Aquateco
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Arrow Energy Surat Gas Project Aquatic Ecology Assessment

FINAL

November 2011

Prepared for: Arrow Energy Pty Ltd

Coffey Environments

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Background

Arrow Energy Pty Ltd proposes expansion of its coal seam gas operations in the Surat Basin through the Surat Gas Project. The need for the project arises from the growing demand for gas in the domestic market and global demand and the associated expansion of LNG export markets.

The project development area covers approximately 8,600 km^2 and is located approximately 160 km west of Brisbane in Queensland's Surat Basin.

The project development area extends from the township of Wandoan in the north towards Goondiwindi in the south, in an arc adjacent to Dalby. Townships within or in close proximity to the project development area include (but are not limited to) Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, Miles and Goondiwindi. Project infrastructure including coal seam gas production wells and production facilities (including both water treatment and power generation facilities where applicable) will be located throughout the project development area but not in towns. Facilities supporting the petroleum development activities such as depots, stores and offices may be located in or adjacent to towns.

The conceptual Surat Gas Project design presented in the environmental impact statement (EIS) is premised upon peak gas production from Arrow's Surat Basin gas fields of approximately 1,050 TJ/d. The peak gas production comprises 970 TJ/d for LNG production (including a 10% fuel gas requirement for facility operation) and a further 80 TJ/d for supply to the domestic gas market.

A project life of 35 years has been adopted for EIS purposes. Ramp-up to peak production is estimated to take between 4 and 5 years, and is planned to commence in 2014. Following ramp-up, gas production will be sustained at approximately 1,050 TJ/d for at least 20 years, after which production is expected to decline.

It is envisaged that development of the Surat Gas Project will occur in five development regions: Wandoan, Chinchilla, Dalby, Kogan/Millmerran and Goondiwindi. Development of these regions will be staged to optimise production over the life of the project.

Arrow has established a framework to guide the selection of sites for production wells and production facilities and routes for gathering lines and pipelines. The framework will also be used to select sites for associated infrastructure such as access roads and construction camps. Environmental and social constraints to development that have been identified through the EIS process coupled with the application of appropriate environmental management controls will ensure that protection of environmental values (resources) is considered in project planning. This approach will maximise the opportunity to select appropriate site locations that minimise potential environmental and social impacts.

Arrow has identified 18 areas that are nominated for potential facility development to facilitate environmental impact assessment (and modelling). These are based on circles of approximately 12 km radius that signify areas where development of production facilities could potentially occur.

Arrow intends to pursue opportunities in the selection of equipment (including reverse osmosis units, gas powered engines, electrical generators and compressors) and the design of facilities that supports the cost effective and efficient scaling of facilities to meet field conditions. This flexibility will enable Arrow to better match infrastructure to coal seam gas production. It will also enable Arrow to investigate the merits of using template design principles for facility development, which may in turn generate further efficiencies as the gas reserves are better understood, design is finalised, or as field development progresses.

Study Methods

The project commenced with an intensive review of existing data and information for the Project development area and the study area. The study area includes the Project development area as well as some surrounding catchment areas to enable comparison of aquatic habitat within and adjacent the project development area. This comparative analysis is integral to quantifying and understanding changes over time, if any, on aquatic habitats associated with project activities.

Seventy three potential aquatic ecosystem sampling sites were initially identified. Through field reconnaissance and careful consideration of physical and ecological factors the number of sites to be physically sampled was reduced to a final 11 sites that were sampled during November 2009 and May 2010. The 11 sites selected are considered representative of ecological conditions across the study area.

Field surveys included physico-chemical water quality, sediment sampling and analysis, fish and macroinvertebrate surveys, aquatic vegetation audits, rapid assessment techniques for riparian health and geomorphological processes. Data interpretation included modelling, univariate and multivariate statistical analysis.

Study Findings

Field surveys confirmed the desktop assessment that aquatic ecosystems within the study area are moderately to highly modified and are in moderate health. A species, *Maccullochella peelii peelii* (Murray cod), listed under Commonwealth environmental legislation was not recorded in the surveys but is known to exist within the area both as a remnant population of wild fish and as a randomly stocked recreational species in the river systems. Two fish species of conservation interest, *Gadopsis mamoratus* (freshwater blackfish) and *Mogurnda adspersa* (purple spotted gudgeon) were recorded at a site just outside of the study area.

Statistical analyses of the field data confirm that the ecological communities (fish, macroinvertebrates and aquatic flora) were similar at most sites within the study area. Habitat type and quality was also relatively uniform across the study area. No pockets of endemism or habitat of unusual quality of composition were identified.

Project Constraints

A significance assessment approach has been used to determine the sensitivity of aquatic ecology values within the project development area and the resulting levels of constraint that should be placed on various project activities. This assessment involved intensive literature and database reviews to identify aquatic species, communities or habitats of conservation significance that are likely to be present within the study area, with targeted field surveys to fill knowledge gaps in relation to identified values.

On the basis of this assessment, the areas of environmental sensitivity and the associated degree to which the project activities should be constrained by aquatic ecosystem values was determined:

- Aquatic ecosystems of particularly high sensitivity are designated “no go” zones. No surface disturbance of these areas is permissible. Directional drilling under watercourses is also not acceptable due to the potential for rock fractures, slumping or other effects that could impact water levels at a localised or larger scale.
- Areas containing significant aquatic ecosystems that may be impacted upon by some aspects of the construction and operations have been designated “highly constrained”. Lower impact activities such as wells, gathering and access infrastructure may be undertaken in these areas, under appropriate environmental controls. Short-term impacts associated with construction are acceptable in these areas, with environmental controls such as strategic selection of disturbance locations and timing of works to avoid wet periods in addition to normal environmental controls.
- Aquatic ecosystems of moderate sensitivity are designated “moderately constrained”. Higher impact activities (e.g. construction of water treatment facilities) may be undertaken in these areas provided appropriate environmental controls are in place
- There are no aquatic ecosystems of low sensitivity. The rationale is that because of connectivity of water flowing down stream networks, every site is linked to every other site, so activities at one site can affect other sites, especially downstream areas. Areas of land beyond the immediate vicinity of streams and their associated riparian zones is generally considered to be of low sensitivity.
- Construction and operations in all remaining areas is permissible in compliance with standard environmental procedures.

In accordance with the risk based approach, one location within the study area has been identified as a “no go” zone:

- The highly sensitive Lake Broadwater, though dry at the time of the November surveys, is a gazetted conservation park and may provide refuge or foraging/spawning habitat for a number of aquatic species including M peelii peelii during periods when it is connected to other regional waterways.

Two areas have been identified as “highly constrained” zones:

- A 1km buffer zone surrounding the Lake Broadwater Conservation Park is recommended to provide further protection to aquatic values associated with this area. In accordance with Environmental Authorities currently held by Arrow, it is recommended that no petroleum activities take place within 200m of Lake Broadwater Conservation Park; and that no activities other than Limited Petroleum Activities occur within 1km of the park, due to its status as a Category A Environmentally Sensitive Area. It is noted that these buffer distances may change pending the outcome of discussions between Arrow Energy and DERM that are currently under way.
- Oakey Creek between Cecil Plains Road and the study area boundary. This reach has some potential to support populations of *G. Mamoratus* and *M. adspersa*, both of which are species whose distribution in the region is now extremely limited.

As construction activities will require small scale clearing of vegetation to facilitate well or pipeline installation, the adoption of appropriate riparian buffer zones along all watercourses is essential. The Regional Vegetation Management Code for Brigalow Belt and New England Tablelands encompasses the study area and provides guidelines for appropriate riparian buffer strip width. These are intended to protect water quality, aquatic habitat and riparian habitat values and have been designated “moderately constrained” for the purposes of this assessment. It is noted that these buffer distances may change pending the outcome of discussions between Arrow Energy and DERM that are currently under way.

Stream Order	Definition	Riparian Bank Buffer Width (m)	Watercourse Sample Site Stream Order Examples
5th or higher	Convergence of two 4th order streams or higher.	200	Condamine River (6th), Myall Creek (5th), Westbrook Creek (5th), Oakey Creek (5th)
3rd or 4th	Convergence of two 2nd order (3rd order) or two 3rd order streams (4th order).	100	Bringalilly Creek (3rd), Wilkie Creek(4th)
1st or 2nd	Streams with no tributaries (1st order) or convergence of two 1st order streams (2nd order)	50	None

Remaining aquatic ecosystems associated with ephemeral, semi-permanent and permanent waterways are moderately sensitive. Higher impact activities (e.g. construction of water treatment facilities) may be undertaken in these areas provided strict environmental controls are in place.

With the exception of one wetland system (Lake Broadwater) and two fish species (*M. adspersa* and *G. mamoratus*), aquatic ecosystem values should pose few constraints on the construction and operation of the project. Throughout most of the project development area the construction and operation of the Surat Gas Project as currently proposed will have minimal impact on aquatic ecosystems at a local, regional, national or international scale provided a common set of environmental management standard operating procedures are implemented.

This report excludes assessment of hydrological and/or water quality impacts associated with beneficial use of treated or untreated coal seam water. These considerations are outside the scope of the EIS and have therefore not been considered as part of this assessment.

Glossary of Terms

Lotic – flowing water

Lentic – non-flowing water

Confluence – where two or more streams or rivers merge.

Tributary – a stream that flows to a larger stream or other body of water.

Drainage basin – the area drained by a river and all its tributaries.

Stream order – A number from that designates the relative position of a stream in a drainage basin network, ranked from headwaters to river terminus.

Ephemeral – a water body that exists for a limited period following precipitation.

Salinity gradient – the difference in salt concentration between water bodies of differing salinity.

pH – a measure of acidity or alkalinity.

Electrical conductivity – a measure of how strongly a material opposes the flow of electric current.

Turbidity – cloudiness of a fluid caused by suspended solids.

Dissolved oxygen – a relative measure of the amount of oxygen that is dissolved in water.

Macroinvertebrate – an animal lacking a backbone and visible to the naked eye.

Assemblages – a group of associated animals found together in a given stratum.

Pristine – unpolluted, inimpacted.

Riffle – a short, relatively shallow and coarse-bedded length of stream over which the stream flows at lower velocity and higher turbulence than it normally does in comparison to a pool.

Taxa – a taxonomic category, as a species or genus.

Family – a taxonomic rank fitting between Order and Genus.

Electrofishing – scientific survey method used to sample fish populations that relies on electricity to temporarily stun fish.

Macrophyte – an aquatic plant that grows in or near water and is either emergent, submergent, or floating.

Riparian – the interface between land and a water body.

Limit of detection – the lowest quantity of a substance that can be distinguished from the absence of that substance within a stated confidence limit.

Eutrophication – the addition of artificial or natural substances into an aquatic system.

Electrophoretic – The migration of charged colloidal particles or molecules through a solution under the influence of an applied electric field.

Genetic divergence – the process in which two or more populations of an ancestral species accumulate independent genetic changes through time, often after the populations have become reproductively isolated for some period of time.

Diurnal – Occurring or active during the daytime rather than at night.

Abbreviations/Acronyms

TOR – Terms of Reference

DERM – Department of Environment and Resource Management (Queensland)

DPI – Department of Primary Industries (Queensland)

LNG – Liquefied Natural Gas

TJ/d – Terajoules per day.

BOM – Bureau of Meteorology

EPBC – Environment Protection and Biodiversity Conservation Act 1999

DSEWPC – Department of Sustainability, Environment, Water, Population and Communities (Commonwealth)

MDBA – Murray Darling Basin Authority

NATA – National Association of Testing Authorities

AusRivAS – Australian River Assessment System

DNRM – Department of Natural Resources and Mines (Queensland)

SIGNAL – Stream Invertebrate Grade Number – Average Level

ANZECC – Australian and New Zealand Environment and Conservation Council

ARMCANZ – Agricultural and Resource Management Council of Australia and New Zealand

BOD – Biochemical oxygen demand

ISQG – Interim Sediment Quality Guidelines

1 Introduction

1.1 Background

Arrow Energy Pty Ltd (Arrow) is preparing a voluntary Environmental Impact Statement (EIS) for the Surat Gas Project under the Queensland *Environmental Protection Act* 1994 and has been determined to be a controlled action under the *Environmental Protection and Biodiversity Conservation Act* 1999, with the Commonwealth assessment being completed under the Bilateral Agreement.

Aquateco Consulting Pty Ltd was contracted by Arrow and Coffey Environments Australia Pty Ltd to undertake an aquatic ecology assessment for the Surat Gas Project.

1.2 Objectives

The objectives of this assessment are to:

- Fulfil the requirements of the final terms of reference (TOR) for the Surat Gas Project EIS as issued by the Queensland Department of Environment and Resource Management (DERM) September 2010 with respect to aquatic ecosystems and values.
- Describe aquatic ecosystems, habitat and communities, including fish, mammals, aquatic macroinvertebrates and aquatic flora occurring in the waterways within the aquatic ecology study area. Amphibians are excluded from the aquatic ecology study, these are specifically addressed as part of the EIS terrestrial ecology study.
- Whilst a specific study of the fisheries resources of the Surat Basin was not undertaken, it is intrinsically covered by this assessment;
- Identify sensitive areas, communities or species (including rare and threatened species), or areas with low resilience to disturbance;
- Characterise aquatic and benthic substrate;
- Identify project activities that have the potential to impact on habitats within the project development area and habitat downstream of the project development area.
- Detail the potential impacts on aquatic ecosystem values of the study area, including an assessment of any residual and cumulative impacts of the project.
- Describe mitigation measures required to manage impacts on aquatic ecology values.

1.3 Project Proponent

Arrow Energy Pty Ltd (Arrow) is an integrated energy company with interests in coal seam gas field developments, pipeline infrastructure, electricity generation and a proposed liquefied natural gas (LNG) projects.

Arrow has interests in more than 65,000 km^2 of petroleum tenures, mostly within Queensland’s Surat and Bowen basins. Elsewhere in Queensland, the company has interests in the Clarence-Moreton, Coastal Tertiary, Ipswich, Styx and Nagoorin Graben basins.

Arrow's petroleum tenures are located close to Queensland’s three key energy markets; Townsville, Gladstone and Brisbane. The Moranbah Gas Project in the Bowen Basin and the Tipton West, Daandine, Kogan North and Stratheden projects in the Surat Basin near Dalby comprise Arrow’s existing coal seam gas production operations. These existing operations currently account for approximately 20% of Queensland’s overall domestic gas production.

Arrow supplies gas to the Daandine, Braemar 1 and 2, Townsville and Swanbank E power stations which participate in the National Electricity Market. With Arrow’s ownership of Braemar 2 and the commercial arrangements in place for Daandine and Townsville power stations Arrow has access to up to 600 MW of power generation capacity.

Arrow and its equity partner AGL Energy have access rights to the North Queensland Pipeline which supplies gas to Townsville from the Moranbah Gas Project. They also hold the pipeline licence for the proposed Central Queensland Gas Pipeline between Moranbah and Gladstone.

Arrow is currently proposing to develop the Arrow LNG Project, which is made up of the following aspects:

- Arrow LNG Plant – The proposed development of an LNG Plant on Curtis Island near Gladstone, and associated infrastructure, including the gas pipeline crossing of Port Curtis.
- Surat Gas Project – The upstream gas field development in the Surat Basin, subject of this assessment.
- Arrow Surat Pipeline Project – (Formerly the Surat Gladstone Pipeline), the 450 km transmission pipeline connects Arrow’s Surat Basin coal seam gas developments to Gladstone.

1.4 Project Overview

Arrow proposes expansion of its coal seam gas operations in the Surat Basin through the Surat Gas Project. The need for the project arises from the growing demand for gas in the domestic market and global demand and the associated expansion of LNG export markets. The project development area covers approximately 8,600 km2 and is located approximately 160 km west of Brisbane in Queensland's Surat Basin. The project development area extends from the township of Wandoan in the north towards Goondiwindi in the south, in an arc adjacent to Dalby. Townships within or in close proximity to the project development area include (but are not limited to) Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, Miles and Goondiwindi. Project infrastructure including coal seam gas production wells and production facilities (including both water treatment and power generation facilities where applicable) will be located throughout the project development area but not in towns. Facilities supporting the petroleum development activities such as depots, stores and offices may be located in or adjacent to towns.

The conceptual Surat Gas Project design presented in the environmental impact statement (EIS) is premised upon peak gas production from Arrow's Surat Basin gas fields of approximately 1,050 TJ/d. The peak gas production comprises 970 TJ/d for LNG production (including a 10% fuel gas requirement for facility operation) and a further 80 TJ/d for supply to the domestic gas market.

A project life of 35 years has been adopted for EIS purposes. Ramp-up to peak production is estimated to take between 4 and 5 years, and is planned to commence in 2014. Following ramp-up, gas production will be sustained at approximately 1,050 TJ/d for at least 20 years, after which production is expected to decline.

Infrastructure for the project is expected to comprise:

- Approximately 7,500 production wells drilled over the life of the project at a rate of approximately 400 wells drilled per year.
- Low pressure gas gathering lines to transport gas from the production wells to production facilities.
- Medium pressure gas pipelines to transport gas between field compression facilities and central gas processing and integrated processing facilities.
- High pressure gas pipelines to transport gas from central gas processing and integrated processing facilities to the sales gas pipeline.
- Water gathering lines (located in a common trench with the gas gathering lines) to transport coal seam water from production wells to transfer, treatment and storage facilities.
- Approximately 18 production facilities across the project development area expected to comprise of 6 of each of the following:

  - Field compression facilities.
  - Central gas processing facilities.
  - Integrated processing facilities.
- A combination of gas powered electricity generation equipment that will be co-located with production facilities and/or electricity transmission infrastructure that may draw electricity from the grid (via third party substations).

Further detail regarding the function of each type of production facility is detailed below.

Field compression facilities will receive gas from production wells and are expected to provide 30 to 60 TJ/d of first stage gas compression. Compressed gas will be transported from field compression facilities in medium pressure gas pipelines to multi-stage compressors at central gas processing facilities and integrated processing facilities where the gas will be further compressed to transmission gas pipeline operating pressure and dehydrated to transmission gas pipeline quality. Coal seam water will bypass field compression facilities.

Central gas processing facilities will receive gas both directly from production wells and field compression facilities. Central gas processing facilities are expected to provide between 30 and 150 TJ/d of gas compression and dehydration. Coal seam water will bypass central gas processing facilities and be pumped to an integrated processing facility for treatment.

Integrated processing facilities will receive gas from production wells and field compression facilities. Integrated processing facilities are expected to provide between 30 and 150 TJ/d of gas compression and dehydration. Coal seam water received at integrated processing facilities is expected to be predominantly treated using reverse osmosis and then balanced to ensure that it is suitable for the intended beneficial use. Coal seam water received from the field, treated water and brine concentrate will be stored in dams adjacent to integrated processing facilities.

It is envisaged that development of the Surat Gas Project will occur in five development regions: Wandoan, Chinchilla, Dalby, Kogan/Millmerran and Goondiwindi. Development of these regions will be staged to optimise production over the life of the project.

Arrow has established a framework to guide the selection of sites for production wells and production facilities and routes for gathering lines and pipelines. The framework will also be used to select sites for associated infrastructure such as access roads and construction camps. Environmental and social constraints to development that have been identified through the EIS process coupled with the application of appropriate environmental management controls will ensure that protection of environmental values (resources) is considered in project planning. This approach will maximise the opportunity to select appropriate site locations that minimise potential environmental and social impacts.

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2 Relevant Legislation

Primary relevant Commonwealth, Queensland state and local government legislation, plans and policies managing potential impacts to the aquatic environment in the study area are summarised below.

Environment Protection and Biodiversity Conservation Act (Cth) 1999

The Environment Protection and Biodiversity Conservation (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 (DSEWPC) (formerly the Department of Environment, Water, Heritage and the Arts). 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 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
- Commonwealth marine areas, and
- nuclear actions.

In addition, the EPBC Act confers jurisdiction over actions that have a significant environmental impact on Commonwealth land, or that are carried out by a Commonwealth agency (even if that significant impact is not on one of the seven matters of 'national environmental significance'). The Surat Gas Project was referred to DSEWPC under this legislation and has been declared a controlled action.

Nature Conservation Act (Qld) 1992

Nature Conservation (Wildlife) Regulation (Qld) 2006

The Nature Conservation Act is administered by DERM and 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 Nature Conservation Act is the conservation of nature, achieved by 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, and
- co-operative involvement of landholders.

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

Environmental Protection Act (Qld) 1994

Environmental Protection (Water) Policy 2009 (EPP Water)

Queensland Water Quality Guidelines 2009

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

The 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).

Fisheries Act (Qld) 1994

The Fisheries Act provides for the management, use and protection of fisheries resources in Queensland and is administered by DERM.

The main purpose of the 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.

The Act's objectives include:

- ensuring fisheries resources are used in an ecologically sustainable way
- achieving the optimum community, economic and other benefits obtainable from fisheries resources
- ensuring access to fisheries resources is fair, and
- ensuring resources are used in an ecologically sustainable manner is the most pertinent objective to this plan.

In the Fisheries Act, ecologically sustainable development 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.

Regional Vegetation Management Code

The guidance of the Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions (DERM, 2009) code has been used to ensure best practise techniques are undertaken to maintain aquatic ecological processes.

Murray Darling Basin Authority

The Murray Darling Basin Authority (MDBA) is currently releasing its draft Basin Plan as required by the Water Act 1997. Presently, the MDBA has released a guide to the Basin Plan, which explains that the eventual plan will, inter alia, propose sustainable diversion limits for both surface water and groundwater resources in the Murray Darling Basin. The project development area is located within the Condamine-Balonne and Border Rivers regions as defined in the guide to the Basin Plan. The proposed Basin Plan will then be finalised and legislated as a Basin Plan. Given the draft Basin Plan has not yet been released, it is not possible to quantify diversion limits, but it does require consideration in the future as and when the document becomes available to interested stakeholders.

Draft Policy for Biodiversity Offsets

Administered by DERM, guides the application of biodiversity offsets to address biodiversity impacts of development projects.

This policy is only used where a State Government agency is the decision maker or a concurrence agency under the (repealed) *Integrated Planning Act 1999.* Level 1 petroleum activities under the *Environmental Protection Act 1994* and permits for clearing protected plants under the *Vegetation Management Act 1999* are covered.

The Coordinator-General may also apply the Policy to projects under Part 4 – ‘Environmental coordination’ of the *State Development and Public Works Organisation Act 1971*.

Land Protection (Pest and Stock Route Management) Act (Qld) 2002

Provides a framework for the management of pest plants and animals, including aquatic and riparian species.

There are three classes of declared plants under the Land Protection (Pest and Stock Route Management) Act 2002. These plants are targeted for control because they have, or could have, serious economic, environmental or social impacts. Declaration under state legislation imposes various legal responsibilities for control by landowners on land under their management, including all landowning state agencies.

