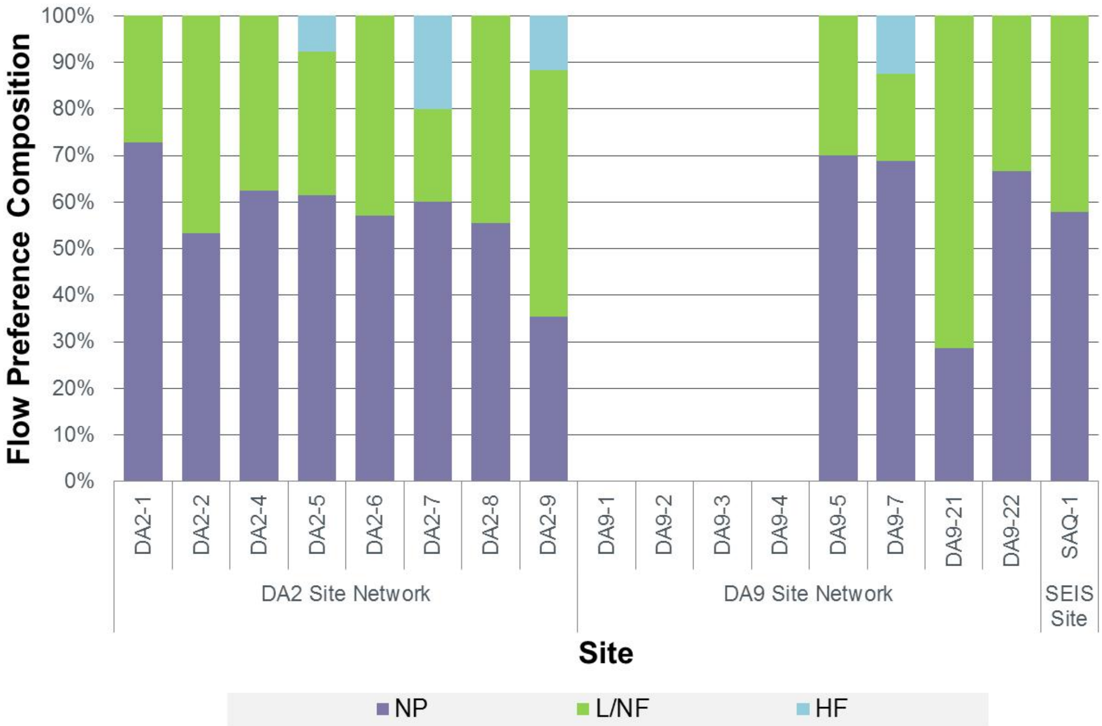

Figure 3.8 Flow Preference of SREISa Bed Macroinvertebrate Communities

Notes: NP = no preference, L/.NF = low / no flow, HF = high flow; No bed sampled was collected at site DA9-1, DA9-2, DA9-3 and DA9-4

3.2.5.8 Community Similarity and Habitat Association (Multivariate Analysis)

NMDS ordination reveals edge macroinvertebrate communities within the DA2 receiving system to be at least 60% similar in composition (**Figure 3.9**). Several clusters are apparent at various levels between the 60% and 80% similarity level. Generally, these clusters separate based on a stream gradient within the receiving system. For example, communities at sites DA2-1 and DA2-2 are more similar to each other than those downstream; communities at sites DA2-8 and DA2-9 are more similar to each other than those upstream, and communities at sites DA2-5 and DA2-6 are more similar to each other than those either upstream or downstream.

SIMPER analysis identified that nine taxa (Atyidae, Baetidae, Chironominae, Corixidae, Culicidae, Dytiscidae, Hydrochidae, Leptoceridae, Parastacidae) while representing only 20% of all taxa collected, accounted for 45% of the difference between communities in the edge samples (**Attachment 3**). Further inspection reveals that only one of these taxa possessed a SIGNAL2 score above five (Leptoceridae), although a further two were also PET taxa (Leptoceridae and Baetidae). Collectively, this suggests that a large portion of the difference between communities was caused by tolerant taxa and indicates that factors other than pollution are responsible for the difference in community structure between sites. No patterns were apparent in these taxa with respect to functional feeding group.

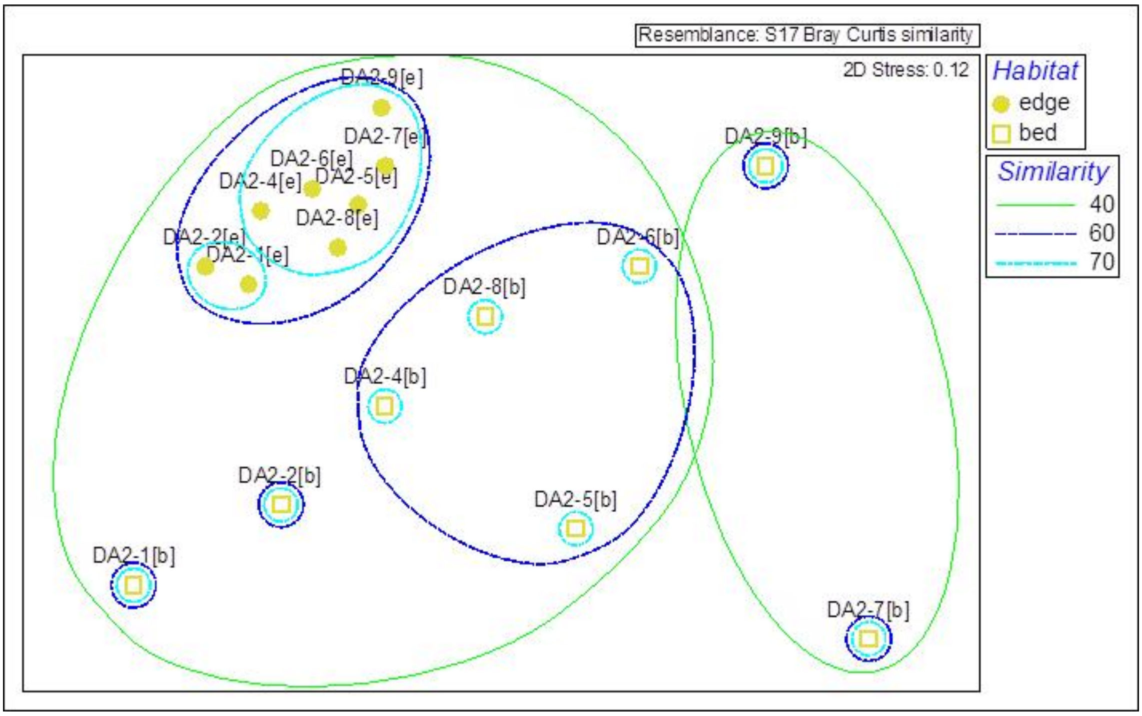

Figure 3.9 **NMDS Ordination Plot of SREISa Macroinvertebrate Communities within the DA2 Site Network**