Back on Track Species Prioritisation Framework (DERM)

The Back on Track species prioritisation framework (Back on Track) is an initiative of the Queensland Department of Environment and Resource Management (DERM) 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; and
- increases the capacity of government, NRM bodies and communities to make informed decisions by making information widely accessible.

3 Assessment Methods

3.1 Study Area

Figure 3-1 shows the study area. The study area includes the project development area as well as some surrounding catchment areas to enable comparison of aquatic habitat within and adjacent the project development area. This comparative analysis is integral to quantifying and understanding changes over time, if any, on aquatic habitats associated with project activities.

The study area for this aquatic ecology impact assessment is approximately bounded by Wandoan to the north, Goondiwindi to the south, Oakey to the east and Miles to the West.

coffey environments	Date: 20.05.2011 MXD: 7040AC_AQ_GIS001_v1_1 File Name: 7040_AQ_F001_GIS_GL	Arrow Energy Surat Gas Project	arrow energy go further	Project Development Area	Figure No: 3-1

3.2 Desktop Study

An extensive review of available relevant aquatic ecology was undertaken for areas within and, where relevant, adjacent to the project development area. A significant body of information, describing a wide range of environmental factors, was identified as part of this review. This extensive list was assessed for its relevance to this project prior to its inclusion in this report. The review incorporated:

- Identification of relevant Legislation.
- Intensive internet search to identify published information, reports, data and/or potential sources of information, reports or data.
- Data held by various agencies which was identified and purchased/procured where available, including Bureau of Meteorology (BOM) climate data and stakeholder organisation data (fishing clubs and fisheries groups).

Database searches were undertaken to determine if any aquatic flora, fauna or areas protected under existing legislation occur within the Project area.

Four databases were utilised to determine the presence of species protected under both Federal and State legislation and included the EPBC Protected Matters Search Tool (DEWHA 2009), Queensland EPA Wildlife Online Search Tool (EPA 2009), Regional Ecosystem Mapping and Moratorium Mapping Tool (DERM 2009).

The DERM report on Aquatic Conservation Assessments for the Condamine Basin using AquaBAMM (Clayton *et.al.*, 2008) was also reviewed in the context of the project.

3.3 Field Surveys

Selection of field sampling sites

Aquatic ecosystems within the study area are relatively diverse with permanent, semi-permanent and highly seasonal lotic (flowing water) and lentic (non-flowing water) environments represented in four river basins (Condamine, Dawson, Weir and MacIntyre). In many instances these systems are highly modified by agriculture, mining, river regulation, urbanisation and power generation, hence land-use impacts are significant and widespread.

The methods employed in this study were designed to ground truth the findings of the desktop studies, identify aquatic values that may constrain development and provide a baseline for compliance monitoring during construction, operations and decommissioning of the project. As the precise location of coal seam gas infrastructure will be determined as the project progresses, a risk based framework approach for selecting representative sampling sites was employed:

- A preliminary list of a large number of potential sampling sites across the study area was prepared based on land-use, waterway/catchment characteristics and strategic factors (i.e., placement of sites above and below the confluence of major tributaries).
- Areas that may contain significant aquatic ecosystem values such as Ramsar wetlands or critical habitat for listed aquatic species were identified.
- Waterways were characterised at the desktop level based on physical and ecological features to ensure that all waterway types were adequately represented in the sampling program. Factors considered during site selection include:

- Drainage Basin.
- The proportion of lentic and lotic bodies within the study area.
- Stream order.
- Hydrological factors (permanently flowing, ephemeral).
- Catchment land-use.
- Salinity gradient (a significant gradient is identified in the Queensland Water Quality Guidelines (DERM, 2009)).
- Location in relation to other waterways (e.g. above or below confluences to enable the influence of key catchments / sub-catchments on ecosystem health to be examined).
- Suitability of habitat for aquatic ecology sampling.
- Accessibility during wet season flows.

Comprehensive desktop assessment indicated 73 sites that were potentially suitable for ground truthing the aquatic ecology desktop findings. Many of these sites were relatively homogeneous in terms of key biophysical attributes such as habitat type, altitude, land use and climate, indicating that a representative subset of sites could be sampled without significant loss of information.

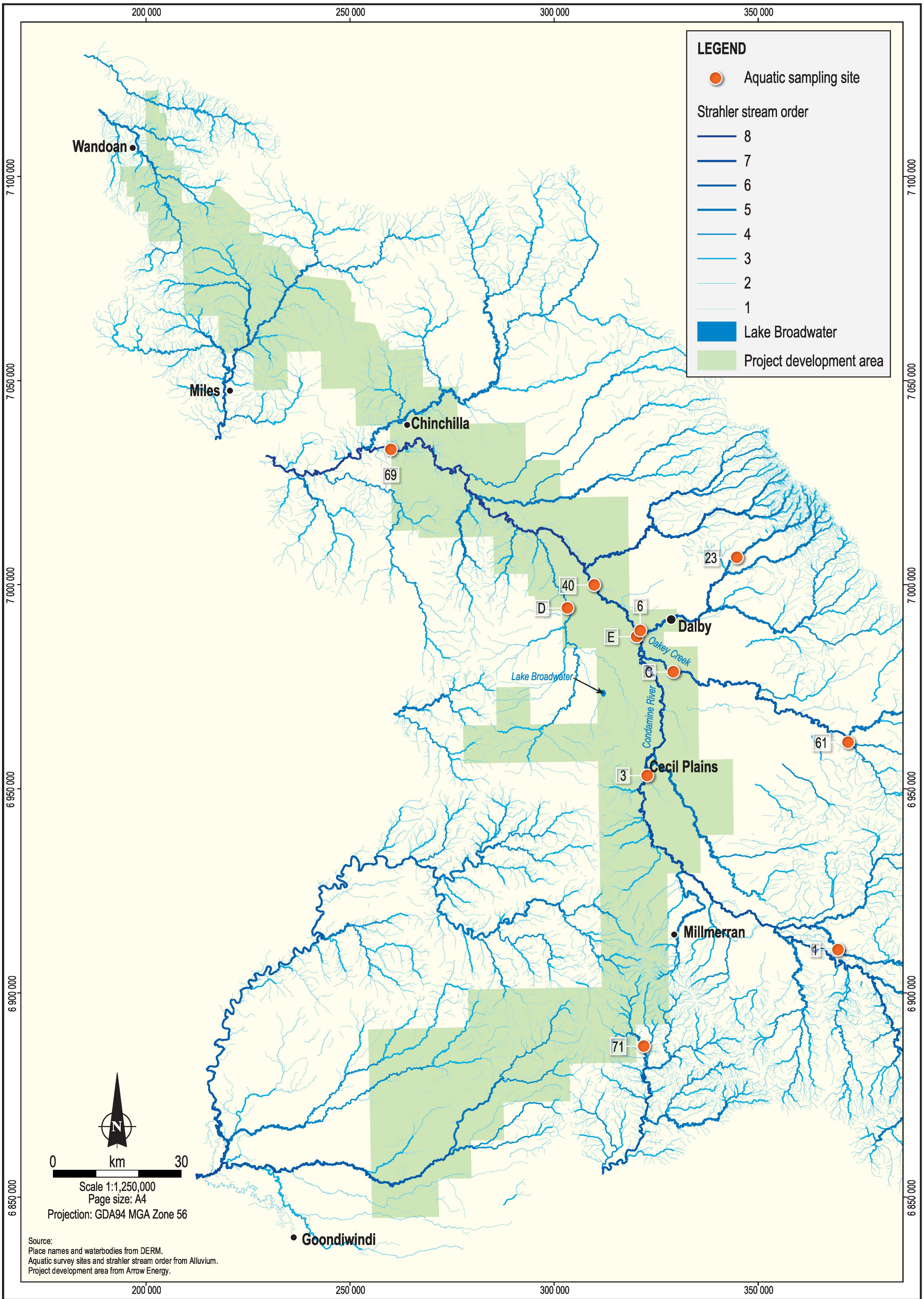
A field reconnaissance trip was undertaken to assess all 73 sites on the basis of the above criteria. Ground truthing identified 11 of those 73 sites as being representative of the entire study area (Figure 3-2)

Eleven sampling sites were selected for field surveys during the 2009 pre-wet and 2010 post-wet periods. The pre-wet and post-wet sampling periods were selected to ensure consistency with the AusRivAS methodology; the preferred methodology for aquatic macroinvertebrate assessments. Survey timing allows the model to more fully analyse annual variation in conditions within a river system, which in turn provides a more comprehensive understanding of habitat quality. Figure 3-3 and Figure 3-4 show the representativeness of the selected field sampling sites. Permanent waterways within the study area were deliberately over-represented because they are more likely to support aquatic ecosystems that are of environmental or recreational significance. These systems are more likely to be sensitive to impacts associated with the coal seam gas development than the highly tolerant ecosystems typically found in ephemeral systems.

The Dawson River system was not assessed as all tributaries within the project development area were highly ephemeral and had no water in them, including during post-wet surveys.

Table 3-1 Aquatic ecology sampling sites during the 2009 field surveys.

Site	Watercourse	Coordinates	Stream Order	Habitat	Basin	Predom. land-use	Salinity Zone	Hydrology
1	Condamine R. @ Karrara Rd	27 55.309S 151 40.469E	5	Lotic	Condamine	Cropping	Condamine-Macintyre	Permanent
3	Condamine R. @ Cecil Plains	27 31.902S 151 12.331E	5	Lotic	Condamine	Cropping	Condamine-Macintyre	Permanent
6	Myall Ck @ Moonie Hwy	27 12.705S 151 11.622E	5	Lotic	Condamine	Cropping, Urban	Condamine-Macintyre	Permanent
23	Myall Ck @ Irvingdale	27 3.146S 151 26.082E	5	Lotic	Condamine	Cropping	Southern Divide	Permanent
40	Braemar Ck @ Kogan Rd	27 06.476S 151 04.805E	3	Lotic	Condamine	Grazing, Mining	Condamine-Macintyre	Ephemeral
62	Westbrook Ck @ Oakey-Pittsworth Rd	27 27.788S 151 42.277E	5	Lotic	Condamine	Cropping, Urban	Southern Divide	Permanent
69	Condamine R. @ Chinchilla Weir	26 48.115S 150 35.159E	5	Lentic	Condamine	Grazing	Condamine-Macintyre	Permanent
71	Brigalilly Ck @ Heckles Rd	28 07.792S 151 11.238E	3	Lotic	MacIntyre	Grazing	Condamine-Macintyre	Ephemeral
C	Oakey Creek @ Cecil Plains Rd	27 18.135S 151 16.365E	5	Lotic	Condamine	Grazing	Condamine-Macintyre	Permanent
D	Wilkie Ck @ Theten Rd	27 09.540S 151 00.800E	4	Lotic	Condamine	Grazing, Cropping	Condamine-Macintyre	Permanent
E	Condamine R. @ Louden Weir	27 13.473S 151 11.059	5	Lentic	Condamine	Grazing, Urban	Condamine-Macintyre	Permanent



coffey environments	Date: 20.05.2011 MXD: 7040AC_04_GIS002_v1_1 File Name: 7040_AQ_F02.01_GIS_GL	Arrow Energy Surat Gas Project	arrow energy go further	Aquatic Ecology sampling sites	Figure No: 3-2

Figure 3-3 Representativeness of the selected sampling sites in terms of major anthropogenic, meteorological and physical influences on aquatic ecology.

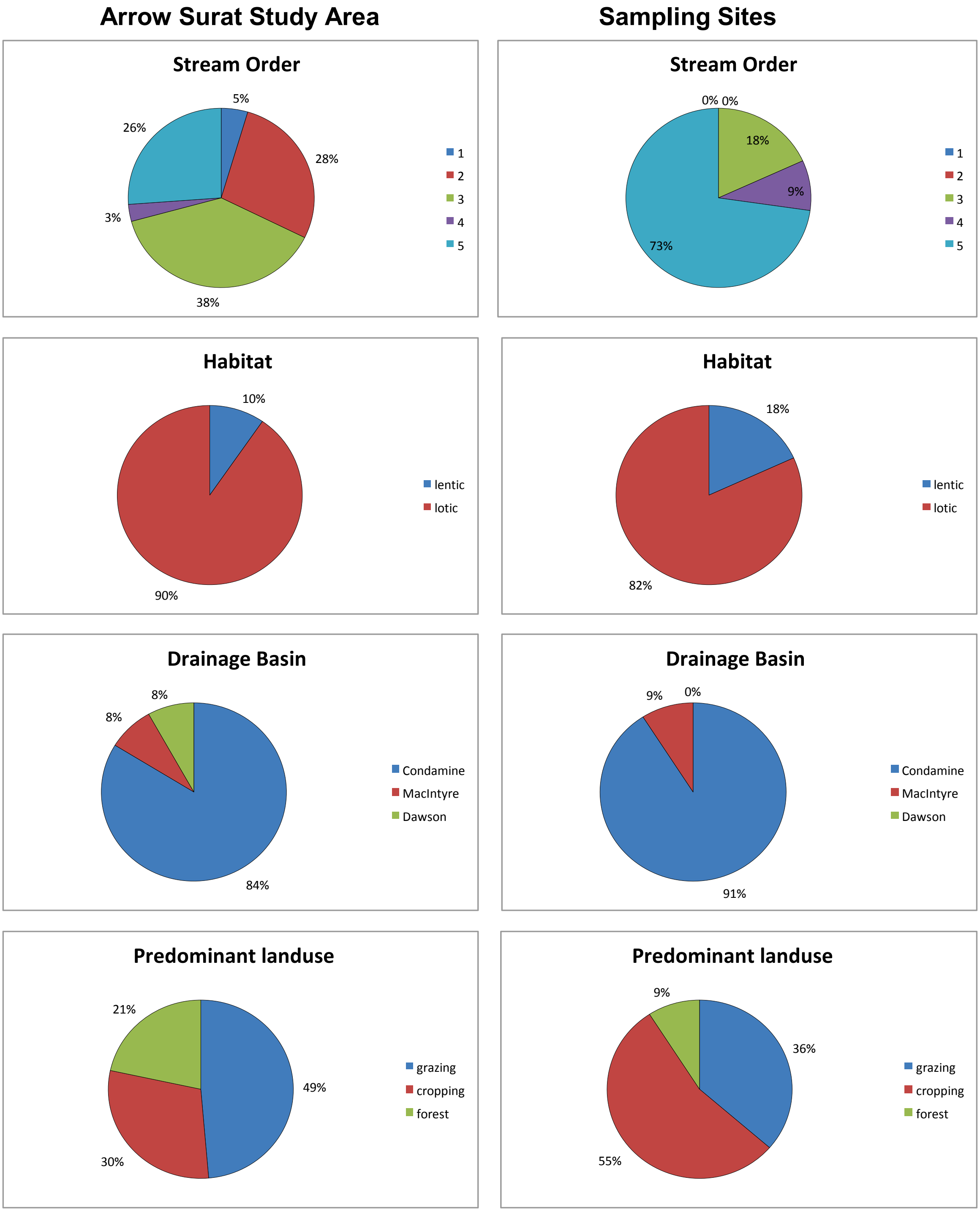


Figure 3-4 Representativeness of the selected sampling sites in terms of major anthropogenic, meteorological and physical influences on aquatic ecology.

3.4 Water Quality

To assist in interpreting ecological data, physico-chemical water quality parameters were assessed in situ using a multiprobe water quality instrument (model TPS 90FL). Instrumentation is calibrated according to manufacturer specifications before each field event to ensure accuracy and consistency. The measured parameters included pH, electrical conductivity, turbidity, water temperature and dissolved oxygen.

3.5 Sediment Quality

Sediment sampling was undertaken using the standardised techniques prescribed in the Monitoring and Sampling Manual 2009 (DERM 2009).

At each of the 11 aquatic ecology sites, composite sediment samples were collected from approximately 10 locations within the creek channel (stratified sampling). Samples were collected with a stainless steel trowel to a depth of approximately 50 mm. The samples were mixed in a bucket and approximately 500 grams was placed into a zip-lock bag and the air squeezed out before being sealed and placed on ice.

Laboratory analyses were undertaken for samples collected at sites C, D, E, 3, 6, 40, 69, 71 and a quality assurance sample which involved preserving additional sediment in glass jars using the same sample procedure as described above. These eight sites were considered representative of different sediment conditions within the study area, therefore the remaining three site samples were not analysed to avoid repetition.

The sediment samples for sites C, D, E, 3, 6, 40, 69, 71 (together with the quality assurance sample) were couriered to a National Association of Testing Authorities (NATA) laboratory (SGS Laboratories) for analysis.

The following analyses were undertaken:

- Particle size (full sieve analysis)
- Metal suite (including Cu, Pb, Zn, Ni, Cd, Hg, As, Co, V, Se, B)
- Ammonia
- Nutrients (Total P, Total N)
- Electrical conductivity
- Total petroleum hydrocarbons (C_6 - C_{36})

The remaining sediment samples from the other three sites were frozen and stored for further analysis if required.

3.6 Aquatic Macroinvertebrates

Macroinvertebrate samples were collected using standard field protocols outlined in the Australian Rivers Assessment System (AusRivAS) Queensland field manual (DNRM, 2001). AusRivAS is the accepted Australian methodology for assessments of this nature and utilises regional models to statistically compare observed invertebrate assemblages at test sites with those expected at comparable but relatively pristine (reference) sites.

Field sampling conventions under this AusRivAS were followed:

- A 250μM mesh triangular net (250 mm x 250 mm x 250 mm) was used to collect kick samples along a 10 m transect at each site, starting from “downstream” and working “upstream”.

- Where possible, two habitat types were sampled at each site. Edge and pool bed habitat were sampled at nine sites; and riffle/pool and riffle/edge were sampled at one site each respectively. 'Gleaning' of rocks was performed where appropriate.
- At Sites 6 and 71 only pool habitat was available, whilst at Site E only edge habitat was available.

Samples were sorted in the field following AUSRivAS protocols:

- Samples were initially picked for 10 minutes to collect the most abundant and/or visible animals with a maximum of 10 examples of each taxon being collected.
- Samples were picked for a further 20 minutes, concentrating on less common or more cryptic taxa. Again, collection of a particular taxon ceased once 10 animals were collected.
- A further 10 minutes picking was performed on each sample and picking ceased if no new taxa were found, otherwise the process continued in 10 minute blocks until either no new taxa were found, or the total time elapsed was 60 minutes.
- Macroinvertebrate assemblages in the preserved samples were identified to family level and counted.

Macroinvertebrate assemblage data were entered into the AusRivAS models (Queensland regional streams west of the Great Dividing Range, pre-wet and post-wet seasons, pool/edge/riffle habitat) or along with predictor variables specifically appropriate to that particular model. The model mathematically predicts the aquatic macroinvertebrate families expected to occur in comparable but unimpacted systems (reference condition) and compares these results with the fauna actually collected. This provides a measure of biological impairment.

The AusRivAS model software outputs specify the ratio of Observed to Expected taxa and abundances (O/E score). The 'Observed' macroinvertebrates are calculated for all families which were observed and which had a predicted probability of occurrence greater than 50%. The 'Expected' variable is calculated as the sum of all probabilities greater than 50%. An O/E value close to 1 indicates that the observed macroinvertebrate assemblages are similar to those of the reference streams, and a value close to zero indicates severe impairment compared to reference condition. Based upon these ratios, band ranking indicating the ecological health of the river is assigned (Table 3.5).

In addition to O/E scores the AusRivAS models calculate a "Stream Invertebrate Grade Number – Average Level" (SIGNAL) score. SIGNAL is a biotic index system that allocates a value to each macroinvertebrate family based largely upon their sensitivity to pollution (a value of 10 indicates high sensitivity, 1 represents high tolerance) (Chessman, 2003). Weighted SIGNAL2 is a revised index that weights the SIGNAL scores of taxa by their abundance, relative to the overall abundance of all taxa at the site. Based on the presence or absence of macroinvertebrate families the environmental quality of the site can be assessed and provide an indication of long-term water quality (Chessman 2003a).

Due to the limitations of using AusRivAS models on an ephemeral system with low overall diversity, a multivariate statistical approach was also utilised to determine whether the sites upstream of the project development area differed in terms of macroinvertebrate assemblages. The statistical package Primer-E v6 was used to perform Bray Curtis similarity analysis on log transformed macroinvertebrate data. The log transformation of the dataset is a commonly used approach for ecological data where assemblages are strongly dominated by a small number of taxa (Clark & Warwick, 2001) and reduces the influence of dominant taxa to reveal the influence of less common taxa. As the common taxa tend to be highly tolerant of a range of water quality, habitat and hydrological regimes, it is the less common taxa that are of greatest interest in distinguishing impacted from unimpacted sites. A cluster analysis was performed on the macroinvertebrate assemblages between sites and has been depicted as a dendogram. Differences between sites were assessed at the 30% similarity level. This similarity level identifies similarities at the 30% level or greater (within the Bray-Curtis similarity matrix) of macroinvertebrate communities between sites.

3.7 Fish

Fish surveys were performed using techniques appropriate to the 23 species expected to be present in the EIS study area (Table 3-2) and to the environmental and site conditions at the time of sampling. Surveys were carried out under Fisheries Permits 114521 (Bowen area) and 130361 (General tag and release) issued to Aquateco Consulting Pty Ltd. Based on an assessment of the aquatic habitats in the study area, a combination of either fyke nets, seine nets, baited traps and/or electrofishing were employed. The sampling techniques deployed for each site are shown in Table 3-3 and Table 3-4.

Table 3-2 Fish species previously recorded within the study area based on desktop reviews. EPBC listed species or those of local conservation significance are highlighted.

Common Name	Scientific Name	Condamine River Catchment	Macintyre Brook Catchment
Native species			
Long-finned eel	*Anguilla reinhardtii*	●	
Bony bream	*Nematalosa erebi*	●	●
Mountain galaxid	*Galaxias olidus*	●	
Australian smelt	*Retropinna semoni*	●	●
Rendahl’s tandan	*Porochilus rendahli*	●	
Hyrtyl's tandan	*Neosilurus hyrtylii*	●	

Common Name	Scientific Name	Condamine River Catchment	Macintyre Brook Catchment
Eel-tailed catfish	*Tandanus tandanus*	●	●
Fly-speckled hardyhead	*Craterocephalus stercusmuscarum*	●	
Murray-Darling rainbowfish	*Melanotaenia fluviatilus*	●	●
Olive perchlet	*Ambassis agassiizii*	●	●
Golden perch	*Macquaria ambigua ambigua*	●	●
Murray cod	*Maccullochella peelii pelii*	●	●
Silver perch	*Bidyanus bidyanus*	●	●
Spangled perch	*Leopotherapon unicolor*	●	●
River Blackfish	*Gadopsis marmoratus*	●	
Dwarf flathead gudgeon	*Philypnodon maculatus*	●	
Purple-spotted gudgeon	*Mogurnda adspersa*	●	●
Western carp gudgeon	*Hypseleotris klunzingeri*	●	●
Midgely's carp gudgeon	*Hypseleotris* Sp.1	●	●
Murray-Darling carp gudgeon	*Hypseleotris* Sp. 3	●	●
Introduced species			
Carp	*Cyprinus carpio*	●	●
Mosquito fish	*Gambusia holbrooki*	●	●
Goldfish	*Carassius auratus*	●	●

Backpack electrofishing (a non-lethal method) was employed as the primary survey technique where possible. A Smith-Root electrofisher backpack was used to shock suitable habitat for a duration of 1200 seconds of actual shocking time. However, at several sites there was insufficient water to sample for the entire 1200 seconds. Captured fish were netted and placed in a bucket with an approved anaesthetic to minimise stress. Environmental factors such as elevated electrical conductivity can limit the effectiveness of this approach and consequently electrofishing was used successfully at 10 of the 11 sites sampled during the November 2009 surveys, with the Westbrook Creek site (Site 62) being too saline for effective electrofishing. All sites were sampled with electrofishing during the May 2010 surveys.

Fine mesh (6mm) seine nets were used in areas where there were limited snags and where the substrate was conducive to this approach. Seine netting was used at 4 of the 11 sites sampled for both survey periods.

Fine mesh (6mm) fyke nets were baited, deployed and left overnight. Single, double and triple wing configurations were used depending on the nature of the site. Fyke nets were set with the cod end buoyed or otherwise suspended to prevent accidental drowning of platypus, turtles or water rats. Fyke netting was used at 4 of the 11 sites sampled during the November 2009 surveys and at 9 of the 11 sites during the May 2010 surveys.

Small unbaited fish traps were deployed at 2 sites for each survey period and were positioned near available in-stream habitat (e.g. structural woody habitat; draping aquatic vegetation; or in-stream aquatic macrophytes) where available.

Captured fish were identified to species level and total count recorded prior to fish being returned unharmed to the site of capture.

Table 3-3 Fish sampling techniques deployed at each site during the November 2009 surveys.

Name	Waterbody	Electrofish	Seine net	Fyke net	Bait trap
Site 1	Condamine River	●			
Site 3	Condamine River	●	●	●	
Site 6	Myall Creek	●			
Site 23	Myall Creek	●			
Site 40	Braemer Creek	●			
Site 62	Westbrook Creek		●		●
Site 69	Condamine River	●	●	●	●
Site 71	Brigalilly Creek	●	●		
Site C	Oakey Creek	●			
Site D	Wilkie Creek	●		●	
Site E	Condamine River	●		●	

Table 3-4 Fish sampling techniques deployed at each site during the May 2010 surveys.

Name	Waterbody	Electrofish	Seine net	Fyke net	Bait trap
Site 1	Condamine River	●		●	●
Site 3	Condamine River	●	●	●	
Site 6	Myall Creek	●		●	
Site 23	Myall Creek	●		●	
Site 40	Braemer Creek	●		●	●
Site 62	Westbrook Creek	●	●		
Site 69	Condamine River	●	●	●	
Site 71	Brigalilly Creek	●	●	●	
Site C	Oakey Creek	●			
Site D	Wilkie Creek	●		●	
Site E	Condamine River	●		●	

3.8 Macrophytes

A list of observed aquatic macrophyte species was developed for each sampling site (Table 4-11) based on species identified in the field.

3.9 Other Aquatic / Semi-aquatic Fauna

Modified fyke nets and opera house turtle nets baited with oily fish were employed to concurrently sample fish and turtles within weirs and 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 employed in the post wet 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.

3.10 Impact assessment

The construction, operation and decommissioning of the project may result in a range of direct and indirect impacts to freshwater aquatic ecosystems, including:

- riparian/aquatic vegetation clearing and/or disturbance.
- loss or fragmentation of aquatic habitat.
- creation of physical or velocity barriers to the movement of aquatic organisms.
- physical disturbance to stream banks or beds.
- changes in water or sediment quality or quantity.
- sediment transport, change in sediment scouring/deposition patterns or smothering of habitat.
- translocation of pest flora and fauna.

These impacts have been assessed in the context of activities undertaken during construction, operation, maintenance and decommissioning of the project. The potential significance of these impacts has been quantified as a function of the sensitivity of freshwater aquatic values and the magnitude of the impact, using the matrix shown in Figure 3-5.

Figure 3-5 Significance Impact assessment matrix for freshwater aquatic ecosystems within the freshwater aquatic ecology study area.

		Sensitivity of Environmental Value		
		High	**Moderate**	**Low**
Magnitude of Impact	**High**	Major	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Negligible

Major Impacts are typically associated with long term, widespread or very severe impacts on iconic environmental values of national or international conservation significance.

High Impacts may relate to lower magnitude impacts on iconic environmental values, or may be the result of long term, widespread or severe impacts on species of state significance.

Moderate Impacts are associated with severe impacts on less sensitive environmental values, or to less severe impacts on environmental values of state or national significance.

Low Impacts are those that are relatively short term, low severity and localised, and that affect environmental values that are marginal or are tolerant of disturbance events.

Negligible Impacts that are of such low magnitude or affect such low value ecosystems that no mitigation or avoidance strategies are warranted.

Sensitivity Criteria for Aquatic Ecosystem Values

The sensitivity of a particular aquatic community or value to impacts associated with the project is determined by considering the following attributes:

Conservation status	Is the waterway 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 environments, or has it been impacted by urbanisation and industrial operations?

	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 communities, aquatic ecology processes, habitat value?
Resilience to change	Are the aquatic 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 ecosystems, communities and processes recover following an impact or disturbance event?

Figure 3-9 shows the criteria used to assign sensitivity rankings to freshwater aquatic ecosystem values. Once an ecosystem had been assessed on the basis of each attribute, it was assigned the sensitivity ranking of the most sensitive of the attributes.

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 criteria below:

Geographic extent of impact	Will the potential impact disturb aquatic systems 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)?
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?

Table 3-5 includes the criteria used to evaluate the magnitude of impacts expected on aquatic ecosystems as a result of the project with normal environmental controls for the protection of aquatic ecosystems, surface and groundwater quality and minimisation of soil erosion in place.

Table 3-5 Criteria used to evaluate the sensitivity of aquatic ecosystems and the magnitude of impacts potentially arising from the Surat Gas Project.

	High	Moderate	Low
Sensitivity			
Conservation status	• wild river status • world heritage status • Ramsar status • EPBC/Nature Conservation listed flora/fauna/communities • high value fishery • International eco-tourism destination	• local government management • species of conservation interest (currently unlisted) • moderate/marginal fishery values • state or local eco- tourism destination	• no formal conservation status • no species, habitat or communities of special conservation significance • no fisheries value • local or no ecotourism value
Intactness	• undisturbed, pristine aquatic system • high quality aquatic habitat • important movement corridor for aquatic species • nursery/spawning area for aquatic fauna	• 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 value
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

	High	Moderate	Low
Resistance to change	• poor tolerance to disturbance events, minor impacts have catastrophic effect	• moderately tolerant or adaptive communities	• highly tolerant or adaptive communities able to survive significant disturbance impacts
Replacement potential	• disturbance likely to cause irreparable damage or permanent loss of values	• communities likely to exhibit moderate to good recovery following disturbance	• communities capable of rapidly recovering/regenerating after disturbance events
Magnitude			
Geographic extent of impact	• impact has potential to affect aquatic ecosystems over a wide spatial range (>20 km)	• impact has potential to affect aquatic ecosystems within a range 0.5 km to 20 km radius	• impact has the potential for localised effects on aquatic ecosystems up to 0.5 km away
Duration of impact	• impact period is from 2 years to perpetuity	• impacts affects aquatic ecosystems for 3 months to 2 years	• impact is short term (<3months)
Severity	• potential for complete loss of aquatic communities	• potential for temporary or partial loss of aquatic communities	• potential for minor, short-term impairment of aquatic communities

4 Description of Existing Aquatic Ecosystems

4.1 Locality Description

The EIS study area (approximately 8600 km^2) covers four sub-catchments in the northern reaches of the Murray-Darling Basin; the Condamine River, Weir River, Dawson River and Macintyre Brook. Aquatic ecosystems within the EIS study area are relatively diverse with permanent, semi-permanent and highly seasonal lotic (flowing water) and lentic (non-flowing water) environments. The far northern section of the study area is located within the Dawson River sub-catchment, a major tributary of the Fitzroy River system (an easterly flowing coastal system). Desktop reviews identified 22 streams within the study area, including the Condamine River itself. The majority of these streams were within the Condamine catchment (16 streams); with two streams in the Dawson River catchment, three in the Weir River catchment and one in the Macintyre Brook catchment. Within the EIS study area there are also numerous smaller creeks and drainage lines, many of which are known to be ephemeral. Several wetlands are located within the EIS study area, of which one (Lake Broadwater) is listed as significant under the EPBC Act. Long Swamp (within the Condamine catchment), although recognised locally and by Arrow as a natural wetland is not listed as an important wetland in state or federal directories and it is not specifically listed under state or federal legislation.

Settlement of the area began in the 1840's with early settlers establishing large grazing enterprises. More intensive settlement was encouraged after Queensland became a State in 1859 and legislation was passed to subdivide larger pastoral holdings for agricultural use. In the early 1900s there was a massive expansion in the region’s agricultural economy. This was partly due to construction of a railway in 1867 and subsequent cropping and dairy industry expansion (Carberry 1995). It is probable that the anthropogenic pressure on aquatic ecosystems increased rapidly over this period.

The main land use within the EIS study area is agriculture (both cropping and grazing), urbanisation and mining (DPI 1995, Biggs & Carey 2006). The main crops are wheat, barley, oats, chick peas, sorghum, sunflower, maize, cotton and mung beans (Biggs & Carey 2006). Cattle and sheep are grazed while intensive animal production includes feedlots, piggeries and poultry farms (Carberry 1995, Biggs & Carey 2006). Coal deposits are mined in a geological unit called the Walloon Coal Measures. Coal seam gas is also extracted in the region. Basalt rock from the Main Range Volcanics is quarried for road, railway and other construction (Biggs & Carey 2006).

4.2 Results of Desktop Study

Climate

The most reliable source of meteorological data for the study area is the Bureau of Meteorology weather stations listed in Table 4-1.

The Surat Basin has a warm climate with mean maximum temperatures ranging from 28.1°C to 34.2°C in January and 16.3°C to 19.7°C in July. Mean minimum temperatures range from 16.7°C to 20.6°C in January and 2.7°C to 6.3°C in July. Hot conditions prevail between October and March with mild to cold conditions between May and August. The average annual rainfall ranges between 573.9mm to 944.0mm although only Toowoomba (944.0mm) exceeds 700mm per year. The majority of rainfall occurs in the warmer months of the year (November to February), although significant variability occurs throughout the region.

Database searches

Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)

Nature Conservation Act 1992 (Qld)

The desktop study identified one EPBC Act-listed nationally significant fish species (Murray cod) that has previously been recorded within 5 km of the project development area and one nationally (EPBC Act-listed) and state significant (under the Nature Conservation Act) reptile species (Fitzroy River Turtle).

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 addressed in the Terrestrial Ecology report.

AquaBAMM

Aquatic Conservation Assessment using AquaBAMM assesses the conservation and ecological value of wetland systems based on a series of national and international criteria, including naturalness (aquatic and catchment), diversity and richness, threatened species/ecosystems, priority species/ecosystems, special features, connectivity and representativeness. The ACA for the Condamine Basin included fluvial, lacustrine and palustrine wetlands. Key findings included:

- 67% of riverine catchments and 68% of non-riverine catchments exhibited an Aquascore in the very low to medium range.
- The Condamine River received a high Aquascore in the reaches from above Dalby to approximately Chinchilla weir, and a very high Aquascore downstream of Chinchilla weir. This reflects the stream order and relative intactness of the main river channel
- All other tributary streams within the study area received very low, low or medium Aquascores, symptomatic of a highly modified agricultural landuse. Charleys Creek was the exception, receiving a very high rating.

Table 4-1 Available meteorological data for the study area.

Site Name (BOM site number)	Location to EIS study area	Status	Duration	Data Parameters (Mean)				
				Temp (C) Mean Summer Max	Temp (C) Mean Summer Min	Temp (C) Winter Max	Temp (C) Winter Min	Rainfall (mm)
Dalby Airport (041522)	Within	Active	1992 – 2010	32.5	18.8	18.7	4.0	606.2
Miles Post Office (042023)	Within	Active	1885 – 2010	33.2	19.5	19.3	3.6	649.2
Pittsworth (041082)	Within	Active	1886 – present	29.9	17.0	16.7	5.0	693.5
Dalby Post Office (041023)	Within	Inactive	1870 – 1992	32.0	18.5	18.7	4.1	676.4
Oakey Aero (041359)	Adjacent	Active	1970 – 2010	30.8	17.8	18.5	2.7	624.6
Surat (043035)	Adjacent	Active	1881 – 2010	34.2	20.6	19.7	4.2	573.9
Toowoomba Airport (041529)	Adjacent	Active	1881 – 2010	28.1	17.8	16.6	6.3	648.1
Toowoomba (041103)	Adjacent	Inactive	1869 – 2007	27.6	16.7	16.3	5.3	944.0

The ACA also identified a number of “priority” aquatic flora and fauna species. These included:

- *Euastacus* species (Spiny Freshwater Crayfish). A higher altitude species not expected within the project area.
- *Galaxias olidus* (Mountain Galaxias). A higher altitude species not expected within the project area.
- *Mogurnda adspersa* (purple spotted gudgeon)
- *Bidyanus bidyanus* (silver perch)
- *Tandanus tandanus* (eel-tailed catfish)
- *Ornithorhynchus anatinus* (platypus)
- *Fimbristylis vagans* (no common name). Riparian species, no record in study area.

- *Aponogeton queenslandicus* (Queensland lace plant). No record in Condamine basin.
- *Clematis fawcettii* (stream clematis). Riparian species, no record in study area.

Semi-aquatic amphibians, reptiles, avifauna and riparian flora have been addressed in the Terrestrial Ecology report.

Local Fisheries and Fishing Clubs

Listed below are the fishing clubs and stocking organisations within the Surat Basin community that would utilise the resource on an ongoing basis and underpin the need for ecological sustainable development principles to be applied to the project to meet the objectives of the Fisheries Act. The first list includes clubs within the project development area and the second list contains clubs adjoining the project development area. It is likely that there are several smaller less official clubs within the project development area. The second list has been included as some fish stocked in the adjoining areas are expected to move into the project development area. These clubs undertake various river improvements (such as reinstating wood instream structure) and fish stocking. Details have not been obtained on stocking locations and numbers. Most fishing activities take place where ever there is road access, this was apparent at most sites surveyed throughout the study area. However, fishing is likely to be well spread throughout private properties by residents and their acquaintances.

Fishing clubs and stocking associations operating within the project area:

- Condamine Alliance
- Oakey Freshwater Fish Stocking Association
- Murray-Darling Basin Commission (Native fish strategy)
- Chinchilla and District Amateur Fishing Club.

Fishing clubs operating adjacent to the project development area:

- Surat fishing and restocking club Inc
- Warwick District Fish Restocking Association Inc.
- Nobby and District Fishing Club Inc
- Murilla Fish Stocking Association Inc.

Both *Gambusia holbrooki* and *Cyprinus carpio* are listed under the Fisheries Act 1994 (Qld) (under Section 74 of the Fisheries (Freshwater) Management Plan 1999) as noxious species. Some of these local groups may target carp for removal, but these are unlikely to have any real effect on numbers.

There are several other locally significant fish species that are unique to the area as they are outside of their normal range/catchment but are not currently listed under state legislation.

Other Aquatic/Semi-Aquatic Fauna

A number of turtle species are known to inhabit waterways of the upper Murray-Darling, predominantly occupying slower moving, deeper pools, waterholes, billabongs and permanent wetlands. The most common species found throughout the Murray-Darling Basin are *Chelodina longicollis* (Eastern Long-neck Turtle), *Chelodina expansa* (Broad-shelled Turtle) and *Emydura macquarii* (Macquarie Turtle).

4.3 Results of Site Inspection and Survey Events

Water Quality

Water quality at the time of the sampling program was spatially variable between the different sampling sites, as would be expected from highly impacted and predominantly ephemeral systems during advanced stages of desiccation. Table 4-2 and Table 4-3 show the results of field physico-chemical water quality assessments at each site, whilst Table 4-4 and Table 4-5 provide a statistical summary of water quality across all sites for the two sample periods. The default ANZECC (Australian and New Zealand Environment and Conservation Council) guidelines for aquatic ecosystems in south-east Australia (which includes south-east Queensland) are also provided (ANZECC & ARMCANZ 2000). These values are derived from regional reference data provided by government agencies and are shown here in the absence of site specific trigger values.

Table 4-2 In situ physico-chemical water quality results, Surat Basin, November 2009 field event.

Parameter	Site 1	Site 3	Site 6	Site 23	Site 40	Site 62	Site 69	Site 71	Site C	Site D	Site E	ANZECC guidelines
Dissolved oxygen (mg/L)	4.4	6.45	9.06	1.24	1.80	5.80	5.63	5.13	6.79	5.91	3.76	
Dissolved oxygen (%satn.)	52	74.5	118	14	20	72	74	80	80	70	45	90-110
Temperature (C)	23.2	23.1	30.1	24.1	23	27	31	28.7	24.9	24.5	24.9	-
Electrical cond. (μS/cm)	130	275	427	240	76.7	1211	183	296	2200	110.7	138.3	125-2200
Turbidity (NTU)	406	14	439	23	347	28.7	661	601	117	597	326	6-50
pH	6.03	7.46	7.9	6.55	6.18	8.28	8.1	7.3	8.02	6.65	7.13	6.5-8.0

Table 4-3 In situ physico-chemical water quality results, Surat Basin, May 2010 field event.

Parameter	Site 1	Site 3	Site 6	Site 23	Site 40	Site 62	Site 69	Site 71	Site C	Site D	Site E	ANZECC guidelines
Dissolved oxygen (mg/L)	10.37	7.32	5.87	2.85	2.67	7.53	8.16	7.96	7.87	4.11	2.10	
Dissolved oxygen (%DO)	101	76	56	28	25	72	83	77	71	45	22	90-110
Temperature (C)	14.4	16.7	13.2	13.7	12.7	13.2	16.3	14.3	11.5	20.1	17.5	-
Electrical cond. (µS/cm)	261	181.6	400	206	176.1	1247	248	292	760	156.6	180	125-2200
Turbidity (NTU)	33.7	417	285	13.4	170.5	41	113.3	273	540	254	99.1	6-50
pH	7.6	7.1	7.16	6.83	6.64	8.48	7.46	7.36	7.83	6.85	7.14	6.5-8.0

Table 4-4 Statistical summary of in situ physico-chemical water quality results across all sites, during the November 2009 surveys.

Parameter	Unit	Mean	Max.	Min.	Std. Dev.	Std. Error	ANZECC guidelines
Dissolved Oxygen	mg/L	5.08	9.06	1.8	2.35	0.74	
Dissolved Oxygen (% satn)		61.95	118	14	30.52	3.41	90-110
Temperature	C	25.58	31.0	23.0	2.88	0.91	-
Electrical conductivity	µS/cm	499.17	1211	76.7	685	216.49	125-2200
Turbidity	NTU	295.87	661	14	239.77	75.82	6-50
pH		7.23	8.28	6.03	0.84	0.27	6.5-8.0

Table 4-5 Statistical summary of in situ physico-chemical water quality results across all sites, during the May 2010 surveys.

Parameter	Unit	Mean	Max.	Min.	Std. Dev.	Std. Error	ANZECC guidelines
Dissolved Oxygen	mg/L	6.07	10.37	2.1	2.74	0.83	-
Dissolved Oxygen (% satn)		59.62	101	22	26.34	7.94	90-110
Temperature	C	14.87	20.1	11.5	2.51	0.76	-
Electrical conductivity	µS/cm	373.48	1247	156.6	337.12	101.64	125-2200
Turbidity	NTU	203.64	540	41	168.62	50.84	6-50
pH		7.31	8.48	6.64	0.52	0.16	6.5-8.0

Dissolved Oxygen

Dissolved oxygen (DO) ranges were outside the ANZECC default guidelines for all sites except Site 1 in May 2010. Site 6 in November 2009 exceeded ANZECC guidelines, while the other sites were below ANZECC guidelines. Sites 23 and 40 were covered by floating mats of rotting macrophytes in November 2009 which explain the extremely poor DO levels of 1.24 mg/L and 1.8 mg/L respectively. The percentage dissolved oxygen saturation was similar between sampling occasions (62 and 60% for November 2009 and May 2010 respectively). Impacted DO conditions observed at other sites, except Site 6 in November 2009, reflect the lack of flows and expected relatively high BOD (Biochemical oxygen demand) loads. Site 6 in November 2009 shows supersaturated oxygen levels, most likely attributed to the significant algal bloom that was present at the time of sampling.

Electrical Conductivity

Electrical conductivity was highly variable, though most sites were relatively fresh. Site 62 (Westbrook Creek) exhibited highly elevated salinity levels (1211 and 1247 µS/cm for November 2009 and May 2010 surveys respectively), as did Site C (Oakey Creek, 2200 and 760 µS/cm for November 2009 and May 2010 surveys respectively). Westbrook Creek is a tributary of Oakey Creek, and receives treated sewage effluent from the Toowoomba treatment plant and was flowing at the times both surveys were undertaken. Concurrently at both sampling times no water was flowing at Site C, possibly as a result of water extraction between the two sites.

Variability in salinity was expected as the system had been reduced to a series of pools at both times of sampling. Conductivity depends on the evaporative losses and local inputs at each site, which in turn are influenced by micro climates, physical conditions and extractive use.

Turbidity

Turbidity was relatively high across the study area exceeding the ANZECC default guidelines for aquatic ecosystems except at Sites 3 and 62 in November 2009 and Sites 1, 23 and 62 in May 2010. Site 62 was flowing at the times both surveys were undertaken (Westbrook Creek), with the reduced turbidity likely related to dilution of ambient turbidity by the treated sewerage inflow.

pH

The pH ranges were outside ANZECC default guidelines for aquatic ecosystems for three sites during the November 2009 surveys. Two of which were slightly to moderately acidic (Sites 1 and 40) and the other slightly basic (Site C). This observation probably reflects warm conditions, low flows and a BOD resulting from the decay of organic material in a non-flowing system. All sites were within the ANZECC guidelines during the May 2010 surveys.

The variability in water quality parameters measured over both survey periods was expected due to the ephemeral nature of streams throughout the study area. These natural variations are further influenced by land-use practices such as water extraction, livestock watering and cropping.

Sediment Quality

Sediment quality was examined at 7 sites with a range of parameters examined including petroleum hydrocarbons, nutrients and metals. The results are summarised in Table 4-6.