NMDS ordination reveals five clusters of bed macroinvertebrate communities in the DA2 receiving system at the 60% similarity level (**Figure 3.9**). The first cluster contains communities from sites DA2-4, DA2-5, DA2-6 and DA2-8, while the other clusters each contain only a single site. All sites are separated beyond the 60% similarity level, with no two sites grouping together. Generally, the differences between these clusters appear to separate based upon geographic location within the receiving system. The strength of this pattern, however, is only weak.

SIMPER analysis identified nine taxa (Chironominae, Copepoda, Tanypodinae, Ecnomidae, Ceratopogonidae, Cladocera, Oligochaeta, Baetidae, Palaemonidae) that were responsible for contributing more than 5% each to the difference in bed communities within the DA2 receiving system (**Attachment 3**). These nine taxa represented 16% of all taxa collected but accounted for 63% of the difference between communities. Further inspection reveals that only one of these taxa possessed a SIGNAL2 score above five

(Leptoceridae). Collectively, this suggests that a large portion of the difference between communities was caused by tolerant taxa, hence factors other than water pollution are likely to be shaping these assemblages. No patterns were apparent in these taxa with respect to functional feeding or flow preference groups.

A higher degree of variability was apparent in bed communities than edge communities in the DA2 receiving system. Results from the ANOSIM revealed the edge and bed communities within the DA2 receiving system to be significantly different (p = 0.0002)

NMDS ordination reveals macroinvertebrate communities in DA9 edge habitat to be 40% similar in composition (**Figure 3.10**). Three ‘groups’ were apparent at the 60% level; the first ‘group’ containing DA9-2, DA9-3 and DA9-4; the second ‘group’ containing DA9-1, DA9-5 and DA9-7 and the third group contained DA9-21 and DA9-22. These groups can generally be explained by geographical location within the receiving system. Communities in the first ‘group’ were found in the head range of Cecil Plains Weir, while the second ‘group’ were either above or below the operating head range of the Cecil Plains Weir. The third group contained Crawlers Creek sites.

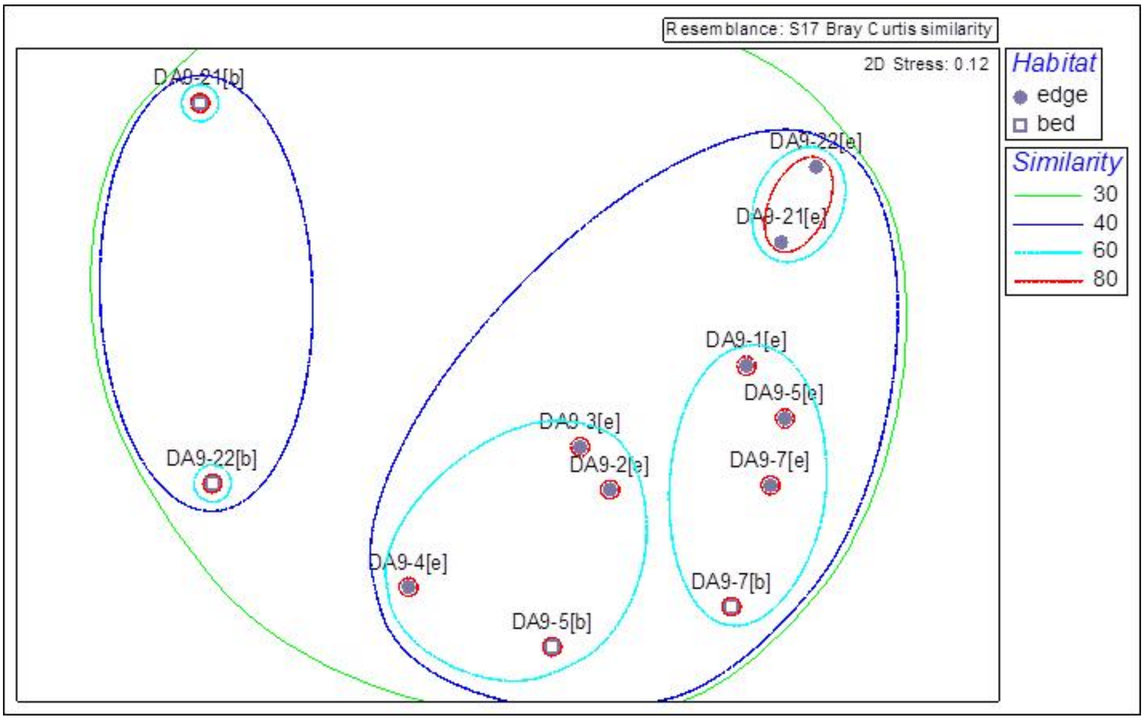

Figure 3.10 NMDS Ordination Plot of SREISa Macroinvertebrate Communities within the DA9 Site Network

SIMPER analysis indicated that seven taxa (Baetidae, Caenidae, Chironominae, Copepoda, Corixidae, Hydraenidae, Palaemonidae) were responsible for contributing more than 5% each to the difference between edge communities within the DA9 receiving system (**Attachment 3**). These seven taxa represented 18% of the taxa collected but accounted for 55% of the difference between communities. Further inspection reveals that only one of these taxa possessed a SIGNAL2 score above five (Leptoceridae), although a further two were also PET taxa (Baetidae and Caenidae). Overall, this suggests that a large portion of the difference between communities was caused by tolerant taxa. No patterns were apparent in these taxa with respect to functional feeding group.