Table 4-6 Sediment quality data summary.

Sediment Data		SITE 3 Condamine R 16/05/2010	SITE 6 Myall Ck 13/05/2010	SITE 40 Braemar Ck 15/05/2010	SITE 69 Condamine R 15/05/2010	SITE 71 Brigalilly Ck 17/05/2010	SITE C Oakey Ck 16/05/2010	SITE D Wilke Ck 14/05/2010	ANZECC ISQG Low mg/kg (dry wt)	ANZECC ISQG High mg/kg (dry wt)
Analyte Description	Units									
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20	<20	<20	<20	<20		
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20	<20	<20	<20	<20		
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50	<50	<50	<50	<50		
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50	<50	<50	<50	<50		
Total Kjeldahl Nitrogen	mg/kg	110	420	1500	120	360	1800	330		
Total Nitrogen (by calc.)	mg/kg	110	420	1500	120	360	1800	330		
Ammonia as N by DA	mg/kg	0.76	7.6	6.3	3.2	6.3	32	8.3		
Electrical Conductivity**	µS/cm	50	96	21	62	35	500	16		
Nitrite as N**	mg/kg	<0.025	0.11	0.036	0.043	0.073	0.45	0.066		
Nitrate as N**	mg/kg	0.99	0.47	0.21	0.24	0.37	0.52	0.18		
Phosphorus	mg/kg	78	460	63	110	130	980	51		
Arsenic	mg/kg	<3	<3	<3	<3	<3	<3	<3	20	70
Boron	mg/kg	<3	<3	<3	<3	<3	7.9	<3		
Cadmium	mg/kg	<0.3	<0.3	<0.3	<0.3	<0.3	0.4	<0.3	1.5	10
Cobalt	mg/kg	2.3	16	2.8	4.5	5.7	24	2.3		
Copper	mg/kg	0.92	13	2.4	1.9	6.5	28	1.2	65	270
Lead	mg/kg	1	5	5	1	7	8	2	50	220
Nickel	mg/kg	3.8	28	1.2	5.2	4.2	67	1.5	21	52
Selenium	mg/kg	<3	<3	<3	<3	<3	<3	<3		
Vanadium	mg/kg	2.8	<0.5	4	3.2	<0.5	<0.5	<0.5		
Zinc	mg/kg	5	39	6.4	5.6	16	74	3.6		
Mercury	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.15	1
Moisture	%	15	24	37	19	22	63	19		
Sediment Composition										
2.36mm (Fine Gravel)	% pass	81	100	98	81	98	96	77		
600µm (Medium Sand)	% pass	18	95	95	34	78	90	41		
300µm (Medium Sand)	% pass	4	87	56	7	48	85	27		
212µm (Fine Sand)	% pass	3	77	42	4	38	81	19		
75µm (Clay - Course Silt)	% pass	2	45	21	2	23	72	8		

** 1:5 soil:water — Except for those parameters denoted **, units are mg/kg dry wt

Petroleum Hydrocarbons

Petroleum hydrocarbon levels were less than the limit of detection in the sediment samples from all sites examined.

Electrical Conductivity

Electrical conductivity was similar at most sites (51 – 130 µS/cm), but moderately elevated at Site C on Oakey Creek (500 µS/cm).

Nutrient Parameters

The ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality (2000) do not present sediment nutrient threshold levels, and indeed suggest that the need to do so “is debatable”. The key issue relating to the impacts from sediment bound nutrients is their remobilisation to become available to biological organisms and the problems this may cause such as algal blooms, oxygen depletion and fish kills. Thus, sediment nutrient levels in streams may be indicative of the potential for nutrient related water quality problems, and where their sources are anthropogenic, the degree of human impact.

Total nitrogen levels varied substantially across the sites examined (110 – 1,800 mg/kg), with the lowest level found in the Condamine River Site 3 sample but markedly elevated levels in the Oakey Creek Site C and Braemar Creek Site 40 samples, particularly the former (1,500 and 1,800 mg/kg respectively). Organic nitrogen constituted most of the Total N found in all sediment samples examined, with inorganic nitrogen (ammonia, nitrate and nitrite) making only very small contributions. Nonetheless, ammonia levels were much higher at Site C (32 mg/kg) than at any of the other sites examined (0.76 – 8.3 mg/kg), and the nitrite/nitrate ratio was greater, indicating a reducing environment in the sediments at that site, at least when sampled in May 2010. In addition, phosphorus levels were highest at Site C (980 mg/kg). Sediment from Site 6 on Myall Creek (460 mg/kg) also showed elevated phosphorus levels relative to the other sites examined (51 – 130 mg/kg), but not as much as Site C.

The sediment samples from Site C and to a lesser extent Site 6 contained a significantly higher proportion of fine silts and clays (less than 75 µm particle size) than the sediment from all other sites. This may be associated with the elevated phosphorus levels at these sites, as phosphorus is known to bind to fine sediment particles (ANZECC/ARMCANZ ISQG).

The high level of fine, organic rich sediment at Site C on Oakey Creek suggests eutrophication at the time of sampling.

Metals

Sediment samples were analysed for a suite of 11 metals. The ANZECC/ARMCANZ Guidelines for Fresh and Marine water Quality (2000) present interim sediment guideline (ISQG) values for six of these, arsenic, cadmium, copper, lead, nickel and mercury.

Only the ANZECC/ARMCANZ ISQG threshold values for nickel were exceeded. The ISQG low and high values for nickel (21 & 52 mg/kg dry weight) were exceeded in the Site C sample (67 mg/kg), and the ISQG (low) value in the Site 6 sample (28 mg/kg).

The toxic metals mercury, cadmium, and arsenic were either not detected or only detected at very low levels in the sediment samples from all sites. Selenium was not detected in any sample and boron only in the sample from Site C. Vanadium and lead levels were very low in all samples.

Cobalt, copper, nickel and zinc levels were similar in all samples except those from Site C and Site 6, where they were higher. Levels at Site C exceeded those at any other site.

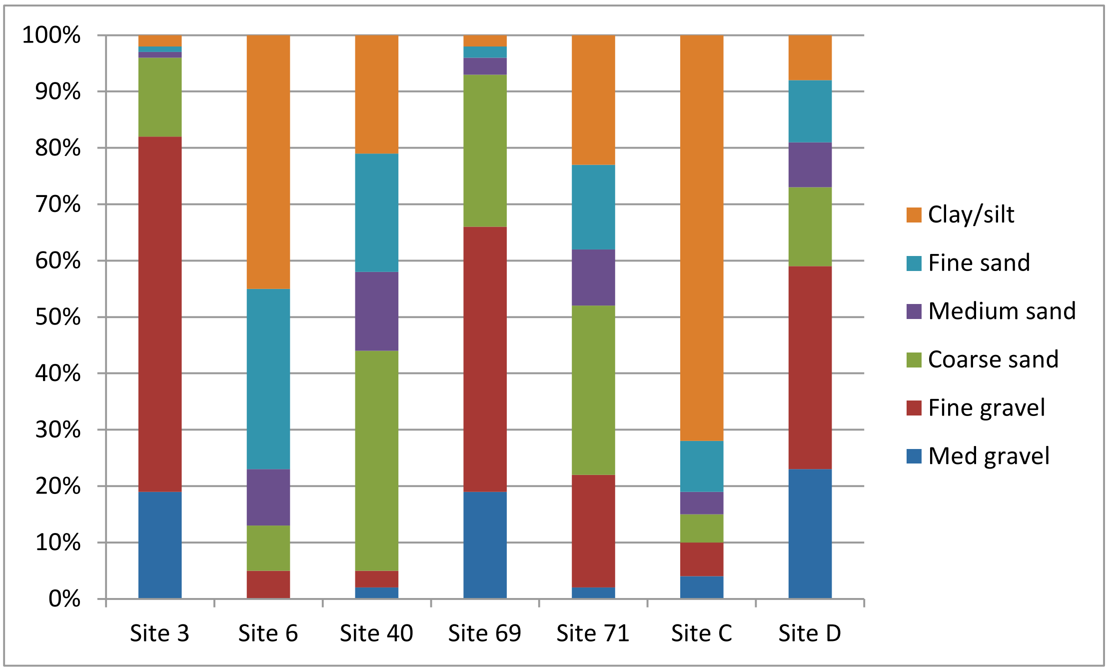
The sediment sample from Site C on Oakey Creek contained the highest metal levels overall of any site examined. Site 6 on Myall Creek showed higher cobalt, copper, nickel and zinc levels than any other site except Site C. As metals adsorb to fine sediment particles, this may, in part, be related to the relative abundance of very fine sediments at these two sites.

Particle Size Distribution

Figure 4-1 indicates the degree of heterogeneity in particle size distribution between sampling sites. Sites 3, 69 and D were predominantly fine to medium gravels, with >80% of particles at site 3 and approximately 60% of particles at sites 69 and D being of greater than 2.36mm diameter.

Sediments at site D were largely clay/silt in nature, whilst those at 6 contained a high proportion of clay/silt mixed with fine sand. Site 70 had the most diverse particle size distribution, being comprised of relatively even proportions of all sizes under 2.36mm diameter.

Figure 4-1 Particle size distribution in sediments.



Conclusions

Sediment nutrient levels were variable across the sites examined, with levels clearly elevated at Site C and to a lesser extent Site 6, relative to the other sites examined. The lowest levels were found at the two Condamine River Sites 3 and 69. Total nitrogen levels were elevated at Site 40, but not other nutrient parameters. Sediment electrical conductivity was also significantly higher at Site C than at other sites. This trend was also observed in the water quality data and may reflect the discharge of treated wastewater upstream of the sampling points, however, natural salt sources (eg groundwater contributions) cannot be ruled out.

Metal levels were generally low and similar in the sediment samples at all sites except for Site C and to a lesser extent Site 6, where they were elevated relative to other sites. The ANZECC/ARMCANZ ISQG threshold values for nickel were exceeded at Site C and Site 6.

Macroinvertebrate Communities

Site Similarity

Bray Curtis similarity log analysis was undertaken given that the assemblages are strongly dominated by a small number of taxa (Figure 4-2). This analysis reduces the influence of dominant taxa to reveal the influence of less common taxa.

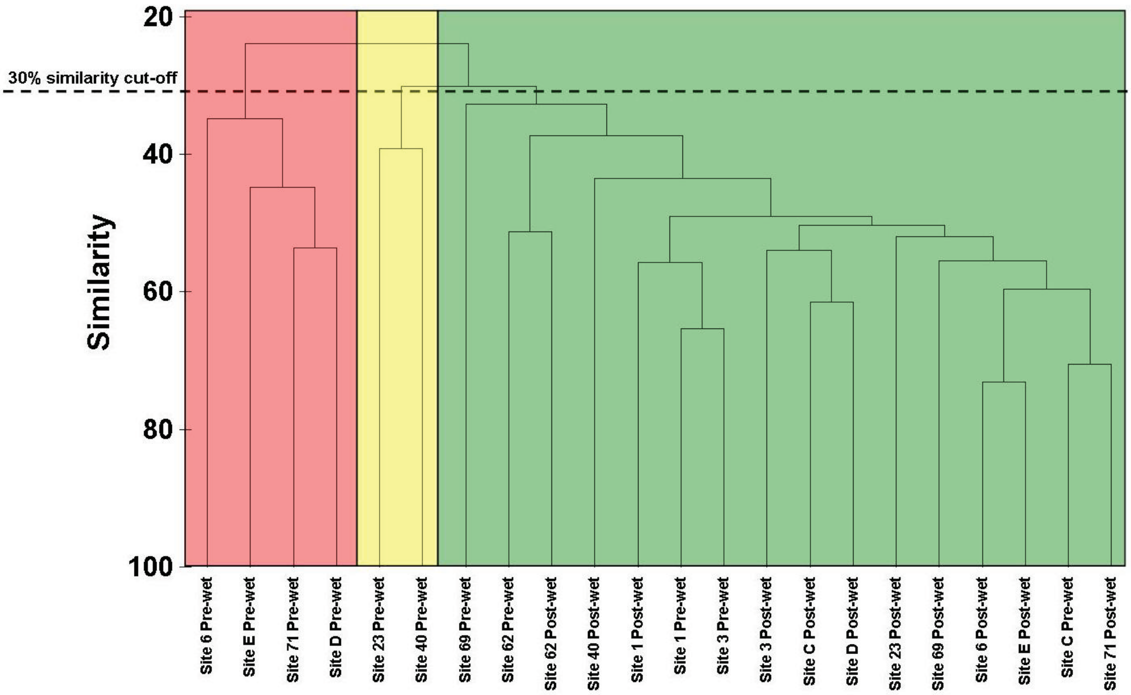
There was substantial similarity in macroinvertebrate assemblages across the Surat Basin between sites. At the 30% similarity cut-off there were only three clusters identified, one of which was comprised of sixteen of the twenty two site samples (the 22 samples consist of combined samples from both the pre- and post-wet season sampling, hence 22 samples were analysed). This cluster included five of the sites during the pre-wet season and all sites during the post-wet survey. These sites were comparable in that they contained largely atyids (shrimps) and corixids (waterboatmen), as well as baetid and caenid larvae (mayflies).

Sites 23 (Myall Creek) and 40 (Braemar Creek) in the pre-wet survey were distinct from all other sites, being largely dominated by chironomids (non-biting midges). Both sites had exhibited distinctly low dissolved oxygen concentrations, explaining the dominance of this family, which is tolerant of poor water quality. Low total abundances of macroinvertebrates were recorded from these sites.

The most distinct cluster included macroinvertebrate assemblages from four sites (sites 6, 71, E and D) during the pre-wet surveys. All these samples had a relatively low abundance of macroinvertebrate individuals and were largely dominated by atyids (shrimps), corixids (waterboatmen) and notonectids (backswimmers).

There were clear seasonal influences on the macroinvertebrate assemblages at most survey sites (as evidenced in six of the eleven sites in the pre-wet surveys distinct from the largest cluster). Of the six sites not within the main cluster five were smaller streams with less permanent water and highly variable water quality. Less permanent water at these sites meant that there was less available habitat for macroinvertebrates during the pre-wet season.

Figure 4-2 Classification analysis of sites for each sampling season in the Surat Basin based on similarities calculated from abundance data. The 3 different Clusters with Bray-Curtis similarities less than 30% have been identified using different colours.



AusRivAS Modelling Results

The Australian River Assessment System (AusRivAS) includes methods and manuals for using macroinvertebrates as indicators of freshwater ecosystem health. A series of models are available for regional Queensland and typically require the collection of macroinvertebrate samples, physico-chemical data and site descriptors. The combined season models for bed, riffle and edge habitat in sites west of the Great Dividing Range are the most appropriate for this assessment. The predictor variables required for input are described below, whilst Table 4-7 and Table 4-8 show the predictor variables and predictor variable values respectively used in the modelling.

Table 4-7 Predictor variables used in AusRivAS modelling of invertebrate data, Combined November 2009/May 2010.

Predictor	Model	Description
Cobble	Edge/Bed/Riffle	% boulder in habitats
DFS	Riffle	Site distance to stream source
Dryrange	Edge/Bed/Riffle	Range mean dry season monthly
Latitude	Edge/Bed/Riffle	Latitude (decimal degrees) to 4 places

Predictor	Model	Description
Longitude	Edge/Riffle	Longitude (decimal degrees) to 4 places
Pebble	Riffle	% pebble in habitats
Process zone	Bed/Riffle	Erosional=2, Transport=1, Depositional=2
WETR	Edge/Riffle	Range in wet season monthly rainfall (mm)
Bedslope	Bed	Slope of bed (m/m)
MDMR	Bed/Riffle	Mean dry season monthly rainfall
RAWD	Edge/Bed/Riffle	Ration mean wet/dry season monthly rainfall
WETPERCENT	Edge/Bed/Riffle	% wet season rainfall
MINTEMP	Bed	Mean daily minimum temperature
MAXTEMP	Riffle	Mean daily maximum temperature
MWMR	Bed	Mean wet season monthly rainfall
RAINFALL	Bed	Mean annual rainfall
RANGETEMP	Bed	Annual range mean monthly rainfall
ALTITUDE	Riffle	Height above sea level
STORDER	Riffle	Stream order

Average monthly rainfall data and annual minimum daily temperature data from the Australian Bureau of Meteorology Dalby Airport station (4152 – 1992 until 2010), Pittsworth station (42023 – 1885 until 2010) and Oakey Aero (41359 – 1970 until 2010) have been used for the modelling, based on proximity of sites to each of the three recording stations.

Table 4-8 Predictor values used in AusRivAS modelling of invertebrate data, Combined November 2009/May 2010.

	SITE										
Predictor	**1**	**3**	**6**	**23**	**40**	**62**	**69**	**71**	**C**	**D**	**E**
Cobble	0	0	0	0	0	10	0	0	0	0	0
DFS	210.25	N/A	N/A	N/A	N/A	39.8	N/A	N/A	N/A	N/A	N/A
Dryrange	10.5	18.3	18.3	18.3	18.3	15.5	18.3	10.5	18.3	18.3	18.3
Latitude	Refer to Table 2.1										
Longitude	Refer to Table 2.1										
Pebble	0	N/A	N/A	N/A	N/A	10	N/A	N/A	N/A	N/A	N/A
Process zone	1	1	1	1	1	1	1	1	1	1	1
WETR	221.1	75.8	75.8	75.8	75.8	74.9	75.8	221.1	75.8	75.8	75.8
Bedslope	0.0059	0.0044	0.0016	0.0037	0.0092	N/A	0.0024	0.0075	0.0012	0.0019	0.0015

	SITE									
Predictor	**1**	**3**	**6**	**23**	**40**	**62**	**69**	**71**	**C**	**D**	**E**
MDMR	35.43	27.93	27.93	27.93	27.93	31.67	27.93	27.93	27.93	27.93	27.93
RAWD	2.06	2.64	2.64	2.64	2.64	2.29	2.64	2.06	2.64	2.64	2.64
WETPERCENT	67.3	72.5	72.5	72.5	72.5	69.6	72.5	67.3	72.5	72.5	72.5
MINTEMP	12.2	12	12	12	12	12.2	12	12	12	12	12
MAXTEMP	27.1	N/A	N/A	N/A	N/A	25.7	N/A	N/A	N/A	N/A	N/A
MWMR	72.93	73.67	73.67	73.67	73.67	72.93	73.67	72.93	73.67	73.67	73.67
RAINFALL	650.2	609.6	609.6	609.6	609.6	650.2	609.6	609.6	609.6	609.6	609.6
RANGETEMP	15.9	14.9	14.9	14.9	14.9	15.9	14.9	14.9	14.9	14.9	14.9
ALTITUDE	339	N/A	N/A	N/A	N/A	396	N/A	N/A	N/A	N/A	N/A
STORDER	6	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	N/A

The AusRivAS models utilise only those taxa calculated to have a 50% or greater probability of occurring at a test site, based on reference site data. This level of resolution represents a compromise that reduces the occurrence of low probability taxa whilst maintaining sufficient analytical resolution to detect significant shifts in species assemblages. The ratio of observed over expected taxa with an occurrence probability of ≥0.5 (50%) is referred to as the OE50 score for a site.

The OE50 score assigned to a site is normally within the range within 0 – 1, with lower scores indicating impacted sites at which the observed macroinvertebrate fauna are depleted in comparison to reference sites. Conversely, sites for which the OE50 score nears a value of 1 have observed macroinvertebrate assemblages similar to those expected from comparable unimpacted sites. On some occasions the species richness may exceed that expected based on the reference sites, resulting in an OE50 score of greater than 1. To simplify interpretation of modelled outputs, the AusRivAS models divide sites into bands based on the OE50 scores obtained. The thresholds for each of these bands are provided in Table 4-9, along with interpretive information.

Table 4-9 Species richness thresholds for AusRivAS assigned OE scores.

Band	Description	O/E Taxa	O/E Taxa Interpretations Band
X	Greater biological diversity than reference sites	O/E greater than 90th percentile of reference sites used to create the model.	O/E Taxa Interpretations More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.

Band	Description	O/E Taxa	O/E Taxa Interpretations Band
A	Biodiversity similar to reference	O/E within range of central 80% of reference sites used to create the model.	Expected number of families within the range found at 80% of the reference sites.
B	Biodiversity significantly reduced	O/E below 10th percentile of reference sites used to create model. Same width as band A.	Fewer families than expected. Potential impact either on water and/or habitat quality resulting in a loss of families.
C	Biodiversity severely impaired	O/E below band B. Same width as band A.	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
D	Biodiversity extremely impaired	O/E below band C down to zero.	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

In addition to OE50 scores, AusRivAS assigns an OE50 signal score to each of the test sites, based on the sensitivity of macroinvertebrate families to pollution. High signal scores indicate the presence of taxa that are sensitive to pollution. Again, a threshold of a 50% probability of a taxon occurring is considered appropriate for this assessment (the OE50 Signal score).

Outputs from the AusRivAS modelling are provided in Table 4-10. OE50 scores for samples collected from the pool beds are considered low, 0.24 to 0.60 scores indicating that 24 to 60 percent of the expected macroinvertebrate taxa were present in the samples respectively. Site C was the only site that exhibited over 50 percent of expected taxa, with all other sites showing poor to very poor representation. As a consequence all sites are in risk band C, except site C, which is in risk band B. This suggests pools are in a significantly degraded state.

Somewhat contrasting, OE50 scores from edge samples show higher representation, with 0.43 to 0.80 scores indicating 43 to 80% of expected macroinvertebrate taxa were present in the samples respectively. Additionally, 8 of the 11 sites showed OE scores of 0.61 to 0.80, indicating most sites had 61 to 80% of expected taxa. As a consequence all sites are in risk band B, except Sites 23, 40 and 69, which are in risk band C. This suggests pool edges are considered to be degraded to significantly degraded and have undergone somewhat significant impacts through anthropogenic processes as well as natural variations associated with ephemeral systems.

Outputs for samples collected from riffles at Sites 1 and 62 were outside the experience of the model and no results were obtained. Results “outside the experience of the model” usually infer that the baseline dataset set within the model used for analysis is limited for that region and has insufficient data to compare against the sample. It does not mean that the sample results fall outside the parameters of the banding system i.e. much worse or much better than the predetermined scale.

Single season pre-wet modelling showed a reverse trend; with pool bed samples showing higher expected taxa present than pool edge samples. This suggests that the most significant issue contributing to the degradation of waterways in the region is water extraction during pre-wet periods. The fact that there is an increase in system health post-wet infers that land management of agricultural practices and other issues affecting waterway health is relatively good. There appear to be little impacts associated with runoff of nitrogen or phosphate typically associated with high flow events in ephemeral systems surrounded by agriculture, suggesting effective land management in the region (Table 4-10).

Table 4-10 OE50 scores, OE50 Signal scores and AusRivAs risk bands for sample sites, combined November 2009/May 2010.

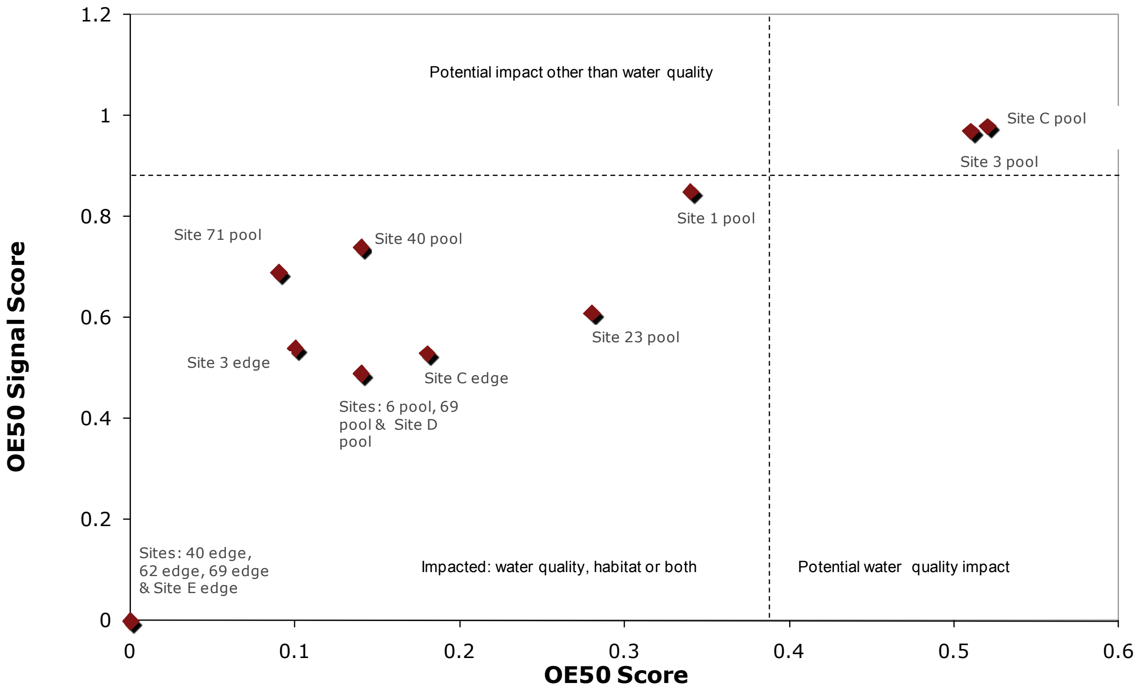
Site	Habitat	OE50	OE50Signal	Band
1	Pool	0.24	0.76	C
1	Edge	0.61	0.97	B
1	Riffle	Outside	Model	Experience
3	Pool	0.42	0.83	C
3	Edge	0.73	1.09	B
6	Pool	0.42	0.97	C
6	Edge	0.67	0.91	B
23	Pool	0.48	0.97	C
23	Edge	0.49	0.94	C
40	Pool	0.24	0.79	C
40	Edge	0.49	0.98	C
62	Riffle	Outside	Model	Experience
62	Edge	0.61	0.92	B
69	Pool	0.24	0.76	C
69	Edge	0.43	0.78	C
71	Pool	0.48	1.09	C
71	Edge	0.61	1.00	B

Site	Habitat	OE50	OE50Signal	Band
Site C	Pool	0.60	0.87	B
Site C	Edge	0.80	1.04	B
Site D	Pool	0.36	0.78	C
Site D	Edge	0.61	0.95	B
Site E	Pool	0.48	1.19	C
Site E	Edge	0.80	0.98	B

Samples collected from the edges of the pools tended to exhibit lower OE50 scores (0.00 to 0.18), indicating that the edge habitat was extremely poor at all sites. This is not surprising given the channelisation that has occurred due to variable hydrological regimes. Assemblages on the edges of pools are more susceptible to water level fluctuations than those in deeper water. Based on the edge habitat assemblages, all sites fell within risk band C or D (severely impaired).

OE50 Signal scores varied across the monitoring sites and habitat types, although they were generally high (0.76 to 1.19), indicating that a relatively high proportion of the pollution sensitive taxa expected from comparable reference sites were observed at the sample sites. Combined, the OE50 and OE50 Signal scores indicate that while the sampling sites have been substantially impacted by current catchment activities, pollution-sensitive taxa are still abundant, suggesting the most significant impact to the system is water extraction, rather than a combination of water extraction and pollution caused by anthropogenic influences such as poor management of agricultural runoff (Figure 4.3).

Figure 4-3 OE50 vs OE50Signal scores for the sampling sites.



Fish

Totals of 1577 and 2857 individual fish were recorded during November 2009 and May 2010 surveys respectively. Seventeen of the 22 fish species previously recorded from the Condamine, Macintyre Brook and Weir River catchments were recorded either within and/or immediately adjacent to the project development area during the November 2009 and May 2010 surveys (Appendix B).
The Murray Darling Basin Commission (MDBC) has extensive verified sources of fish data over a range of time spans in the Condamine and Weir River catchments (Davies et al. 2008, Lintermans 2007). Additionally, a number of sites were sampled in the Condamine and Border rivers subcatchments through the Sustainable Rivers Audit (Davies et al. 2008); and the Fitzroy catchment has been extensively sampled Queensland DPI and Griffith University (Berguis & Long 1999, Pusey et al. 2004, Hagedoorn, & Smallwood 2007).

Total fish abundance across the entire study area was largely dominated by *Gambusia holbrooki* (mosquito fish) and *Cyprinus carpio* (common carp) (Figure 4-4 and Figure 4-5). However, 97% of the *C. carpio* were recorded from a single site (Site C, Oakey Creek above the Condamine confluence) during both pre-wet and post wet surveys. The two most abundant native fish taxa were the *Hypseleotris* species complex (carp gudgeons) and *N. erebi* (bony bream), both of which are widespread and abundant throughout most of the Murray-Darling Basin.

Three exotic fish species were recorded in the November 2009 and May 2010 surveys; *C. carpio* (common carp), *Carrasius auratus* (goldfish) and *G. holbrooki* (mosquito fish).

Although it is considered likely that *Oreochromis mossambicus* (tilapia) is present in the system, numbers are sufficiently low that no individuals were detected in the November 2009 and May 2010 surveys.

Limited numbers of species with recreational or commercial fishing significance were recorded, including several specimens of *M. ambigua* (golden perch) and *T. tandanus* (eel-tailed catfish). Several fish species of lesser recreational significance were also recorded (*C. carpio* (Common carp), *C. auratus* (Goldfish), *G. mamoratus* (River blackfish) and *L. unicolor* (Spangled perch)).

Figure 4-4 Relative proportion of fish species recorded across the sampling sites, November 2009.

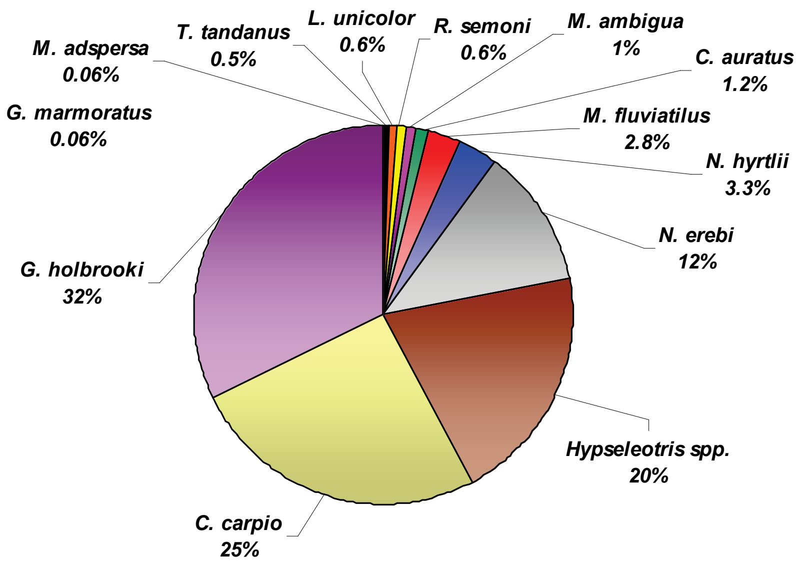
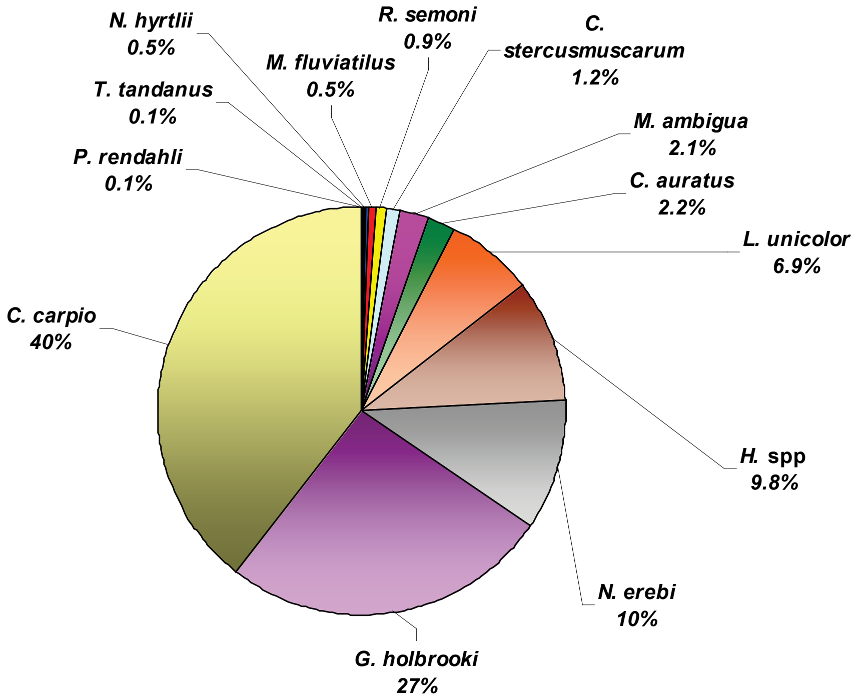


Figure 4-5 Relative proportion of fish species recorded across the sampling sites, May 2010.



Total fish abundance and species richness varied between sites and sampling occasions (Figure 4-6 and Figure 4-7). A higher mean abundance was recorded during the May 2010 sampling period than in November 2009. However it must be noted that the high number of fish recorded from Site C was largely composed of schooling juvenile *C. carpio*, and when excluded from the data set, a comparable number of individuals were recorded during each survey.

Species richness ranged from a single species at Site 23 (Myall Creek at Moonie Highway) in November 2009 to 10 species at Site 3 (Condamine River at Cecil Plains) in November 2009. While these species richness values are low relative to coastal fish communities they are typical of the lowland zones of the Murray-Darling Basin.

Figure 4-6 Number of fish and species richness by site during the November 2009 field survey.

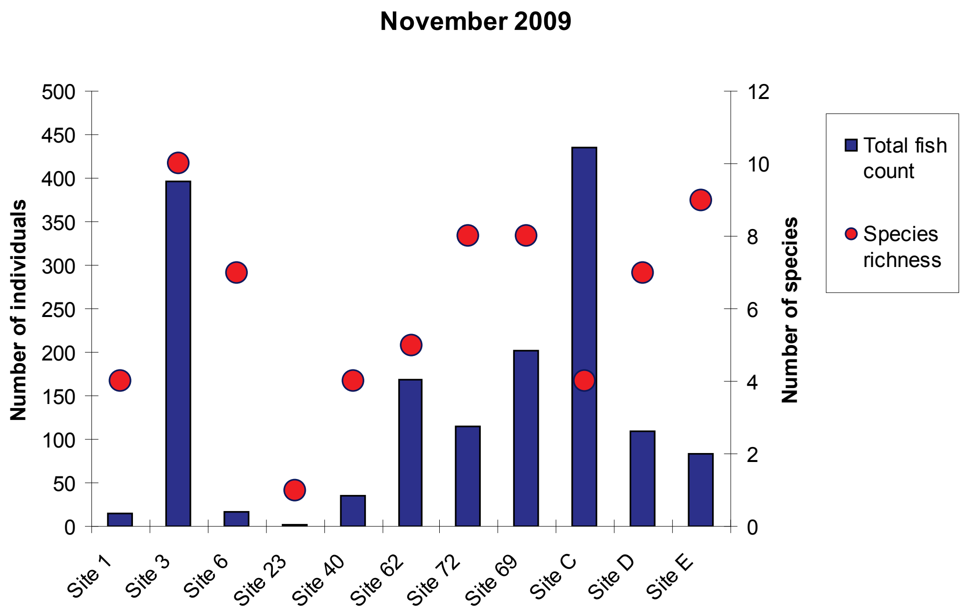
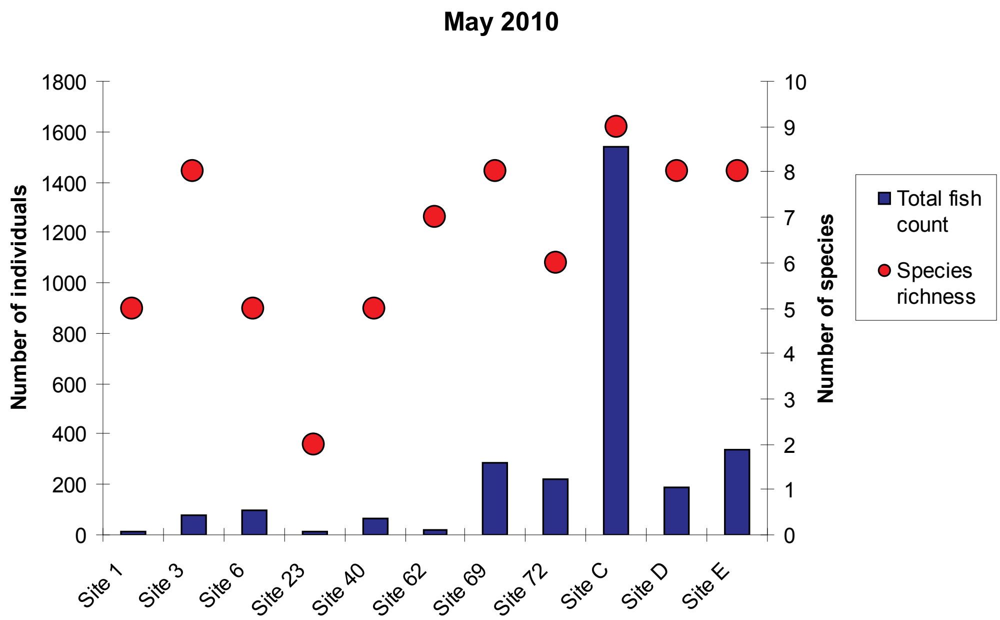


Figure 4-7 Number of fish and species richness by site during the May 2010 Surat Basin surveys.

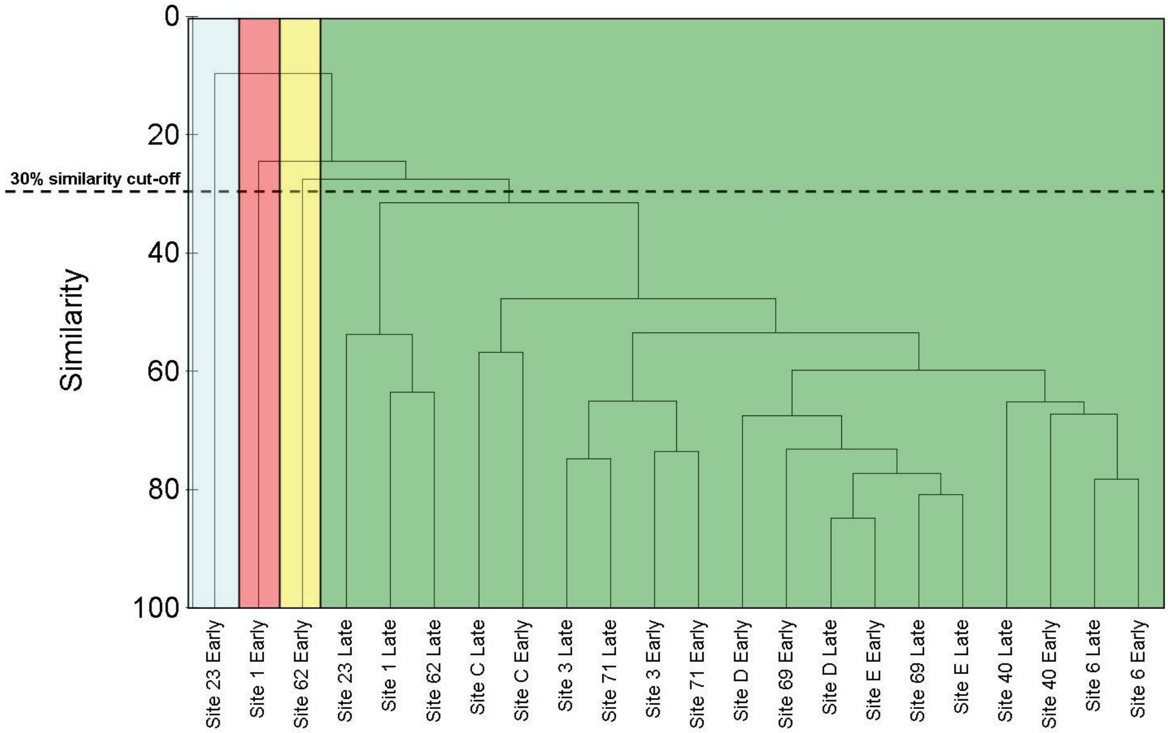


Classification analysis identified four site clusters at the 30% similarity cut-off (Figure 4-8). Three sites sampled in November 2009 (pre-wet season) were sufficiently different to be classified individually. The site with the least similarity to the other sites was Site 23 (Myall Creek) from which a single *C. carpio* (observed) was the only fish recorded. Site 1

(Condamine River at Karrara Road) differed from the other sites largely due to the extremely low abundance and diversity of fish. The third distinct cluster contained Site 62 (Westbrook Creek) which differed from the remaining sites due to the presence of two species (*G. marmoratus* – River blackfish and *M. adspersa* - Purple spotted gudgeon) that were not caught elsewhere during either the November 2009 or May 2010 surveys.

The remaining cluster contained site and season samples with fish assemblages largely represented by abundant *Hypseleotris* species, *G. holbrooki*, *C. auratus*, *C. carpio* and *N. erebi*.

Figure 4-8 Classification analysis of fish assemblages between sampling sites based on similarities calculated from abundance data. The 4 different Clusters with Bray-Curtis similarities less than 30% have been identified using different colours.



Abundance and Distribution of Individual Fish Species

The following describes the abundance and distribution of individual fish species recorded during the November 2009 and May 2010 surveys, as well as those known to be present from historical surveys. Information on the basic biological and ecological characteristics of each species is provided in Appendix C.

Native fish species

The Hypseleotris species complex (Carp gudgeons) was the most abundant and widespread native fish taxa recorded during the November 2009 and May 2010 surveys, being collected in all but two sites. There is considerable confusion over the identification of the Hypseleotris complex in south-eastern Australia. There are at least four taxa present in the Murray-Darling Basin, as well as a range of hybrids, often occurring sympatrically (Lintermans 2007). H. klunzingeri (western carp gudgeon), H. Sp 1 (Midgley's carp gudgeon) and H. Sp 1. (Murray-Darling carp gudgeon) were clearly identified at several sampling sites (Appendix B). However, the majority of individuals of the *Hypseleotris* complex were not clearly identifiable down to the species level in the field due to their small size and/or apparent hybridisation.

N. erebi (Bony bream) was one of the more widespread native fish species recorded during the November 2009 surveys collected at six of the eleven sites sampled and eight of the eleven sites in May 2010. At some sites juveniles of this species were highly abundant, particularly Site 71 (Condamine River at Chinchilla Weir).

L. unicolor (Spangled perch) was widespread throughout the survey area, being recorded from five of the eleven sites sampled in November 2009 and ten of the eleven sites in May 2010. Across both surveys, *L. unicolor* individuals were recorded at every site surveyed. *L. unicolor* was far more abundant across the study area during the May 2010 surveys.

M. ambigua (Golden perch) were relatively widespread being collected at four of the eleven sites during the November 2009 surveys and six of the eleven sites in May 2010. While generally recorded in low abundance, 42 individuals were caught at Site 69 (Oakey Creek) during the November 2009 surveys. The large number of *M. ambigua* recorded at this site during the May 2010 surveys is likely to the fish being concentrated in the contracting pools.

N. hyrtlii (Hyrtyl's tandan) was recorded at three of the eleven sites sampled both in November 2009 and May 2010 surveys. While generally recorded in low abundance, 44 individuals were caught at Site 69 (Condamine River at Chinchilla Weir) during the November 2009 surveys.

M. fluviatilus (Murray-Darling rainbowfish) were relatively widespread being collected at four of the eleven sites during the November 2009 surveys and three of the eleven sites in May 2010. *M. fluviatilus* were generally recorded in low abundance; however were abundant in the November 2009 surveys at Site 3 (Condamine River at Cecil Plains) with 28 individuals recorded.

T. tandanus (Eel-tailed catfish) is reputedly a hardy species being recorded across a wide range of environmental extremes. In the November 2009 surveys *T. tandanus* were only recorded from one site and in May 2010 recorded in two of the eleven sites in low abundance.

C. stercusmuscarum fulvus (Un-specked hardyhead) was recorded in relatively low abundance at two sites (Site 62 Westbrook Creek and Site C Oakey Creek) in May 2010 surveys. No specimens of *C. stercusmuscarum fulvus* were recorded during the November 2009 surveys.

R. semoni (Australian smelt) was recorded at two sites during the November 2009 surveys and at four of the eleven sites in May 2010 although in relatively low abundance.

Two individual *P. rendahli* (Rendahl's catfish) were recorded at site E (Louden Weir on the Condamine River). No specimens of *P. rendahli* were recorded during the November 2009 surveys. 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).

A single specimen of *G. marmoratus* (River blackfish) was recorded from Westbrook Creek. This site is situated well outside the project development area and it is considered unlikely habitat for *G. marmoratus* (i.e. not prime habitat, low in the catchment). It is likely that the artificial flows through Westbrook Creek (resulting from treated sewerage releases) facilitated the movement of the juvenile *G. marmoratus* recorded outside what might be considered its natural range. No specimens of *G. marmoratus* were recorded during the May 2010 surveys.

The single specimen of *M. adspersa* (Purple spotted gudgeon) was collected from Site 62 (Westbrook Creek) outside the study area during the November 2009 surveys. *M. adspersa* is a relatively common species of coastal drainages of Eastern Australia north of the Clarence River, NSW (Allen et al. 2002). However, recent electrophoretic studies indicate that Murray-Darling populations display considerable genetic divergence and warrant classification as a separate taxon (DEWHA 2009). The abundance of *M. adspersa* in the Murray Darling Basin has undergone significant declines; however it is still locally abundant in the Upper Condamine catchment (Lintermans 2007).