NMDS ordination reveals two clusters of bed macroinvertebrate communities within the DA9 receiving system at the 40% similar level (**Figure 3.10**). The first cluster contained DA9-21 and DA9-22 (Crawlers Creek sites), whilst the other group contained the only two sites from the Condamine River sites that were able to be sampled.

SIMPER analysis identifies four taxa (Chironominae, Palaemonidae, Baetidae, Corixidae) responsible for contributing more than 20% to the difference between bed communities within the DA9 receiving system (**Attachment 3**). These four taxa represented 11% of the taxa collected but accounted for 69% of the difference between communities. Further inspection reveals that only one of these taxa possessed a SIGNAL2 score above five (Leptoceridae). Collectively, this suggests that a large portion of the difference between communities was caused by tolerant taxa. No patterns were apparent in these taxa with respect to functional feeding group or flow preference group.

3.2.6 Fish

A summary of fish species recorded at sites DA2-8 and DA2-9 during SREISa field surveys is presented in **Table 3.7**.

Fish species diversity was recorded to be two and four at sites DA2-8 and DA2-9, respectively. *Hypseleotris* species complex was the most abundant fish species at both sites. None of the species collected were of conservation significance.

Table 3.7 Summary of Fish Species collected during SREISa Surveys

Species Name	Common Name	Site		
		DA2-8	DA2-9	SAQ-2 *
Potadromous				
Hypseleotris spp.^	carp gudgeons	7	12	
Macquaria ambigua	golden perch		2	
Nematalosa erebi	bony bream		1	
Retropinna semoni	Australian smelt	1	2	
Catadromous				
-				
Anadromous				
-				

Notes:
^ Indicates *Hypseleotris* species complex
* Indicates site dry at the time of sampling
- indicates no species collected with this life history strategy

Survey effort at sites DA2-8 and DA2-9 was hindered by the presence of deep waters and poor water clarity. Accordingly, the results presented above most likely provide an underestimate of species diversity.

3.2.7 Turtles

No turtles were collected or observed during SREISa surveys.

4. EXISTING ENVIRONMENT SUMMARY

To complement the SREIS the existing environment summary has been divided into two sections; ‘other indicators’ (incorporating physical habitat, aquatic flora, fish and turtles) and ‘macroinvertebrates’.

4.1 Other Indicators

Water quality, physical habitat, fish (and other vertebrates) data for sites DA2-8 and DA2-9 are generally similar to those reported in the SREIS for other sites within the DA2 receiving system. No additional species of conservation significance were recorded.

The presence of *Salvinia molesta* at site DA2-9 is noteworthy. *Salvinia molesta* is listed as a ‘Class 2 declared pest’ under the *Land Protection (Pest and Stock Route Management) Act 2002* and was not recorded throughout the DA2 receiving system during other SREIS surveys.

SAQ-2 was situated on a small ephemeral waterway, Commoron Creek, occurring within the Macintyre and Weir Rivers catchment. For the majority of the hydrological cycle this waterway would exist only as dry stream bed. For a fraction of the hydrological cycle, typically during the wet season, shallow surface water would persist.

Although sampling of macroinvertebrates, fish and other vertebrates could not be completed, the assessment of habitat suggests these assemblages would be similar to those found in ephemeral watercourses in other catchments within the project development area.

4.2 Macroinvertebrates

No macroinvertebrate taxa of conservation significance were recorded.

The diversity of macroinvertebrate communities within the DA2 receiving system decreased with distance downstream and the analyses further indicated that physical location (proximity) of sites was the major determinant in the similarity groupings of assemblages.

Within DA9, the diversity of edge and bed communities in the Condamine River was lowest in the vicinity of Cecil Plains Weir and increased with distance upstream or downstream. Taxonomic diversity in edge habitat was higher in Crawlers Creek than the Condamine River, but the opposite was noted for bed habitat

The community structure of edge and bed assemblages were significantly different at DA2, with edge communities having greater taxa richness but lower SIGNAL2 scores than bed communities. At DA9 macroinvertebrate community structure was not significantly different ($p=0.079$) between bed and edge habitat.

There was little correlation between overall taxonomic diversity and the diversity of sensitive (PET) taxa or SIGNAL2 score at DA2, but the opposite was noted for DA9, where there was good correlation between these indicators. These outcomes are in part attributable to naturally low PET values in southern Queensland inland streams, which skews the analysis.

SIGNAL2 scores across all sites indicated that physical factors (e.g. microhabitat diversity and type, hydrology etc.), rather than water quality are shaping assemblages. However, a conflicting outcome is indicated by SIGNAL2 vs taxa richness results, which indicates high salinity or nutrients are shaping assemblages. It should be noted that the generic boundaries used in this assessment may not be suitable locally, which may be causing the conflict. Further, periods of high salinity during desiccation are typical of ephemeral systems during the approaching dry season.

Poorly represented 'specialist' feeding groups (shredders and grazers) reflect the ephemeral nature of the system, as does the dominance of bed communities by taxa exhibiting 'no preference' or 'low or no-flow' preference.

The presence of Cecil Plain Weir is a major determinant of community structure and, along with natural hydrological influences, explains many of the observed differences between the assemblages observed within Crawlers Creek and the Condamine River sites.

Macroinvertebrate communities present at site SAQ-1 were assessed as being diverse and in 'good' condition. These communities are generally representative of those occurring in semi-permanent waterways throughout the region that are experiencing only minor impacts from anthropogenic sources (including agriculture).

No macroinvertebrate sampling could be completed at site SAQ-2 due to the absence of surface water.

5. IMPACT ASSESSMENT

The analysis herein compliments that presented in the SREIS and characterises baseline aquatic ecosystem health and function within the SREIS study area, although it should be noted that this entire assessment is predicated on a single season ecological sampling within what is known to be a very dynamic and highly variable system.

The results indicate that a change to the description of potential impacts, sensitivity of aquatic receiving systems, magnitude of potential impacts, assessment of impacts (unmitigated or residual) or proposed mitigation measures provided in the SREIS is not warranted at the current time.