No specimens of *A. agassizii* (Olive perchlet) were recorded during the November 2009 surveys. *A. agassizii* has previously been recorded as locally abundant in parts of the Condamine catchment.

No specimens of *A. reinhardtii* (Long finned eel) were recorded during the November 2009 surveys.

No specimens of *B. bidyanus* (Silver perch) were recorded during the November 2009 surveys. Once widespread throughout the Murray-Darling Basin numbers of *B. bidyanus* has declined dramatically over its range, including throughout the study area (Lintermans 2007). The species is still abundant in isolated areas within the mid-Murray River.

No specimens of *G. olidus* (Mountain galaxias) were recorded during the November 2009 surveys. This was not unexpected as *G. olidus* 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 as far downstream as the study area.

No specimens of *M. peelii peelii* (Murray cod) were recorded during the November 2009 surveys. *M. peelii peelii* was formerly widespread and abundant in the lower and mid-altitude reaches of the Murray-Darling Basin including within the study area (Allen et al. 2002). Numbers have since declined dramatically and the species now has a patchy distribution across its historic range. *M. peelii peelii* was listed as nationally threatened in 2003 (Lintermans 2007).

No specimens of *P. macrostomas* (Dwarf flathead gudgeon) were recorded during the November 2009 and May 2010 surveys. *P. macrostomas* are relatively common in coastal streams from southern Queensland through to Wilsons Promontory in Victoria (Allen et al. 2002). Populations in the Murray-Darling are patchily distributed and sparse. Specimens have been recorded from the Condamine River near Chinchilla (Lintermans 2007) and more recently from Louden Weir (Brooks, pers. Comm. 2010).

Exotic fish species

G. holbrooki (Mosquito fish) was found at eight of the eleven sites surveyed in November 2009 and ten of the eleven sites in May 2010. They were typically one of the most abundant species.

C. auratus (Goldfish) were recorded in five of the eleven sites surveyed in November 2009 and seven of the eleven sites in May 2010. While being relatively widespread they were typically recorded in low abundance.

C. carpio (Common carp) were recorded in eight of the eleven sites surveyed in November 2009, although were only abundant at Site C (Oakey Creek). At this location all but one *C. carpio* caught or observed were schooling juveniles (mean length 26 mm). As such, this highlights this location as a potential key breeding area for *C. carpio* within the Condamine catchment. In May 2010 *C. carpio* was recorded at six of the eleven sites, with the large majority caught at Site C (Oakey Creek). In May 2010 pools at this site were retracting and fish had been highly concentrated in the remaining water. Most of the *C. carpio* recorded (94%) were less than 100 mm in length and are likely to have been the same age class as the juvenile sampled at this site in November 2009.

Macrophytes

None of the macrophyte species identified at the sampling sites are listed under the Land Protection (Pest and Stock Route Management) Act 2002 (Qld).

In the Act there are several aquatic plants and plant species found along riparian zones that listed as Class 1 (potential to become a serious pest), Class 2 (has already spread over extensive areas but needs to be controlled), and several Class 3 (commonly established and is causing or has the potential to cause an adverse impact). There were no listed species recorded at the study sites, however a class 3 plant (*Salix spp*) was observed within the project development area.

Table 4-11 shows the macrophyte species recorded at each of the aquatic ecosystem sampling sites.

Aquatic macrophytes across the study area were dominated by emergent and floating (free and attached) taxa. The complete absence of submerged aquatic flora is symptomatic of the relatively high turbidity observed at all sites, which attenuates light penetration and hence reduces the potential for submerged species to grow.

Table 4-11 Aquatic macrophyte species recorded across the sampling sites during the November 2009 and May 2010 surveys.

		Sampling Site										
Species	**Common name**	**1**	**3**	**6**	**23**	**40**	**62**	**69**	**71**	**C**	**D**	**E**
Azolla pinnata	Ferny Azolla				●	●					●	●
Bulboschoenus fluviatilis	Marsh Clubrush		●	●	●	●	●	●	●	●	●	●
Cyperus difformis			●						●			
*Cyperus eragrostis**	Umbrella Sedge	●		●						●		
Cyperus exaltus	Giant sedge			●			●					
Damasonium minus	Starfruit						●					
Diplachne fusca	Brown beetle grass	●	●					●			●	●
*Echinochloa crus-galli**	Barnyard Grass				●					●		
Eleocharis acuta	Common spike-rush					●			●			
Juncus usitatus	Common Rush	●	●	●	●	●		●	●	●	●	●
Lemna spp.	Duckweed				●						●	●
Leptochloa digitata	Umbrella Canegrass		●	●	●	●	●	●	●	●		●
Ludwigia peploides	Water Primrose		●		●	●		●	●		●	●
Marseilea mutica	Nardoo			●								
Myriophyllum spp.									●			
Persicaria attenuata			●	●		●	●	●		●		
Persicaria decipiens	Slender Knotweed	●		●		●		●		●		●
Phragmites australis	Common Reed		●		●		●	●		●	●	●
Potamageton crispus	Curly Pondweed		●									
Potamogeton c.f. octandrus								●				
*Rumex crispus**	Curled Dock	●	●	●			●	●		●	●	●
Triglochin procera	Ribbon weed								●			
Typha orientalis	Cumbungi	●							●			

* denotes exotic species.

Twenty three species of aquatic macrophytes were recorded, including three exotic species. Details of the exotic species are provided below:

- *Cyperus eragrostis* (Umbrella sedge) is a native of South America and is a tufted perennial sedge. Whilst not a native species, it does assist in stabilizing earth banks and provides habitat for aquatic biota. It is considered a weed in most waterways but was not found to be present in dense populations within the study area.
- *Rumex crispus* (curled dock) is a native of Europe and is a serious weed in agricultural cropping areas. It is a prolific plant that thrives in seasonal wetlands, but was recorded at only two sites during the surveys and was not present in large numbers at either site.

- *Echinochloa crus-galli* (barnyard grass) is a native of Europe and is ranked among the worst weeds in the world, but is particularly damaging in rice plantations. E. *Crus-galli* was recorded only at the Oakey Creek site during these surveys. However, it is a very prolific seed producer and should be considered a threat to aquatic ecosystems in the region.

None of the native macrophyte species recorded are considered to be of conservation significance in a regional context and no listed species have been identified for the study area in field surveys or database searches.

A cluster analysis using a Bray Curtis similarity matrix (untransformed) of macrophyte composition was undertaken using presence/absence data (Figure 4-9).

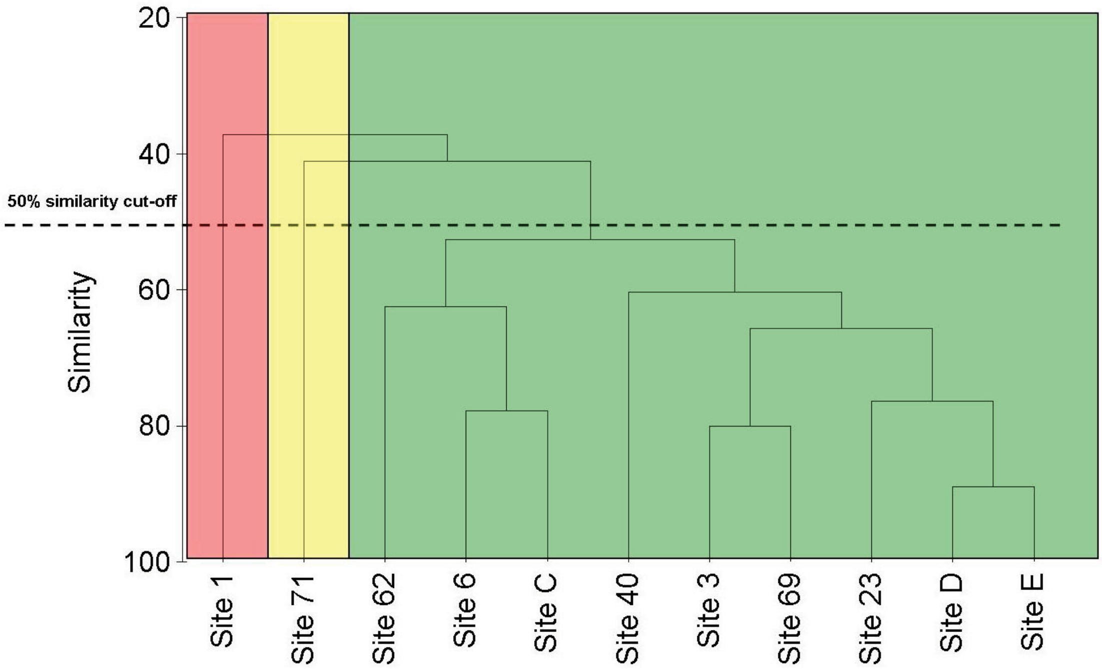
There was substantial similarity in macroinvertebrate assemblages across the Surat Basin between sites. At the 30% similarity cut-off there were only three clusters identified, one of which was comprised of eight of the eleven sites sampled.

Sites 1 (Condamine River) and 72 (Brigalilly Creek) were distinctly different from all other sites being the only two sites to have *Typha orientalis* (Cumbungi) present.

Site 23 (Myall Creek) differed from the remaining sites in that *Azolla pinnata* (ferny azolla) and *Lemna* spp (duckweed) were recorded.

The largest cluster, which included all other sites, were characterised primarily by the presence of *Phragmites australis* (common reed), *Juncus usitatis* (common rush) and *Bulboschoenus fluviatilis* (marsh clubrush).

Figure 4-9 Bray Curtis similarity matrix (untransformed) cluster analysis of macrophyte composition using presence/absence data.



Other Aquatic / Semi-aquatic Fauna

Four of the 11 sites sampled in November 2009 were considered suitable for setting modified fyke nets. Nine of the 11 sites were sampled with modified fyke nets during the May 2010 surveys (Table 2.4). Between one and three nets were set depending on the availability of suitable sites for effective placement. Five turtle opera house nets were deployed in May 2010 to more effectively sample the deeper water associated with the sites following the wet season (Sites 3, 40, 69, D and E). Nets were set between 6 and 7pm and collected between 5 and 6 am the following day.

A total of 46 turtles were caught from two species; *Chelodina expansa* and *Emydura macquarii* across both November 2009 and May 2010 survey periods (Table 4-12). A higher abundance (39 turtles) were captured in May 2009. This is likely to be due to lower water conditions concentrating the turtles into smaller areas and making them easier to trap. Two species; *Chelodina expansa* and *Emydura macquarii* were recorded. Both *C. expansa* and *E. macquarii* appeared to be widespread throughout the study area each being caught in three and four sites of the nine sites sampled. The most abundant species recorded during the November 2009 and May 2010 surveys was *E. macquarii*, with 37 individuals collected from the four sites. Neither of these species are considered to threatened and are abundant across a wide distributional range.

Table 4-12 Turtles caught during November 2009 and May 2010 surveys of the study area.

		November 2009				May 2010			**Totals**
Common name	Scientific name	Site 3	Site 69	Site D	Site E	Site 69	Site D	Site E	
Macquarie Turtle	*Emydura macquarii*	11	-	8	14	-	3	1	**37**
Broad shelled turtle	*Chelodina expansa*	1	2	3	-	1	-	2	**9**

4.4 Sensitivity of aquatic environmental values

Lake Broadwater

Lake Broadwater is listed in the Directory of Nationally Important Wetlands, hence has a high conservation value. The area also has a high degree of intactness, with important seasonal aquatic habitat, hence falls into the **highly sensitive** category under the criteria outlined in Table 2-5.

Oakey Creek (upstream of sampling Site C)

The area upstream of Site C on Oakey Creek has been designated **highly sensitive**.

Whilst this area does not have formal conservation status and is relatively disturbed by agricultural landuse, two species of conservation significance (*M. adspersa* and *G. mamoratum*) were recorded upstream of the site. The tolerance of these species to disturbance events and the replacement potential of both species is very low, resulting in the assignment of a **"highly sensitive"** rating.

Permanent Waterways (excluding Upper Oakey Creek and Lake Broadwater)

Permanent freshwater ecosystems include the Condamine River, Wilkie Creek, Oakey Creek and Braemar Creek. These systems contain water all year around, although in many cases they are reduced to series of isolated pools during the dry season.

Permanent and semi-permanent streams are considered to have a **moderate sensitivity** to impacts (refer to table 2-5) associated with the project because:

- They support a number of species of conservation significance, including Murray cod, golden perch and silver perch, although the value of these communities is reduced by the fact that they are maintained by artificially restocking.

- They are utilised to a limited degree as recreational fisheries. However, they are not considered high value in the context of the overall recreational fishing resources in SE Queensland and are not heavily used by recreational anglers.
- Ranging from minimally disturbed to highly disturbed, these systems contain many areas of good quality aquatic habitat that are known to support a relatively diverse range of aquatic species including fish, turtles and invertebrates. Spawning habitat for aquatic species is present but does not represent critical spawning habitat.
- These systems are unique only at a local scale in terms of biota, communities and processes.
- Deeper pools and remnant waterholes provide refugia for a range of aquatic species, and these communities “seed” populations when wet season flows provide connectivity between watercourses.
- The communities in permanent and semi-permanent watercourses tend to be longer lived than those from ephemeral systems and are less likely to recolonize following disturbance, hence there is greater possibility of these species or communities becoming locally extinct.

On the basis of this assessment, permanent waterways within the project development area have been assigned a sensitivity rating of **“Moderate”**.

Ephemeral Waterways

A high proportion of the ephemeral systems within the study area are unnamed first or second order systems that flow for very limited periods each year. The simplest of these systems are often little more than drainage lines through agricultural or forested areas, although the more substantial examples hold water for longer periods of time and have slightly higher habitat value for aquatic fauna.

These systems ranged from being only moderately disturbed by existing landuse activities to being highly disturbed agricultural drainages.

In terms of their sensitivity to disturbance events, ephemeral watercourses within the project development area have the following attributes (refer to table 2-5):

- They have no formal conservation status, no species, habitat or aquatic communities of special conservation significance, no fisheries values and no eco-tourism potential.
- They provide marginal aquatic habitat due to the short periods during which they contain water, lack of connectivity to larger, permanent waterways and minimal spawning/nursery habitat.
- They are not unique on a local or regional scale and represent a very small proportion of similar aquatic habitat regionally.

- They are likely to be opportunistically utilised by aquatic fauna and flora that are tolerant of significant disturbance events and which are adapted to rapidly colonise and regenerate when conditions are suitable.

Overall, aquatic communities and values associated with these ephemeral systems are considered to have relatively **low sensitivity**.

4.5 Summary of Existing Aquatic Ecosystems

There is a very long history of disturbance of catchments within the study area as a result of agricultural activity, mining, urban development and other industry (e.g. power generation). There is a scarcity of data predating this disturbance, although anecdotally it would seem that there has been a decline in the diversity and abundance of aquatic communities. The species and communities that have prevailed to the present time are generally robust, able to tolerate a wide range of conditions and resilient to disturbance events. The exception are the unusual fish assemblages at Westbrook Creek, which are generally considered to be more sensitive to ambient conditions and are discussed further below.

Eleven aquatic sampling sites were assessed in the course of this investigation, with the site selection process tailored to ensure that all aquatic ecosystems were proportionately represented (refer to Section 3-3). Permanent water courses were over represented in the pre-wet survey as a proportion of all waterways within the study area, but this approach is justified given that these systems provide dry season refuge for aquatic biota and are more likely to contain less resilient species, communities or habitats than ephemeral systems.

Taken holistically, aquatic ecosystems within the study area are in moderately good health, although the Myall Creek system (Sites 6 and 23) and Braemar Creek (Site 40) were in particularly poor health due to significant oxygen depletion.

Macroinvertebrate assemblages from pool beds were markedly healthier than those in edge or riffle habitat, probably indicating greater availability and utilisation of habitat in the pools. Edge and riffle habitat is more susceptible to water fluctuation and both seasonal and diurnal temperature cycles.

Typical of lowland systems within the Murray-Darling Basin, fish assemblages within the Murray-Darling portion of the Surat Basin are species poor and are dominated by a small number of taxa. The only fish species identified through the database searches that are of conservation significance was *M. peelii peelii* (Murray Cod). However, there were populations of several species that were identified in the literature as being potentially threatened, including; *B. bidyanus* (silver perch), *G. marmoratus* (river blackfish), *M. adspersa* (purple-spotted gudgeon) and *P. rendahli* (Rendahls tandan).

Despite the relatively disturbed nature of the catchment, aquatic weeds were neither widespread nor locally abundant.

Statistical analysis of macroinvertebrates, fish and aquatic macrophytes indicates a high degree of similarity in the composition of populations between sampling sites, irrespective of drainage basin or catchment land-use. Two exceptions to this observation are Site 23 (upper Myall Creek) and Site 40 (Braemar Creek), both of which were severely oxygen depleted as a result of high BOD loads caused by decaying *Azolla pinnata* (Site 23) and leaf litter (Site 40). Whilst this observation at Braemar Creek is considered a natural event caused by lack of flow and an accumulation of leaf litter from the dense riparian vegetation, at Myall Creek it is likely to be the result of nutrient enrichment, which manifested as a dense bloom of *A. pinnata.*

The Westbrook Creek site (Site 62) is dissimilar to the other sites due to the presence of two fish species that weren't recorded elsewhere: *Mogurnda adspera* (purple spotted gudgeon) and *Gadopsis mamoratus* (River blackfish). The distribution of *M. adspersa* has diminished greatly throughout the Murray-Darling Basin, and recent genetic studies suggest that it may soon be classed as a separate taxon to the coastal variety. If this occurs it is likely that the Murray-Darling *M. adspersa* will be federally listed. The Murray-Darling population is currently listed as endangered in NSW and critically endangered in Victoria. *G. mamoratus* was a particularly interesting find, due to its presence at a much lower altitude and higher latitude than normally recorded and the fact that it was present outside of its normal habitat type (heavily wooded habitat). This site was outside of the study area, but was included in the surveys as an upstream reference site. It is considered likely that this stream would be an ephemeral system except for the discharge of treated sewage effluent upstream of the sampling site, and it is possible that the stable flow regime over the drier months has contributed to the additional fish species being supported within this system.

5 Baseline Impact Assessment

The project components and infrastructure detailed in section 1-4 comprise processes that are considered potentially threatening to the environmental values of the aquatic ecosystems of the project development area. The potentially threatening processes and issues are summarized in Appendix E and the baseline mitigation controls for each potential impact are detailed in Section 6.2 and 6.3. The assessment of impacts assumes that industry standard management practices (e.g. for management of construction projects and storage of fuels, lubricants, dangerous goods and wastes) will be applied as baseline mitigation controls.

5.1 Application of Impact Magnitude Criteria

Site clearing and levelling

Description of activity/impact:

The removal of riparian or aquatic vegetation, or terrestrial vegetation in close proximity to watercourses may result in short-term exposure of soil to erosion and sediment transport processes, particularly if sodic soils are disturbed or denuded. This may impact on aquatic ecosystems through the creation of poor water quality or smothering of benthic habitat with sediment.

It is expected that this disturbance will be minimal due to the very small footprint of individual well sites and the fact that they will not be sited within or in close proximity to waterways for operational and safety reasons. The small footprint also favours the use of silt curtains, buffer zones and other generic controls for managing sediment transport and the selection of sites so as to minimise the amount of clearing and levelling required. Short exposure times and completion of works during drier months also minimise the potential for sediment transport.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

Impacts include:

- Water quality decline due to sediment transport, biochemical oxygen demand (BOD), nutrient loads etc.
- Algal blooms.
- Smothering of benthic aquatic habitat.

As each pad will have a small footprint and be sited so as to minimise the need to remove vegetation, these impacts will be minimal. Generic environmental controls, as outlined in section 6.2, are expected to further reduce the impacts. In the event that sediment transport does occur the small footprint of each pad will ensure that the effects are localised, of short duration. Partial loss of aquatic communities is possible within Lake Broadwater, Oakey Creek above Site 3 and in permanent and semi-permanent waterways, but the impacts on ephemeral systems would be minor.

This activity has therefore been assigned an impact magnitude rating of "Moderate" for Lake Broadwater, Oakey Creek and permanent/semi-permanent waterways, and "Low" for ephemeral systems.

<u>Impact assessment</u>

(Refer to Table 3-5 for impact assessment matrix).

Table 5-1 Baseline impact of site clearing and levelling.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

<u>Impact mitigation</u>

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Construction of access tracks

<u>Description of activity/impact:</u>

The construction of tracks to enable access of machinery for the construction, operation and maintenance of wells, gathering lines and pipelines may require the removal of vegetation and earthmoving activities. Impacts on aquatic ecosystems as a result of this activity are largely associated with the construction phase, when freshly denuded and/or disturbed soils are most at risk of erosion, although ongoing sediment transport can be an impact of track construction.

There is potential for contamination of waterways as a result of fuel, oil or chemical spills, use of herbicides during track maintenance and increased public access (litter)

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

Impacts include:

- Water quality decline due to sediment transport, biochemical oxygen demand (BOD), nutrient loads etc.
- Algal blooms.
- Smothering of benthic aquatic habitat.
- Physical disturbance of stream beds/banks and or aquatic habitat/substrate if creek crossings are required.
- Barriers to the movement of fish and other aquatic biota in the vicinity of creek crossings where fords, bridges or culverts may be required.
- Transfer of aquatic weeds on earth moving machinery.
- Fuel, oil or chemical spills during construction.

Whilst tracks themselves may cover a wide geographic range, their impacts on aquatic ecosystems is likely to be more localised, being restricted to those areas in which sediment laden runoff finds its way into creeks or where tracks must physically cross creeks.

Impacts are likely to be of relatively short duration, with storm events during the construction period of greatest concern, although lower level, ongoing impacts are possible. Creeks within the area are of muddy substrates with little if any areas of gravel or cobble, hence smothering of benthic habitat is unlikely to be of concern, and the impacts of sediment transport will ease when water quality is restored.

With normal environmental controls in place, minor impairment of aquatic communities is the most likely scenario, with temporary or partial loss of aquatic values a possibility.

This activity has therefore been assigned an impact magnitude rating of “Moderate” for Lake Broadwater, Oakey Creek and permanent/semi-permanent waterways, and “Low” for ephemeral systems.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-2 Baseline impact track construction.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Use of vehicles/plant/machinery near waterways

Description of activity/impact:

There is potential for contamination of waterways as a result of fuel, oil or chemical spills, use of herbicides during track maintenance and increased public access (litter). The geographic extent, duration and severity of such an event would depend on hydrological conditions and on the nature and volume of the contaminants involved. However, the normal protocol of restricting refuelling and maintenance operations to designated, bunded facilities largely overcome the potential for such impacts.

If tracks are constructed close to waterways or include creek crossings, there is potential for physical disturbance of stream beds/banks and or riparian or aquatic vegetation or habitat. Poorly formed and maintained tracks may be prone to rutting and erosion, which can result in ongoing sediment transport during storm events.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.

- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

The use of vehicles and machinery near waterways will be most common during the construction and commissioning of wells, gathering lines and pipelines, with reduced activity once each well/pipeline enters the operational phase.

Impacts include:

- Water quality decline due to sediment transport, biochemical oxygen demand (BOD), nutrient loads, chemical/fuel contamination etc.
- Smothering of benthic aquatic habitat as a result of erosion and sediment transport.
- Physical disturbance of stream beds/banks and or aquatic habitat/substrate if creek crossings are required.
- Fuel or other chemical spills.
- Transfer of aquatic weeds.

If the mitigation measures outlined in section 6.2 and section 6.3 are observed impacts associated with the use of vehicles and machinery near waterways are most likely to be localised and of short duration. Minor, short-term impairment of aquatic communities is the most likely level of severity, although temporary/partial loss of aquatic values is possible, hence this impact has been assigned a “moderate” impact magnitude rating.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-3 Baseline impact of vehicles and machinery.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Waste management

Description of activity/impact:

Specific waste streams associated with the construction and operation of the project include:

- Sewage and human waste.
- Construction waste.
- Chemical. oil and fuel waste.
- Drilling waste (eg bentonite, lubricants and other drilling chemicals).
- Green waste.
- Concentrated brine from RO of CSG water.
- Spoil.

It is understood that sewage and human waste will be removed from well and pipeline construction sites for disposal at registered facilities. Sewage from water treatment and other facilities will be treated on site in a registered sewage treatment facility or will be transported to a registered facility.

It is understood that all construction waste will be removed promptly from sites shortly after such waste is generated and will be disposed of to a registered landfill facility. It is also understood that chemical, oil and fuel will be contained within bunded facilities and waste will be disposed of to a registered waste transfer facility and that drilling waste will be contained within wastewater sumps with no discharge to creeks.

Green waste resulting from the removal of vegetation to facilitate construction will not be disposed of in or close to waterways. But will be removed for disposal in an approved manner. The use of composted or mulched material will not occur within or close to waterways.

Spoil from quarrying, drilling or other activities will not be disposed of within or close to watercourses. Runoff from stockpiled spoil will not be allowed to enter watercourses.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

Waste management on site will follow normal protocols, as outlined in Appendix D, which is expected to minimise impacts on aquatic ecosystems. Most of these activities are very unlikely to occur within or in close proximity to watercourses.

Potential impacts include:

- Water quality decline due to sediment transport, biochemical oxygen demand (BOD), nutrient loads, chemical/fuel contamination etc.
- Smothering of benthic aquatic habitat as a result of erosion and sediment transport.
- Algal blooms and pathogen loads as a result of sewage contamination.
- Turbidity as a result of sediment transport and/or bentonite or other drilling chemicals.
- Organic enrichment and oxygen depletion from decaying green waste.
- Physical disturbance of stream beds/banks and or aquatic habitat/substrate if creek crossings are required.

For most of the above waste streams the geographic extent of impacts under the protocols outlined in Appendix D are expected to be localised, although they could be more widespread if contamination occurred during wet season flows. The duration and severity of impacts under normal protocols are likely to be moderate, hence this activity has been assigned a "Moderate" rating.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-4 Baseline impact of waste on aquatic ecosystems.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Gathering Line and Pipeline Trenching

Description of activity/impact:

It is understood that trenching operations will largely be restricted to the construction phase of the project, although it may become necessary to excavate pipelines in the event that emergency maintenance is required.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings)

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts)

Potential impacts of trenching operations include:

- Water quality decline due to sediment mobilisation and/or transport, biochemical oxygen demand (BOD), nutrient loads.
- Smothering of benthic aquatic habitat as a result of erosion and sediment transport.
- Physical disturbance of stream beds and banks and loss of aquatic habitat.
- Stream bed/bank erosion during flow/storm evens as a result of exposure of soils, poor rehabilitation or changed flow patterns.
- Fuel or chemical spills from machinery.
- Introduction of aquatic weeds during trenching at creeks and drainage lines.
- Barriers to the passage of aquatic biota.

These impacts are generally likely to be quite localised and of short duration. However, changes to bank and in-stream erosion and sediment transport impacts may be longer term and may result in temporary or partial loss of aquatic ecosystem values, hence this activity has been assigned a “moderate” impact magnitude rating.

Impact assessment

(Refer to Table 3-5 for impact assessment matrix).

Table 5-5 Baseline impact of gathering and pipeline trenching.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Drilling operations – sumps for waste water/ drilling product management

Description of activity/impact:

Sumps are often constructed to enable containment of wastewater and drilling products during drilling of wells and bores. Sump construction and drilling operations generally occur during drier periods and require track access and some clearing and levelling of predetermined drilling locations. Several holes are usually drilled and involve continual wetting of the drill during operations. Formation water extracted during the drilling operations will be removed from the well site and transported to treatment dams.

These ground disturbance activities have the potential to impact on the environmental values of artefacts of archaeological significance, soils, vegetation, watercourses and water quality.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings)

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

Potential impacts of trenching operations include:

- Water quality decline due to sediment mobilisation and/or transport, biochemical oxygen demand (BOD), nutrient loads.
- Smothering of benthic aquatic habitat as a result of erosion and sediment transport.
- Discharge of toxic or potentially toxic chemicals.

These impacts are only likely to occur in the event of a severe storm event, when sumps may potentially overflow. At these times, water quality in streams within the study area is likely to be relatively poor, with elevated turbidity and suspended solids loads. Dilution of drilling sump overflow is therefore likely to reduce the severity but increase the geographical extent of this impact. This impact has therefore been assigned a “Low” impact magnitude rating.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-6 Baseline impact of drilling operations.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Low	Moderate	Nil
Oakey Creek (u/s Site 3)	High	Low	Moderate	Nil
Permanent/semi-permanent waterways	Moderate	Low	Low	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Altered surface water hydrology – emergency water releases

Description of activity/impact:

Emergency water releases may become necessary during periods of high rainfall, when demand for beneficial use can be expected to be low, but production of treated water remains constant.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.

- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts)

Potential impacts of emergency water release include:

- Increased flow resulting in velocity barriers to the movement of aquatic biota.
- Increased flooding of wetlands, oxbows, lagoons etc, with altered aquatic processes and potential to expand the distribution of noxious species such as carp and goldfish.
- Altered water quality, depending on the quality and quantity of water released and on the flow and quality of the receiving waters.
- Short-term increased surface water flow in permanent/ephemeral systems.
- Potential unseasonal flow in ephemeral systems.

Emergency releases are most likely to occur during periods of naturally high flow, when these impacts are unlikely to have a significant effect in light of conditions in the receiving environment. However, if releases occur during the dry season, the severity and geographic extent of the impacts will be increased. Unseasonal flows are more likely to have ecological consequences if they are made into ephemeral or semi-permanent systems during the dry season.

The impact severity and geographic extent for this activity is dependent on seasonal and other conditions within the receiving waters and on the magnitude and duration of discharge. In addition, the potential to facilitate the movement of exotic species could create long-term impacts and these releases have therefore been assigned a “high” magnitude rating across all systems.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-7 Baseline impact of emergency releases.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	High	Major	Nil
Oakey Creek (u/s Site 3)	High	High	Major	Nil
Permanent/semi-permanent waterways	Moderate	High	High	Nil
Ephemeral waterways	Low	High	Moderate	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Operation and maintenance activities

Description of activity/impact:

The potential impacts of these activities will vary depending on the nature of the activity. For example, routine inspections of wells, pipeline easements and tracks will have negligible impact on aquatic ecosystems. Vegetation management along pipeline easements can be expected to have relatively low impacts. However, in the event that a pipeline must be excavated for repair or replacement, the impacts could be substantially higher.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

The impacts associated with routine inspection have been addressed under the section on vehicle and machinery use near waterways.

If a pipeline must be excavated for repair or maintenance, potential impacts of operational activities will be similar to those for the initial trenching operations and include:

- Water quality decline due to sediment mobilisation and/or transport, biochemical oxygen demand (BOD), nutrient loads.
- Smothering of benthic aquatic habitat as a result of erosion and sediment transport.
- Physical disturbance of stream beds and banks and loss of aquatic habitat.
- Stream bed/bank erosion during flow/storm evens as a result of exposure of soils, poor rehabilitation or changed flow patterns.
- Contamination of water with fuels or other chemicals.
- Contamination of water with herbicides.

- Accidental introduction of aquatic weeds.

This activity has therefore been assigned a “moderate” impact magnitude rating except for ephemeral systems, where the magnitude of impacts is likely to be lower.

Impact assessment
(Refer to Table 3-5 for impact assessment matrix).

Table 5-8 Baseline impact of operation and maintenance.

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Moderate	High	Nil
Oakey Creek (u/s Site 3)	High	Moderate	High	Nil
Permanent/semi-permanent waterways	Moderate	Moderate	Moderate	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

Maintenance of access tracks and overhead powerline easements

The maintenance of access tracks involves management of vegetation, erosion and water runoff. Activities may include vegetation clearing, spraying, grading or resurfacing.

Potential impacts on aquatic ecosystems include:

- Mobilisation of sediments as a result of soil erosion or runoff from unformed roads.
- Contamination of water with fuels or other chemicals.
- Contamination of water with herbicides.
- Accidental introduction of aquatic weeds.

Potentially affected aquatic ecosystems and sensitivity

(Refer to Section 3.10 for derivation of sensitivity ratings).

- Lake Broadwater – High Sensitivity.
- Oakey Creek upstream of Site 3 – High sensitivity.
- Permanent and semi-permanent watercourses – Moderate sensitivity.
- Ephemeral watercourses – Low sensitivity.

Magnitude of potential impacts

(Refer to Table 3-5 for criteria used to assess the magnitude of impacts).

The activities associated with track maintenance are similar to those for track construction, although the extent and duration of works are likely to be less than for construction of a new track. With the exception of waterway crossings, these tracks will be remote from waterways and riparian zones, hence the impacts on aquatic systems will be limited in duration, severity and geographical area.

Track maintenance in the vicinity of waterway crossings has higher potential to impact on aquatic systems, but remains low in terms of extent, duration and severity.

They have therefore been assigned an impact magnitude rating of "Low".

Table 5-9 Maintenance of access tracks and overhead power lines

Location	Sensitivity	Magnitude	Impact	Notes
Lake Broadwater	High	Low	Moderate	Nil
Oakey Creek (u/s Site 3)	High	Low	Moderate	Nil
Permanent/semi-permanent waterways	Moderate	Low	Low	Nil
Ephemeral waterways	Low	Low	Negligible	Nil

Impact mitigation

Generic and specific mitigation measures to manage these potential impacts are outlined in section 6.2 and section 6.3 respectively.

5.2 Summary of baseline impact assessment

The pre-mitigated significance assessment of potential impacts on aquatic communities, habitat and processes is summarised in Table 5-10 below.

Table 5-10 Summary of pre-mitigation significance assessment.

Activity	Lake Broadwater	Oakey Creek	Permanent waterways	Ephemeral waterways
Site clearing and levelling	High	High	Moderate	Negligible
Construction of access tracks	High	High	Moderate	Negligible
Use of vehicles and machinery near waterways	High	High	Moderate	Negligible
Waste management	High	High	Moderate	Negligible
Gathering line and pipeline trenching	High	High	Moderate	Negligible
Pipeline/access road creek crossings	High	High	Moderate	Negligible
Drilling operations	Moderate	Moderate	Low	Negligible
Altered hydrology	Major	Major	High	Moderate
Operation and maintenance	High	High	Moderate	Negligible
Maintenance of access tracks and overhead powerline easements	Moderate	Moderate	Low	Negligible

6 Avoidance, Mitigation and Management Measures

Proposed avoidance, mitigation and management measures are detailed below.

6.1 Avoidance Measures – Project Constraints

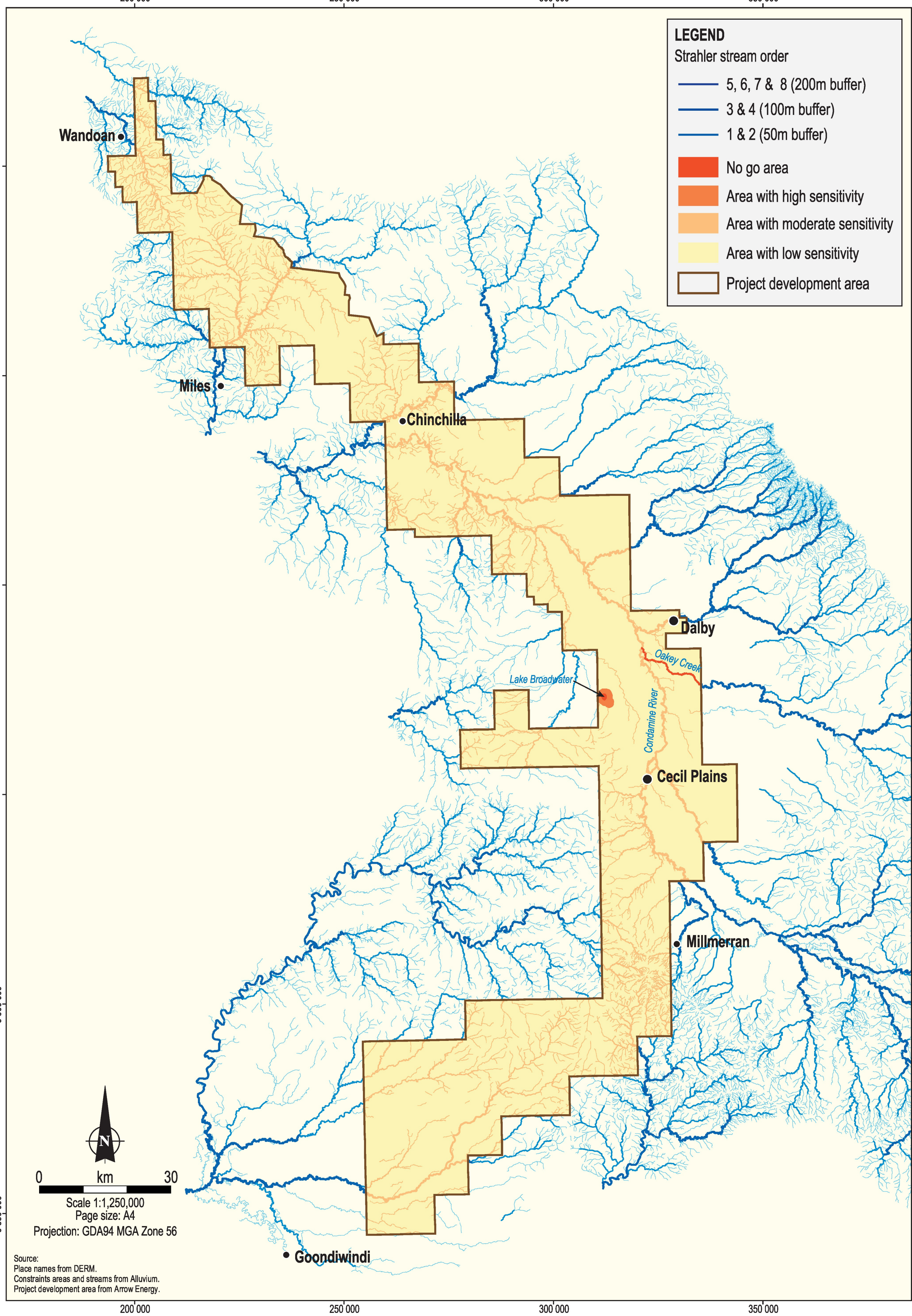
With the exception of one wetland system (Lake Broadwater) and two fish species (*M. adspersa* and *G. mamoratus*), aquatic ecosystem values should pose few constraints on the construction and operations of the project. Throughout most of the project development area the construction of the Surat Gas Project as currently proposed will have minimal impact on aquatic ecosystems at a local, regional, national or international scale provided a common set of environmental management standard operating procedures are implemented. This is because:

- Most of the waterways in the study area are ephemeral, and impacts to the aquatic environment posed by creek crossings (road and pipeline) and other construction and operations activities can be minimized by timing construction to coincide with periods of dryness and ensuring rehabilitation is complete before wet season flows.
- The biota living within these systems are generally resilient species that tolerate a wide range of conditions and are not affected by disturbances of the nature posed by this project.
- There are few listed rare, threatened or endangered aquatic species, communities or ecosystems in the study area (those that are present are discussed below).
- Similarity analysis indicates that the habitat and biota are relatively similar across the catchment (i.e. very few pockets of unusual or locally endemic species or communities have been identified).

Table 6-1 presents the risk-based constraints framework used to determine the level of environmental management or remediation required for the key Surat Gas Project activities. Figure 6-1 depicts the aerial extent of the various constraint levels based on aquatic ecology desktop and field assessments described in this report.

Table 6-1 Constraints framework.

Constraint	Project Activity			Applicable Framework
	Drilling Wells	Installing Gathering Pipelines	Facilities Installation	
'No Go'	N	N	N	Avoidance principle applies. No activity permitted. Procedural and behavioural controls in place to ensure strict compliance.
High	Y	Y	N	Very strict controls apply. These are discussed below
Moderate	Y	Y	Y	Standard operating procedures apply for wells and pipelines. Site specific controls must be in place for water treatment and storage facilities to ensure that aquatic ecosystems are un-impacted by altered surface water hydrology.
Low	Y	Y	Y	Standard operating procedures apply.



coffey environments

Date: 20.05.2011
MXD: 7040AC_04_GIS002_v1_1
File Name: 7040_AQ_F04.01_GIS_GL

Arrow Energy
Surat Gas Project

arrow energy go further

Aquatic Ecology constraints

Figure No: 6-1

The level of constraint assigned to waterways and riparian zones across the majority of the study area is “moderate”. This reflects that waterways within the project development area are already significantly disturbed, largely ephemeral, in moderate health and contain few listed aquatic species or communities.

However, additional assessment of the potential effects of beneficial use of treated coal seam water have not been considered further as they fall outside the scope of Arrow’s EIS. The fundamental assumption that the beneficial use of treated coal seam water will occur in compliance with a regulatory framework that formally permits its use, and controls the allocation of the treated coal seam water and its subsequent use is applied.

Two areas have been assigned a higher level of constraint and are discussed in Section 6.3 – Specific Mitigation Measures.

6.2 Generic Mitigation Measures

The following generic mitigation measures should be implemented for each component of the project.

SITE LEVELLING AND CLEARING

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management** Plan must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) below.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to):

- Controls for working in, on or near waterways.
- No off track access.
- All vehicle and machinery movement and activity to be within the pegged disturbance envelope.
- No uncontrolled release of water from the site, including sumps that may be required for drilling.

- Preventing potentially harmful materials, including drilling waste products (including water) entering directly to a waterway or drainage line.

Ground disturbance works are to be planned:

- Cut and fill earthworks, and disturbance of rootstock and topsoil is to be minimised.
- Understand the soil profile (type, depth, thickness) prior to commencement of land disturbance works.
- Limit land disturbance to the minimum necessary for conducting the petroleum activity.
- Clearly identify and mark the designated work site i.e. the area of proposed land disturbance including the area of vegetation to be cleared and the area required for stripping of topsoil, excavation and stockpiling of topsoil, spoil and clearing residue. The area of land required for the designated work site will be determined by the requirements of the work to be completed.
- Arrange for temporary fencing (e.g. star pickets and barricade tape / fencing) of areas containing rare or threatened plants, significant vegetation communities and fauna habitat.
- Remove vegetation in accordance with an approved vegetation management plan
- Obtain all permits, authorities and consents required to carry out the proposed works.
- Drainage and sediment controls are to be in place at the completion of clearing works.

Ground Disturbance Works must be controlled by:

- Do not clear vegetation outside of the designated work site.
- Do not clear any riparian vegetation (vegetation along the land / water interface) or allow vehicles, plant and equipment to enter or traverse riparian vegetation. Riparian vegetation is to be clearly identified and marked prior to commencement of ground disturbing works in the vicinity of watercourses or water bodies.
- Do not push clearing residue into a watercourse or water body or drainage line and remove any residue that might block or constrict flows in a watercourse or drainage line.
- Topsoil shall be stripped and stockpiled in areas where soil will be highly disturbed or compacted, or where excavation will take place. The nominal stripping depth is to be 150mm unless site conditions indicate otherwise.
- Stockpile topsoil separately from vegetation clearing residue (if any), subsoil, or any other excavated materials and minimise the opportunity for mixing, e.g., through separation or a geotextile shield (but do not cover topsoil).

Soil shall not be placed:

- in or within 1000 metres from any nationally or internationally listed wetland.
- In or within 200 metres of a “Highly Constrained” watercourse

- in or within 50 metres of the high bank of any other watercourse.
- in a way that isolates clumps or dissects corridors of vegetation resulting in a reduction in the current level of ecosystem functioning, an increase in threatening processes, or the dissection of corridors of vegetation that provide connection between contiguous tracts of vegetation.
- in a way that damages adjacent live vegetation.
- on slopes greater than 10%.
- on dispersible soils without first taking appropriate measures to stabilise the site first; and
- in existing or potential discharge areas.

Locate stockpiles:

- Within the designated work area.
- Outside drainage lines.
- Out of the way of traffic, operational, or maintenance activities.
- So that they are recoverable after completion of land disturbance activity.

Install breaks in topsoil and subsoil stockpile windows at least every 50m or at strategic locations to allow runoff, vehicles, stock or wildlife to pass through.

Install erosion controls to protect topsoil and subsoil stockpiles from erosion.

Install diversion drains, berms, and/or sediment barriers (e.g., geotextile silt fences) up-slope of disturbed areas to direct clean stormwater run-off away from the site.

If there is a cessation of activities due to weather conditions, stabilise soils and install and maintain appropriate erosion controls.

Discharge any trench or excavation water to land through energy dissipating structures and sediment traps (e.g. straw bale and geotextile basin) and minimise runoff to waterways and drainage lines.

On completion of works, backfill trenches or excavations to match original soil profile by:

- Replacing and compacting subsoil to as near as possible (75 to 85%) to the in-situ density of surrounding soils to minimise the risk of subsidence.
- Removing and disposing of excess spoil in accordance with landowner requirements.
- Spreading and shaping topsoil to match the surrounding contours.

Install and maintain erosion control structures (e.g., silt fences, straw-bale barriers).

To manage the transfer of aquatic/riparian weeds on machinery, a **Weed Management Plan** must be developed, and should include the following actions:

- Train and induct personnel in the requirements of weed management before commencing project activities.
- Ensure personnel are aware of the location and extent of weed infestations in the vicinity of the work area and the risks involved in moving from one vegetation type to another.
- Develop washdown procedures based on the risk matrix developed in the *Petroleum Industry – Minimum Pest Spread Advisory Guidelines*.