6. RECOMMENDATIONS

The following recommendation is proposed:

1. Completion of pre-wet season surveys during October – December, 2013

   Such surveys would greatly increase the understanding of seasonal variability in macroinvertebrate assemblages and habitat present within aquatic ecosystems potentially impacted by the Project. Additionally, the completion of dual season sampling is a typical expectation by regulatory authorities (such as DEHP).

This recommendation was also proposed in the SREIS. As the results from this assessment highlight the potential for large fluctuations in macroinvertebrate community structure between the pre-wet and post-wet season, it has been reiterated.

7. CONCLUSION

This assessment has complimented the SREIS to complete the aquatic ecology assessment by:

1. Characterisation of macroinvertebrate communities
   a. Within waterways to be impacted as a result of potential discharge of coal seam gas water to the receiving environments in Drainage Area 2 and Drainage Area 9
   b. Within the Dawson River and Macintyre and Weir Rivers catchments
2. Characterisation of other aquatic indicators (water quality, physical habitat, macrophytes, fish and other vertebrates) at three proposed survey sites which could not be accessed during the February and March 2013 SREIS surveys

The macroinvertebrate communities sampled across all sites in May 2013 were typical of ephemeral streams within the Condamine and upper Fitzroy Basins. Macroinvertebrate taxa present were largely comprised of families that are tolerant to a wide range of water quality parameters. Community structure appeared to be based largely on physical factors and microhabitat diversity/abundance, rather than water quality or other parameters. There was a clear influence associated with proximity to the Cecil Plains Weir, with communities within the operating head range differing from sites downstream.

No high value aquatic habitat, fish, turtles, flora or other aquatic values of conservation significance were identified during the May 2013 sampling event. One listed aquatic macrophyte pest species (Salvinia) was recorded in the DA2 receiving system.

The findings of this is assessment do not warrant change to the description of potential impacts or mitigation measures proposed by the SREIS.

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ATTACHMENT 1 – ENVIRONMENTAL DATA

Parameter	DA2-1		DA2-2		DA2-4		DA2-5		DA2-6		DA2-7		DA2-8		DA2-9	
	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
General																
Min Velocity (m/sec)	0	0	0	0	0	0.001	0	0.001	0	0.01	0.01	0.01	0	0	0	0.01
Max Velocity (m/sec)	0.005	0.015	0.001	0.01	0.01	0.05	0.01	0.1	0.02	0.2	0.2	0.2	0.001	0.005	0.01	0.3
Mean Sample Depth (m)	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.5	0.2	0.4	0.2	0.3	0.2	0.5	0.2	0.2
Mean Wetted Width (m)	10	10	3	3	5	5	6	6	5	5	4	4	10	10	20	10
Min Channel Width (m)	2	2	2	2	3	3	4	4	6	6	6	6	10	10	10	10
Max Channel Width (m)	15	15	6	6	8	8	10	10	10	10	10	10	15	15	20	20
Canopy Cover (%)	15	15	15	15	35	35	20	20	40	40	35	35	30	30	30	30
Shading (%)	40	40	50	50	75	75	60	60	80	80	80	80	50	50	70	70
Substrate																
Bedrock (%)	50	70	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Boulder (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cobble (%)	0	0	0	0	0	0	5	5	0	0	0	0	0	0	2.5	10
Pebble	0	0	10	10	0	0	10	10	0	0	0	0	0	0	2.5	40
Gravel (%)	50	10	10	10	10	70	10	10	30	20	0	50	0	0	0	
Sand (%)	50	20	80	80	80	30	45	55	70	80	70	80	70	5	80	40
Silt/Clay (%)	0	0	0	0	0	0	30	20	0	0	30	30	30	95	15	5
Woody Debris																
Detritus (%)	25	20	20	10	25	5	20	20	20	10	30	15	15	15	60	10
Sticks (%)	10	1	5	1	5	2	10	10	10	5	10	1	2	2	30	5
Branches (%)	2	0	0	0	5	0	20	5	20	5	5	1	1	0	10	0
Logs (%)	0	0	0	0	2	1	20	20	20	0	2	0	0	0	10	0
Other Attributes																
Periphyton (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moss (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Parameter	DA2-1		DA2-2		DA2-4		DA2-5		DA2-6		DA2-7		DA2-8		DA2-9	
	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Filamentous algae (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrophytes (%)	20	0	5	0	20	0	0	0	0	0	0	0	0	0	0	0
Bank Overhang Vegetation (%)	30	0	20	0	20	0	20	0	40	0	30	0	20	0	30	0
Trailing Bank Vegetation (%)	30	0	20	0	30	0	20	0	20	0	15	0	20	0	5	0
Water Quality (in-situ)																
Water Velocity (m/sec)	0	0	0	0	0	0	0	0	0.1	0.1	0.01	0.01	0	0	0.001	0.001
Water Temperature (°C)	19.5	19.5	20.4	20.4	17.4	17.4	16	16	18.5	18.5	17.4	17.4	18.3	18.3	17.2	17.2
Conductivity (µs/cm)	104	104	94	94	145	145	122	122	128	128	132	132	138	138	109	109
pH	5.83	5.83	6.13	6.13	6.08	6.08	6.78	6.78	6.52	6.52	6.52	6.52	6.15	6.15	6.84	6.84
Turbidity (NTU)	43.8	43.8	10	10	25	25	73.1	73.1	102	102	90.9	90.9	78.3	78.3	51.6	51.6

Parameter	DA9-1	DA9-2	DA9-3	DA9-4	DA9-5		DA9-7		DA9-21		DA9-22	
	Edge	Edge	Edge	Edge	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
General												
Min Velocity (m/sec)	0	0	0	0	0.001	0.001	0.01	0.05	0	0	0	0
Max Velocity (m/sec)	0	0.001	0.005	0	0.01	0.01	0.1	0.15	0	0	0	0
Mean Sample Depth (m)	0.3	0.25	0.25	0.25	0.25	0.25	0.25	0.3	0.2	0.5	0.2	0.5
Mean Wetted Width (m)	25	25	35	25	6	6	10	10	7.5	7.5	2	2
Min Channel Width (m)	25	25	25	25	5	5	8	8	0	0	10	10
Max Channel Width (m)	30	30	40	30	25	25	15	15	8	8	20	20
Canopy Cover (%)	10	10	10	10	15	15	20	20	35	35	20	20
Shading (%)	30	30	30	30	35	35	40	40	50	50	40	40
Substrate												
Bedrock (%)	0	0	0	0	0	0	0	0	5	20	15	20
Boulder (%)	0	0	0	0	0	0	0	0	2.5	5	0	0
Cobble (%)	0	0	0	0	0	0	0	0	2.5	2.5	1	1
Pebble	0	0	0	0	10	30	0	20	1	1	1	1
Gravel (%)	0	0	0	0	20	30	0	20	0	0	0	0
Sand (%)	5	0	5	0	20	20	40	50	75	61.5	73	68
Silt/Clay (%)	95	100	95	100	50	20	60	10	10	10	10	10
Woody Debris												
Detritus (%)	15	15	15	20	20	5	20	20	15	5	20	5
Sticks (%)	2	1	5	5	5	5	10	10	5	2	5	1
Branches (%)	1	2.5	2.5	1	2	0	5	0	5	2	5	1
Logs (%)	0	0	1	2	2	0	0	0	5	2	5	1
Other Attributes												
Periphyton (%)	0	0	0	0	0	0	0	0	0	0	0	0
Moss (%)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter	DA9-1	DA9-2	DA9-3	DA9-4	DA9-5		DA9-7		DA9-21		DA9-22	
	Edge	Edge	Edge	Edge	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Filamentous algae (%)	0	0	0	0	0	0	0	0	0	0	0	0
Macrophytes (%)	0	0	0	0	0	0	0	0	0	0	0	0
Bank Overhang Vegetation (%)	10	20	20	0	0	0	0	0	30	0	5	0
Trailing Bank Vegetation (%)	20	25	5	15	0	0	0	0	70	0	0	0
Water Quality (in-situ)												
Water Velocity (m/sec)	0	0.01	0.01	0	0.01	0.01	0.01	0.01	0	0	0	0
Water Temperature (°C)	16.6	18.2	20.4	20.9	17.8	17.8	16.9	16.9	18.9	18.9	16.8	16.8
Conductivity (µs/cm)	506	466	466	502	397	397	451	451	485	485	359	359
pH	7.34	7.54	7.42	7.61	7.46	7.46	7.2	7.2	7.06	7.06	6.86	6.86
Turbidity (NTU)	8.5	12.9	11.3	7.9	16.1	16.1	15.2	15.2	62.3	62.3	39.6	39.6

ATTACHMENT 2 – RAW MACROINVERTEBRATE DATA

Class/Order	Family	DA2-1	DA2-1	DA2-2	DA2-2	DA2-4	DA2-4	DA2-5	DA2-5	DA2-6	DA2-6	DA2-7	DA2-7	DA2-8	DA2-8	DA2-9	DA2-9
		Edge	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**	**Edge**	**Bed**
Acarina	Acarina	10	11			2	2					2		5		4	
Bivalvia	Hyriidae	1															
Coleoptera	Dytiscidae	11	9	10		5		1		1		1		8		7	
Coleoptera	Gyrinidae		1			1		2		2		9					
Coleoptera	Heteroceridae																
Coleoptera	Hydraenidae						2			2		1	1			3	
Coleoptera	Hydrochidae	2		4	2	9	1	5		4	2	12		3		4	1
Coleoptera	Hydrophilidae	1						1		2		1		5		2	
Coleoptera	Noteridae					1		1		2				2		5	
Coleoptera	Staphylinidae							1									
Collembola	Collembola					1				1		1					
Decapoda	Atyidae	6		6		3	5	1		4	1	9		3	1	4	1
Decapoda	Decapoda																
Decapoda	Palaemonidae							3	5	1	3	1	3	1	2	4	2
Decapoda	Parastacidae	3		1		2		3		4		3		2	1	1	
Diptera	Ceratopogonidae	1	1		1	1	5	3	7	2	4			2	2	1	
Diptera	Chironominae	7	3	11	7	7	9	16	11	9	8	14	6	6	15	19	17
Diptera	Culicidae	1		2	1	1		1		1		1		6		2	
Diptera	Diptera															1	
Diptera	Empididae																
Diptera	Ephydridae																
Diptera	Orthocladiinae					1					2	1	1				2
Diptera	Psychodidae							1									
Diptera	Simuliidae												2				4

Class/Order	Family	DA2-1	DA2-1	DA2-2	DA2-2	DA2-4	DA2-4	DA2-5	DA2-5	DA2-6	DA2-6	DA2-7	DA2-7	DA2-8	DA2-8	DA2-9	DA2-9
		Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Diptera	Tabanidae																
Diptera	Tanypodinae	12	3	3	8	3	6	8	2	6		5	1	21	10		
Diptera	Tipulidae				1							1					
Ephemeroptera	Baetidae	1	3	10	6	3		2	1	1		7	2	5	4	3	
Ephemeroptera	Caenidae	5	4	6	6	6	2			3				1			
Ephemeroptera	Ephemeroptera			1						1	1						
Ephemeroptera	Leptophlebiidae	5		10	12	3	1	5	5	6	2	3		3			
Gastropoda	Ancylidae	1			1			1				1				1	
Gastropoda	Lymnaeidae			1												1	
Gastropoda	Physidae																
Gastropoda	Planorbidae			2		1								2			
Hemiptera	Corixidae	2	2	5		10	5	4	2	4		4		9	1	8	
Hemiptera	Gelastocoridae							1									
Hemiptera	Gerridae	1														1	
Hemiptera	Hydrometridae					1				1		2					
Hemiptera	Nepidae													1			
Hemiptera	Notonectidae			2				3		1		7		1		2	
Hemiptera	Pleidae	2				1				1				2		1	
Hemiptera	Veliidae			2		1		1		1		2		1		3	1
Hirudinea	Eropdellidae																1
Hirudinea	Glossiphoniidae													1			
Hydrozoa	Hydridae															2	20
Isopoda	Cirolanidae																
Lepidoptera	Pyralidae															1	
Microcrustacea	Cladocera	1		1	1	1	1	1	1		1	1		1	1	1	1

Class/Order	Family	DA2-1	DA2-1	DA2-2	DA2-2	DA2-4	DA2-4	DA2-5	DA2-5	DA2-6	DA2-6	DA2-7	DA2-7	DA2-8	DA2-8	DA2-9	DA2-9
		Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Microcrustacea	Copepoda	1	1	1	1	1	1		1	1	1	1		1	1	1	1
Microcrustacea	Ostracoda	1		1	1									1	1	1	1
Nematoda	Nematoda	1				1						2					
Odonata	Coenagrionidae	1		3		2		5		3	1				1		
Odonata	Gomphidae	1				4	2	1		1	1	2		2	1	5	1
Odonata	Hemicorduliidae															1	1
Odonata	Isostictidae							1			1	1		5	4	3	
Odonata	Libellulidae	3		1											4		
Odonata	Protoneuridae																
Odonata	Synthemistidae																
Odonata	Zygoptera			1													
Oligochaeta	Oligochaeta	1		10	1		3	2	1	1	5	2		1	1	1	2
Trichoptera	Ecnomidae					2	2	3	9	1	1	1	1	3	2	1	10
Trichoptera	Hydropsychidae								1				4				7
Trichoptera	Hydroptilidae																
Trichoptera	Leptoceridae	5	1	9	9	10	7	3		6		3		3	3	6	
Trichoptera	Trichoptera											1		3			
Turbellaria	Temnocephalidae	1							2				1				
Turbellaria	Dugesiidae															1	

Class/Order	Family	DA9-1	DA9-2	DA9-4	DA9-3	DA9-5	DA9-5	DA9-7	DA9-7	DA9-21	DA9-21	DA9-22	DA9-22	SAQ-1	SAQ-1
		Edge	Edge	Edge	Edge	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Acarina	Acarina		1		1					1		1		2	3
Bivalvia	Hyriidae													1	
Coleoptera	Dytiscidae		2					2		5		2		7	15
Coleoptera	Gyrinidae													1	1
Coleoptera	Heteroceridae	1										1			
Coleoptera	Hydraenidae	25	13	9	11	5	1	4	2	5		5			1
Coleoptera	Hydrochidae		2					3		5		4		4	
Coleoptera	Hydrophilidae	1				2						1		1	
Coleoptera	Noteridae	1								3	1	1			
Coleoptera	Staphylinidae				1					2					
Collembola	Collembola	1			1				1	1		1			
Decapoda	Atyidae	4	3		1	2				8	4	1		2	1
Decapoda	Decapoda										2				
Decapoda	Palaemonidae	7	6	11	8	6	3	6	1		2		3	3	3
Decapoda	Parastacidae					1		3				7		1	
Diptera	Ceratopogonidae	1					2	1		2				3	5
Diptera	Chironomidae														
Diptera	Chironominae	2	14	6	6	4	30	4	3	18	17	17	1	36	38
Diptera	Culicidae	2				2		2		7		9			
Diptera	Diptera														
Diptera	Empididae								1						
Diptera	Ephydridae									1					
Diptera	Orthocladiinae	1			1	6	4	7	15	2				1	
Diptera	Psychodidae														
Diptera	Simuliidae					2			3						
Diptera	Tabanidae													1	

Class/Order	Family	DA9-1	DA9-2	DA9-4	DA9-3	DA9-5	DA9-5	DA9-7	DA9-7	DA9-21	DA9-21	DA9-22	DA9-22	SAQ-1	SAQ-1
		Edge	Edge	Edge	Edge	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Diptera	Tanypodinae							2	1	4		6	1	15	17
Diptera	Tipulidae							1							
Ephemeroptera	Baetidae	1	2	2	2	8	1	6	24	6		12	1	11	2
Ephemeroptera	Caenidae	2	2	1	2	8	8	10	40	2		1			1
Ephemeroptera	Ephemeroptera									1				1	
Ephemeroptera	Leptophlebiidae		2			15		6	5						
Gastropoda	Ancylidae											1		2	
Gastropoda	Lymnaeidae														
Gastropoda	Physidae									4					
Gastropoda	Planorbidae									1		1			
Hemiptera	Corixidae	24	13	26	12	12	4	5	6	3		35	1	5	1
Hemiptera	Gelastocoridae														
Hemiptera	Gerridae		1	2						1				1	
Hemiptera	Hydrometridae									2		1			
Hemiptera	Nepidae					1						2			
Hemiptera	Notonectidae	2				2		3		5		36		1	
Hemiptera	Pleidae													2	
Hemiptera	Veliidae					3				3		8		2	
Hirudinea	Eropdellidae														
Hirudinea	Glossiphoniidae														
Hydrozoa	Hydridae														
Isopoda	Cirolanidae		2	3	4	3							2		
Lepidoptera	Pyralidae														
Microcrustacea	Cladocera									1	1	1	1	1	1
Microcrustacea	Copepoda	1	1	1	1	1	1	1		1	1	1		1	1
Microcrustacea	Ostracoda	1								1		1		1	1

Class/Order	Family	DA9-1	DA9-2	DA9-4	DA9-3	DA9-5	DA9-5	DA9-7	DA9-7	DA9-21	DA9-21	DA9-22	DA9-22	SAQ-1	SAQ-1
		Edge	Edge	Edge	Edge	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
Nematoda	Nematoda			1				1	1	1		4		3	
Odonata	Coenagrionidae													7	
Odonata	Gomphidae									1				2	1
Odonata	Hemicorduliidae											1		1	
Odonata	Isostictidae														
Odonata	Libellulidae											3			
Odonata	Protoneuridae							1							
Odonata	Synthemistidae									1		1			
Odonata	Zygoptera		1												
Oligochaeta	Oligochaeta				1	2		2	2	1		3	1	8	1
Trichoptera	Ecnomidae			1			1							1	1
Trichoptera	Hydropsychidae								30						
Trichoptera	Hydroptilidae											1			
Trichoptera	Leptoceridae	1	1			4		1	1	8				4	
Trichoptera	Trichoptera							1							
Turbellaria	Temnocephalidae			1							1	13	16	3	3
Turbellaria	Dugesiidae														

ATTACHMENT 3 – PRIMER RESULTS

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: DA2
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity

Factor Groups

Sample	Habitat
DA2-1[e]	edge
DA2-2[e]	edge
DA2-4[e]	edge
DA2-5[e]	edge
DA2-6[e]	edge
DA2-7[e]	edge
DA2-8[e]	edge
DA2-9[e]	edge
DA2-1[b]	bed
DA2-2[b]	bed
DA2-4[b]	bed
DA2-5[b]	bed
DA2-6[b]	bed
DA2-7[b]	bed
DA2-8[b]	bed
DA2-9[b]	bed

Group edge
Average similarity: 73.55

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Atyidae	1.00	3.68	15.87	5.01	5.01
Baetidae	1.00	3.68	15.87	5.01	10.02
Chironominae	1.00	3.68	15.87	5.01	15.02
Corixidae	1.00	3.68	15.87	5.01	20.03
Culicidae	1.00	3.68	15.87	5.01	25.04
Dytiscidae	1.00	3.68	15.87	5.01	30.05
Hydrochidae	1.00	3.68	15.87	5.01	35.05
Leptoceridae	1.00	3.68	15.87	5.01	40.06
Parastacidae	1.00	3.68	15.87	5.01	45.07
Leptophlebiidae	0.88	2.80	1.69	3.81	48.88
Tanypodinae	0.88	2.80	1.69	3.81	52.69
Oligochaeta	0.88	2.77	1.69	3.77	56.46
Cladocera	0.88	2.77	1.69	3.77	60.23
Veliidae	0.88	2.76	1.69	3.75	63.99
Copepoda	0.88	2.73	1.69	3.71	67.70
Gomphidae	0.88	2.68	1.70	3.65	71.34
Notonectidae	0.75	1.98	1.05	2.69	74.04
Ceratopogonidae	0.75	1.94	1.05	2.64	76.67
Hydrophilidae	0.75	1.92	1.05	2.61	79.28
Ecnomidae	0.75	1.90	1.05	2.59	81.87

Group bed
Average similarity: 49.17

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chironominae	1.00	7.18	8.04	14.61	14.61
Copepoda	0.88	5.14	1.67	10.46	25.07
Tanypodinae	0.75	3.94	1.04	8.01	33.08
Ecnomidae	0.75	3.74	1.04	7.61	40.69
Ceratopogonidae	0.75	3.73	1.04	7.59	48.27
Cladocera	0.75	3.51	1.05	7.14	55.41
Oligochaeta	0.75	3.51	1.05	7.14	62.55
Baetidae	0.63	2.71	0.72	5.52	68.07
Palaemonidae	0.63	2.55	0.72	5.19	73.25
Corixidae	0.50	1.50	0.51	3.04	76.29
Leptophlebiidae	0.50	1.48	0.51	3.01	79.31
Leptoceridae	0.50	1.44	0.51	2.93	82.24

Groups edge & bed
Average dissimilarity = 49.70

Species	Group edge Av.Abund	Group bed Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Parastacidae	1.00	0.13	2.16	2.55	4.34	4.34
Culicidae	1.00	0.13	2.14	2.54	4.30	8.65
Dytiscidae	1.00	0.13	2.11	2.55	4.24	12.89
Veliidae	0.88	0.13	1.91	1.84	3.85	16.74
Notonectidae	0.75	0.00	1.83	1.69	3.69	20.42
Hydrophilidae	0.75	0.00	1.79	1.70	3.60	24.03
Noteridae	0.63	0.00	1.50	1.27	3.02	27.04
Pleidae	0.63	0.00	1.48	1.27	2.98	30.03
Coenagrionidae	0.63	0.25	1.40	1.11	2.82	32.85
Acarina	0.63	0.25	1.34	1.12	2.70	35.55
Caenidae	0.63	0.38	1.30	1.05	2.61	38.16
Atyidae	1.00	0.50	1.27	0.99	2.56	40.73
Gomphidae	0.88	0.50	1.26	0.99	2.53	43.25
Hydrochidae	1.00	0.50	1.25	0.98	2.52	45.78
Leptoceridae	1.00	0.50	1.24	0.98	2.50	48.28
Leptophlebiidae	0.88	0.50	1.23	0.98	2.47	50.75
Corixidae	1.00	0.50	1.23	0.98	2.47	53.23
Ostracoda	0.50	0.38	1.22	0.98	2.46	55.69
Gyrinidae	0.50	0.13	1.21	0.99	2.43	58.11
Isostictidae	0.50	0.25	1.20	0.99	2.42	60.53
Ancylidae	0.50	0.13	1.20	0.99	2.41	62.95
Palaemonidae	0.63	0.63	1.15	0.92	2.32	65.26
Orthocladiinae	0.25	0.38	1.07	0.87	2.15	67.41
Hydraenidae	0.38	0.25	1.05	0.87	2.11	69.52
Planorbidae	0.38	0.00	0.94	0.76	1.90	71.42
Ecnomidae	0.75	0.75	0.94	0.76	1.90	73.32
Hydropsychidae	0.00	0.38	0.94	0.76	1.89	75.21
Ceratopogonidae	0.75	0.75	0.93	0.76	1.88	77.08
Nematoda	0.38	0.00	0.89	0.77	1.79	78.87
Baetidae	1.00	0.63	0.88	0.77	1.78	80.65

SIMPER
Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: DA9
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity

Factor Groups

Sample	Habitat
DA9-1[e]	edge
DA9-2[e]	edge
DA9-4[e]	edge
DA9-3[e]	edge
DA9-5[e]	edge
DA9-7[e]	edge
DA9-21[e]	edge
DA9-22[e]	edge
DA9-5[b]	bed
DA9-7[b]	bed
DA9-21[b]	bed
DA9-22[b]	bed

Group edge
Average similarity: 58.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Baetidae	1.00	5.39	5.06	9.15	9.15
Caenidae	1.00	5.39	5.06	9.15	18.30
Chironominae	1.00	5.39	5.06	9.15	27.45
Copepoda	1.00	5.39	5.06	9.15	36.60
Corixidae	1.00	5.39	5.06	9.15	45.75
Hydraenidae	1.00	5.39	5.06	9.15	54.89
Palaemonidae	0.75	3.32	1.04	5.64	60.53
Atyidae	0.75	2.70	1.02	4.58	65.11
Orthocladiinae	0.63	1.84	0.72	3.12	68.23
Leptoceridae	0.63	1.82	0.72	3.08	71.31
Oligochaeta	0.63	1.68	0.72	2.85	74.16
Culicidae	0.63	1.60	0.72	2.72	76.89
Notonectidae	0.63	1.60	0.72	2.72	79.61
Cirolanidae	0.50	1.42	0.51	2.41	82.02

Group bed
Average similarity: 42.83

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chironominae	1.00	10.22	6.10	23.87	23.87
Palaemonidae	1.00	10.22	6.10	23.87	47.75
Baetidae	0.75	4.59	0.90	10.72	58.47
Corixidae	0.75	4.59	0.90	10.72	69.19

Cladocera	0.50	2.08	0.41	4.86	74.06
Temnocephalidae	0.50	2.08	0.41	4.86	78.92
Copepoda	0.50	1.96	0.41	4.58	83.50

Groups edge & bed
Average dissimilarity = 52.56

Species	Group edge Av.Abund	Group bed Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atyidae	0.75	0.25	2.14	1.20	4.06	4.06
Leptoceridae	0.63	0.25	1.98	1.09	3.77	7.83
Culicidae	0.63	0.00	1.96	1.23	3.74	11.57
Notonectidae	0.63	0.00	1.96	1.23	3.74	15.31
Caenidae	1.00	0.50	1.91	0.95	3.64	18.95
Hydraenidae	1.00	0.50	1.91	0.95	3.64	22.59
Cirolanidae	0.50	0.25	1.90	0.95	3.62	26.21
Cladocera	0.25	0.50	1.88	0.94	3.58	29.78
Temnocephalidae	0.25	0.50	1.85	0.95	3.51	33.29
Orthocladiinae	0.63	0.50	1.81	0.95	3.44	36.73
Oligochaeta	0.63	0.50	1.79	0.95	3.41	40.14
Tanypodinae	0.38	0.50	1.74	0.96	3.31	43.44
Nematoda	0.50	0.25	1.72	0.94	3.26	46.71
Collembola	0.50	0.25	1.69	0.95	3.22	49.93
Acarina	0.50	0.00	1.69	0.93	3.22	53.15
Copepoda	1.00	0.50	1.69	0.95	3.22	56.37
Dytiscidae	0.50	0.00	1.60	0.95	3.04	59.42
Hydrochidae	0.50	0.00	1.60	0.95	3.04	62.46
Leptophlebiidae	0.38	0.25	1.54	0.85	2.94	65.40
Noteridae	0.38	0.25	1.50	0.82	2.85	68.25
Ceratopogonidae	0.38	0.25	1.50	0.84	2.85	71.09
Gerridae	0.38	0.00	1.41	0.73	2.68	73.78
Hydrophilidae	0.38	0.00	1.20	0.75	2.28	76.06
Parastacidae	0.38	0.00	1.18	0.75	2.25	78.32
Ecnomidae	0.13	0.25	1.18	0.64	2.24	80.55

ANOSIM
Analysis of Similarities

One-Way Analysis

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factor Values
Factor: Habitat
edge
bed

Factor Groups

Sample	Habitat
DA2-1[e]	edge
DA2-2[e]	edge
DA2-4[e]	edge
DA2-5[e]	edge
DA2-6[e]	edge
DA2-7[e]	edge
DA2-8[e]	edge
DA2-9[e]	edge
DA2-1[b]	bed
DA2-2[b]	bed
DA2-4[b]	bed
DA2-5[b]	bed
DA2-6[b]	bed
DA2-7[b]	bed
DA2-8[b]	bed
DA2-9[b]	bed

Global Test
Sample statistic (Global R): 0.47
Significance level of sample statistic: 0.02%
Number of permutations: 6435 (All possible permutations)
Number of permuted statistics greater than or equal to Global R: 1

Outputs
Plot: Graph7

ATTACHMENT 4 – SITE PHOTOS

SAQ1 – Weringa Creek (Looking Upstream)

SAQ1 – Weringa Creek (Looking Downstream)

DA2-1 – Bottle Tree Creek (Looking Upstream)

DA2-1 – Bottle Tree Creek (Looking Downstream)

DA2-2 – Bottle Tree Creek (Looking Upstream)

DA2-2 – Bottle Tree Creek (Looking Downstream)

DA2-4 – Bottle Tree Creek (Looking Upstream)

DA2-4 – Bottle Tree Creek (Looking Downstream)

DA2-5 – Dogwood Creek (Looking Upstream)

DA2-5 – Dogwood Creek (Looking Downstream)

DA2-6 – Dogwood Creek (Looking Upstream)

DA2-6 – Dogwood Creek (Looking Downstream)

DA2-7 – Dogwood Creek (Looking Upstream)

DA2-7 – Dogwood Creek (Looking Downstream)

DA9-1 – Condamine River (Looking Upstream)

DA9-1 – Condamine River (Looking Downstream)

DA9-2 – Condamine River (Looking Upstream)

DA9-2 – Condamine River (Looking Downstream)

DA9-3 – Condamine River (Looking Upstream)

DA9-3 – Condamine River (Looking Downstream)

DA9-4 – Condamine River (Looking Upstream)

DA9-4 – Condamine River (Looking Downstream)

DA9-5 – Condamine River (Looking Upstream)

DA9-5 – Condamine River (Looking Downstream)

DA9-6 – Condamine River (Looking Upstream)

DA9-6 – Condamine River (Looking Downstream)

DA9-7 – Condamine River (Looking Upstream)

DA9-7 – Condamine River (Looking Downstream)

DA9-21 – Crawlers Creek (Looking Upstream)

DA9-21 – Crawlers Creek (Looking Downstream)

DA9-22 – Crawlers Creek (Looking Upstream)

DA9-22 – Crawlers Creek (Looking Downstream)