Before commencing work:

- Plan maintenance activities so that movement of plant and equipment between properties or areas with weed infestations is minimised.
- All vehicles, plant and equipment must be thoroughly washed down with high-pressure water before travelling to the designated work site and commencing any activities.

When establishing a designated work site:

- Prior to establishing a designated work site and commencing scheduled activities, engage a suitably qualified specialist to assess the presence of, and appropriately treat, any infestations of environmental and/or noxious weeds.
- The assessment is to be undertaken at least one month prior to the commencement of scheduled maintenance activities.
- If weeds are not actively growing at the time of inspection, the location and extent of the infestation is to be recorded, the area of the infestation fenced or marked to exclude traffic (if practicable and by agreement with the landowner) and treatment of the infestation undertaken later when the weeds are actively growing.
- Treat weeds only with target-specific, non-persistent (i.e., bio-degradable) herbicides except on properties where organic or biodynamic farming is practiced, where the method of treatment will be agreed with the landowner.
- Do not remove weeds by hand.
- Segregate weeds removed from designated work sites from all other materials and allow to decompose.
- Erect temporary fencing (e.g., electric fence) around designated work sites to exclude stock from any stripped area or excavation or stockpile.
- Site temporary washdown facilities to ensure that run-off is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas. Where there is a high risk of run-off to adjacent areas, construct a washdown pad comprising a sump lined with an impervious membrane and filled with coarse crushed rock. Pump out

sump, as required, and dispose of run-off water to the infected area or property, in accordance with landowner requirements.

When sourcing maintenance materials, ensure that materials such as bedding sand, topsoil, straw bales and sand bags are only be brought to site once ascertained that the materials are not contaminated with weeds and plant or animal pathogens. A Weed Hygiene Declaration form must be requested from the supplier where there is possible risk of contamination in products.

Weed control must be managed by:

- Engaging a suitably qualified specialist to undertake, or to train personnel to undertake, routine inspections of areas disturbed by activities (e.g. well sites, access roads, pipelines) for environmental and noxious weed infestations. The inspection must be undertaken at least one month before the end of the period in which weeds are actively growing to allow adequate time for effective treatment.
- Recording the location and extent of environmental and noxious weed infestations and engage a suitably qualified weed control contractor to treat the infestations.
- Following completion of activities and rehabilitation, monitor designated work sites where environmental or noxious weeds were identified or where works involved ground disturbance for outbreaks of environmental and noxious weeds and engage a suitably qualified weed control contractor to treat the infestations.
- Keep to designated access tracks and avoid driving over boggy or disturbed soils.

Precautionary procedures must be adopted, and should include:

- Regularly inspect temporary fencing for breaches and correct operation, in particular prior to leaving the designated work site at the end of each workday where the maintenance activities extend for more than one day.

CONSTRUCTION OF ACCESS TRACKS

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) below.

WASTE MANAGEMENT

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

For the management of waste, a **Waste Management Plan** must be developed and the following procedures must be adopted:

- Identify all waste streams on site and establish a waste stream inventory identifying the nature, classification, storage, transport, tracking and disposal requirements for the waste.
- Develop the site's waste stream inventory and employ appropriate procedures for disposal.
- Train personnel in the principles of avoid, reduce, reuse, recycle, and the appropriate disposal of domestic and industrial wastes.
- Provide appropriate domestic waste disposal facilities at designated work sites, including general rubbish bins, cigarette bins, and toilet facilities.
- Provide appropriate industrial waste disposal facilities at designated work sites, to permit appropriate segregation, storage and disposal of waste.
- No litter present.
- All spills, including minor spills, are to be cleaned up immediately.
- Wastes segregated and stored according to classification.
- Do not store waste within designated work sites. Rather, establish waste disposal facilities based on the following hierarchy of principles:
- Minimise waste generation.

- Segregate main waste types (dedicated receptacles may facilitate segregation).
- Reuse materials or equipment.
- Recycle materials or equipment.
- Appropriate disposal in accordance with regulatory requirements.
- Putrescible solid waste will be stored in covered waste containers to prevent odours and public health hazards, and disposed of by a licensed waste contractor.
- Do not locate waste storage facilities within 100 m of waterways.
- Waste must not be burnt or buried without local government and/or DERM approval.

For **domestic waste**, the following procedures must be adopted:

- Locate self-contained portable toilet facilities at designated work sites, ensuring they are accessible to all operation and maintenance personnel and are regularly maintained.
- Dispose of sewage and grey water from toilet facilities (portable toilets) via a chemical treatment system or transport to municipal sewage plant by a contractor licensed to transport such material.
- Locate designated domestic waste facilities at designated work sites, and ensure they are regularly removed and/or emptied.
- Take recyclable wastes to appropriate recycling plants, or arrange removal by a suitably qualified recycling contractor.
- Take remaining reusable or recyclable wastes to applicable sections of local municipal rubbish tip or transfer station.
- Dispose of non-reusable or non-recyclable waste to local municipal rubbish tip or transfer station.

For **industrial waste**, the following procedures must be adopted:

- Where a market exists, salvage and store any reusable or recyclable wastes such as timber, plastic, metal, tyres and containers in designated skips / areas for removal at regular intervals by delivery to recycling plant or by arrangement with a suitably licensed recycling contractor.
- Where appropriate recycling schemes are in place with the supplier, return any excess or reusable wastes for reuse.
- Waste receptacles (i.e. oil dams, interceptor pits, and storage tanks) must be checked weekly for waste build-up (especially hazardous liquid wastes). When the waste level is nearing the designated limit, a licensed waste contractor must be contacted for removal.

GATHERING LINE AND PIPELINE TRENCHING

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

Erosion control works are to be planned, and must include:

- Train and induct all supervisory, maintenance and contractor personnel in rehabilitation procedures.
- Engage suitably qualified and experienced contractors to undertake rehabilitation of disturbed ground.
- Maintain a photographic record of rehabilitation including a pre-existing condition assessment. Have particular regard to sites susceptible to erosion.

A Revegetation Plan must be prepared and should include:

During revegetation, works must include:

- Commence preliminary rehabilitation activities promptly and progressively as ground disturbance works are completed, to stabilise soils and minimise periods of exposed disturbed ground.
- Treat weed infestations in soil and clearing residue stockpiles before using these materials in rehabilitating disturbed ground.
- Ensure best-practice replacement of disturbed soils is undertaken.
- Manage residue from vegetation clearing.
- Rip compacted soils along contours to a maximum depth of 300 mm before subsoil and topsoil are returned to and redistributed over the site. Replace and reshape soils to conform to the original surface and re-form drainage lines.
- Cover topsoil where there is a high risk of erosion (e.g. jute mat or an equivalent pinned at 4 pins/m^2; thick mulch layer; hydroseeding with bonding fiber matrix).

- If topsoils are not returned to disturbed areas because they have been buried or lost or were not present in native vegetation, fertilise disturbed area with a low phosphate fertiliser as per the recommended rate, unless otherwise directed by the landowner.
- Where regeneration does not stabilise the site and provide adequate cover, augment with seed or seedlings of local provenance sourced from registered seed banks. Order seed or seedlings at least six months in advance of stock being required for rehabilitation.
- Install physical barriers to restrict access to the area undergoing rehabilitation. This may involve the erection of temporary fences to landowner specifications and on public land, the construction of berms and/or distribution of logs to restrict access to the site.

PIPELINE OR ACCESS ROAD CREEK CROSSINGS

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) above.

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

In addition, the following controls must be implemented:

- Do not travel mechanical equipment across waterways unless an appropriate crossing that minimises disturbance to waterway bed and banks and riparian vegetation is available.
- Causeways, fords or other road crossings must be sited to avoid waterholes, waterway junctions and where possible, waterway reaches with steep banks.
- Design vehicular crossings to enable passage of flows resulting from a 100 year ARI flood event. The design must consider waterway barrier effects, as well as the potential for waterway channel erosion leading to headward erosion, scouring or accretion. Any of these effects may lead to potential for channel avulsion.

- Obtain all relevant permits required under the *Fisheries Act 1994*, including permits for construction of waterway barriers or disturbance of fish habitat.
- Install sediment booms and erosion control measures before commencing earthworks to minimise sediment transport and elevated turbidity.
- Protect the upstream and downstream faces of any causeway with rock rip-rap or other suitable material. Install erosion control structures on road/access track table drains to minimise sediment transport to the waterway.
- Stabilise and revegetate road/access track batters to reduce the potential for erosion leading to sedimentation of waterways and water bodies.
- Ensure that culverts used to construct waterway crossings are suitably sized to enable fish passage.
- Design linear infrastructure routes (e.g., gas flow lines, gas transmission pipelines, water pipelines and overhead transmission lines) to avoid water bodies.
- Design the waterway crossing based on the environmental values to be protected and the application of an appropriate crossing method.
- Plan waterway crossings to occur during periods of low rainfall and low flows.
- Plan and program construction activities to ensure the waterway crossing is completed as promptly as possible to minimise the duration of disturbance.
- Check local weather reports daily during construction to manage the risk of high flows or flooding affecting the waterway crossing.

Rehabilitation must be controlled by:

- Remove all temporary structures from the waterway including cofferdams, culverts, vehicle, plant and equipment causeways and waste e.g., temporary shoring materials.
- Backfill trenches using excavated materials to reinstate the original waterway bed strata. Ensure soil horizons are reinstated. Where possible, use excavated waterway sediments to seed the disturbed area. Where necessary, protect the reinstated waterway bed with adequate armouring including where necessary rock spalls and/or mattresses. Avoid changes to waterway channel profiles when reinstating crossings, as changed flow patterns could result in headward erosion or scouring.
- Replace any large woody debris (snags) or other structures of potential aquatic fauna and fisheries value, which were disturbed/removed during pipeline construction works.
- Stabilise banks using jute matting, geo-textile materials, rock rip-rap or rock gabion baskets to prevent erosion. Revegetate banks as soon as practicable to ensure successful rehabilitation. Where appropriate use sterile grasses to bind and hold soils while rehabilitation with endemic species is undertaken. Monitor and control weed infestations.

- Compact backfill sufficiently to ensure surface water run-off and/or drainage channels are not diverted to the pipe trench, paying particular attention to those areas adjacent to the waterway. Install and maintain erosion control berms and structures to divert surface water run-off from the pipe trench.

A **Revegetation Plan** must be prepared before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

DISTURBANCE OF BANKS, RIPARIAN ZONES AND SUBSTRATE

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Revegetation Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

DRILLING OPERATIONS – SUMPS FOR WASTE WATER/DRILLING PRODUCT MANAGEMENT

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) above.

CONSTRUCTION ACTIVITIES

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Revegetation Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) above.

OPERATIONS AND MAINTENANCE ACTIVITIES

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Revegetation Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

A **Waste Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Waste Management) above.

MAINTENANCE OF ACCESS TRACKS AND OVERHEAD POWERLINE EASEMENTS

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Revegetation Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

MAINTENANCE OF CREEK CROSSINGS

A **Water Management Plan** must be prepared, and should include management of water resources and water quality, and must incorporate water for dust control, overspray and runoff, and use of additives.

An **Acid Sulphate Soil Management Plan** must be prepared in accordance with the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*, 2002).

A **Weed Management Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site clearing and levelling) above.

An **Erosion and Sediment Control Plan** must be prepared in accordance with *Best Practice Erosion & Sediment Control – for building and construction sites* (IECA, 2008). The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Site Clearing and Levelling) above.

A **Revegetation Plan** must be developed before construction. The plan must include (but not limited to) specific actions outlined in Section 6.1 – Mitigation Measures (Gathering line and pipeline trenching) above.

6.3 Specific Mitigation Measures

One location within the study area has been identified as a "**no go**" zone. The highly sensitive Lake Broadwater is a gazetted conservation park and may provide refuge or foraging/spawning habitat for a number of aquatic species. As a consequence, it is recommended that **no activities take place within, or adjacent to Lake Broadwater**. It is noted that Arrow Energy is currently engaged in discussions with DERM regarding appropriate buffer distances from Lake Broadwater and that the activities that are permissible within or adjacent to these waterways may change pending the outcomes of these discussions.

Two areas have been identified as "**highly constrained**" zones:

- No petroleum activities within 200m of Lake Broadwater Conservation Park; no activities other than Limited Petroleum Activities within 1km of Lake Broadwater Conservation Park (i.e Category A ESA).
- Oakey Creek between Cecil Plains Road and the study area boundary. As construction activities could require small scale clearing of vegetation to facilitate well or pipeline installation, the adoption of appropriate riparian buffer zones along all watercourses is essential. The Regional Vegetation Management Code for Brigalow Belt and New England Tablelands encompasses the study area and provides guidelines for appropriate riparian buffer strip width (Table 6.2).

Buffer zones are to be adopted for all project activities, and include:

- In "Highly Constrained" areas a buffer of 200m, measured from the bank edge, must be adopted during all phases of the project.
- For "Moderately Constrained" areas, the following buffer zones, measured from the bank edge, must be adopted during all phases of the project:
- A riparian buffer of 50m either side of first and second order streams.

- A riparian buffer of 100m width on either side of third and fourth order streams.
- A riparian buffer of 200m width on either side of fifth and higher order streams.
- Where creek crossings for access tracks or pipelines are required, adopting buffer zones is impractical, therefore mitigation measures outlined for these activities in section 6.2 and section 6.3 must be adopted instead.

Buffer zones adopted are based on the Regional Vegetation Management Code for Brigalow Belt and New England Tablelands, which designate buffer widths based on stream order (Table 6-2).

Table 6-2 Buffer zone designations.

Stream Order	Definition	Riparian Bank Buffer Width (m)	Watercourse Sample Site Stream Order Examples
5th or higher	Convergence of two 4th order streams or higher.	200	Condamine River (6th), Myall Creek (5th), Westbrook Creek (5th), Oakey Creek (5th)
3rd or 4th	Convergence of two 2nd order (3rd order) or two 3rd order streams (4th order).	100	Bringalilly Creek (3rd), Wilkie Creek(4th)
1st or 2nd	Streams with no tributaries (1st order) or convergence of two 1st order streams (2nd order)	50	None

Construction of access tracks

It is anticipated that the construction of access tracks will be kept to a minimum, with the use of existing tracks and roads preferred wherever possible. As much of the study area has been previously cleared for agriculture, access in most areas does not require the removal of vegetation.

Tracks will not be constructed in riparian zones, hence damage to riparian buffer strips, stream beds and banks will be avoided, except in the immediate vicinity of creek crossings.

Where waterway crossings are unavoidable, measures will be taken to ensure that the movement of aquatic species is not impacted. The specific measures that will be applied will be negotiated with DPI Fisheries personnel when an application for a waterway barriers permit is prepared. Mitigation measures may include fish friendly design of culverts, alternative routes for passage, minimizing the amount of dark areas and providing baffles or other structures to provide resting points out of the stream flow.

During the design and construction of waterway crossings, care will be taken to minimise the footprint of the structure and to avoid unnecessary disturbance to stream beds and banks.

Construction will occur during dry months where possible and the use of machinery and vehicles on stream beds and banks will be avoided if possible.

Use of vehicles and machinery near watercourses

The use of vehicles and machinery near waterways will be avoided wherever possible.

As previously described, the use of vehicles or machinery within waterways or riparian zones will be avoided wherever possible and is expected to be minimal.

Machinery hygiene protocols will minimise the potential for the transfer of aquatic weeds on vehicles and machines.

Waste management

All waste that is brought to the site during gas well and gathering system constructions will be removed from site and disposed of in accordance with the operating procedures outlined in Table 4-1. During operation, personnel numbers at these installations will be minimal and short-term and waste will be removed as per the construction phase.

Larger numbers of personnel and greater volumes of construction materials will be associated with other project facilities (eg water treatment plant etc), particularly during the construction phase. Solid waste from these sites will be removed and disposed of to a registered landfill, or treated onsite using approved treatment facilities and processes, as per the operating procedures outlined in Table 4-1.

The most significant waste streams associated with the CSG facilities will be treated waste water and concentrated brine. Coal seam water received at integrated processing facilities is expected to be predominantly treated using reverse osmosis and then balanced to ensure that it is suitable for the intended beneficial use. Coal seam water received from the field, treated water and brine concentrate will be stored in dams adjacent to integrated processing facilities.

Trenching for pipelines and gathering lines

Wherever possible, the gathering lines and pipeline will be designed to avoid creeks, drainage lines and riparian areas (particularly permanent waterways or perennial aquatic habitat), thus minimising impacts on aquatic ecosystems.

The most significant potential for impacts will occur where the pipeline crosses waterways, which will be minimised by ensuring that the trenching occurs perpendicular to the creek, thus minimising the footprint. The width of the easement will also be narrowed at these points, further reducing impacts on stream banks, beds and riparian zones by restricting the area of waterway that will be disturbed.

Trenching within or in the vicinity of watercourses will occur during the drier months of the year, which will reduce the potential for water quality decline as a result of sediment mobilization. In the case of ephemeral systems, rehabilitation of trench lines will be completed prior to the wet season flow events, hence no impacts are anticipated. This strategy will also avoid restricting the movement of aquatic biota that may opportunistically move into ephemeral systems.

Pipeline/access road creek crossings

Pipeline and access track crossings of waterways will be kept to a minimum by designing the gathering system so that multiple feeder lines are gathered into one pipeline prior to crossing.

Drilling operations

The potential impacts of drilling on aquatic systems are associated with spillage, overflow or discharge from sumps used to contain waste water and/or chemicals associated with drilling (eg bentonite). All of the likely maintenance drilling activities have been covered by the preceding discussions and by the operating procedures outlined in Table 4-1.

Surface water hydrology – emergency release

The unplanned emergency discharge of high quality, treated water may occasionally occur from the water treatment/storage facility. Such releases would occur only when Beneficial use disposal options are unavailable due to unforeseen issues, such as periods of significant prolonged rainfall or flooding (not annual wet season flows) and the holding dams are near or at Design Storage Allowance (DSA). This action would then become necessary to ensure dam integrity is maintained.

Operation and maintenance activities

Vegetation management along pipeline easements can be expected to have relatively low impacts.

All of the likely maintenance and operational activities (including digging up pipelines) have been covered by the preceding discussions and by the operating procedures outlined in Table 4-1.

Maintenance of access tracks and easements

The use of herbicides in the vicinity of waterways or within riparian zones will be limited to those chemicals registered and approved for use in these areas (eg Roundup Bioactive), and in agreement with the landholder.

7 Residual Impact Assessment

7.1 Application of Specific Mitigation Measures

Site clearing and leveling

In terms of preparing sites for the construction of wells gas gathering and coal seam gas water treatment, the application of the project constraints guidelines outlined in section 6 will have the following implications for the aquatic ecosystems within the project area:

- No clearing or levelling of any areas within "designated "No go" zones. This will eliminate impacts associated with site clearing and levelling impacts on Lake Broadwater.

With the exception of limited track construction and pipeline trenching (addressed elsewhere), no clearing or levelling will occur within highly constrained areas. This will eliminate impacts associated with site clearing and levelling on Oakey Creek and a 1km buffer around the Lake Broadwater Conservation Park to "low". We note that acceptable buffer distances may change pending the outcomes of discussions between Arrow Energy and DERM.

- Establishment of 200m buffer zones from the banks of all 5th order streams. As no clearing or site levelling will occur within this zone, impacts on permanent and semi-permanent waterways will be eliminated.
- Establishment of 50m buffer zones (1st and 2nd order streams) and 100m buffer zones (3rd and 4th order streams) from ephemeral, permanent and semi-permanent waterways. As no clearing or site levelling will occur within these zones, impacts on permanent and semi-permanent waterways will be eliminated.
- The Regional Vegetation Management Code for Brigalow Belt and New England Tableland Bioregions has been adopted as the basis for defining appropriate buffers to watercourses. Table 2 of the code, which applies to terrestrial ecosystems, prescribes buffers to watercourses based on stream order. The intent of Table 2 is to protect riparian vegetation, a key factor in stream health and biodiversity. Aquateco notes that this is inconsistent with Arrow's current EA conditions which specify a 100 m buffer to all watercourses. The magnitude of potential impacts and identified risks assessed as part of this study do not support a blanket 100 m buffer for all watercourses. Aquateco recommends that the EA condition be reviewed to resolve inconsistency with the Regional Vegetation Management Code for Brigalow Belt and New England Tableland Bioregions.

Table 7-1 Residual impacts of site clearing and levelling on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	N/A	N/A
Permanent Waterways	Moderate	N/A	N/A
Ephemeral Waterways	Low	N/A	N/A

Construction of access tracks

In terms of constructing access tracks, the application of the constraint guidelines outlined in section 6 will have the following implications for the aquatic ecosystems within the project area:

- No tracks will be constructed within designated "No go" zones. This results in reassignment of the magnitude of impacts on Lake Broadwater to "low".
- Track construction within highly constrained zones will avoided where possible and will be kept to a minimum where this is not possible. Where track construction must occur, the application of other specific mitigation measures outlined in section 6 will reduce impact magnitude to "low".
- Within buffer zones of moderately constrained parts of the project area, the number of tracks to be constructed will be minimised. Other specific mitigation measures described in section 6 will result in impacts of track construction within these areas being assigned an impact magnitude rating of "low".

Table 7-2 Residual impacts of construction of access tracks on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	Low	Moderate
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Use of vehicles/plant/machinery near waterways

In terms of constructing access tracks, the application of the constraint guidelines outlined in section 6 will have the following implications for the aquatic ecosystems within the project area:

- No vehicles, plant or machinery will be used within designated "No go" zones. This eliminates these impacts on Lake Broadwater.

- The use of vehicles, plant and machinery within highly constrained zones must be avoided where possible and will be kept to a minimum where this is not possible. Where this must occur, the application of other specific mitigation measures outlined in section 6 will reduce the impact magnitude to "low".
- Within buffer zones of moderately constrained parts of the project area, the use of vehicle, plant and machinery will be minimised. Other specific mitigation measures described in section 6 will result in impacts of track construction within these areas being assigned an impact magnitude rating of "low".

Table 7-3 Residual impacts of vehicles/plant/machinery near waterways on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	Low	Moderate
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Waste management

The following constraints have been placed on waste generation and management under the constraints analysis outlined in section 6:

- No activities that will generate waste will be undertaken within designated "No go" zones. This eliminates these impacts on Lake Broadwater.
- With the exception of track construction and pipeline trenching (which will be kept to a minimum) no construction activities will occur within highly constrained areas. This will eliminate many waste streams from these zones, including sewage, construction waste, chemicals/oils/fuels drilling waste, concentrated brine and/or spoil.
- Within buffer zones in moderately constrained parts of the project area, the generation of waste will be minimised. Other specific mitigation measures described in section 6 will result in waste management within these areas being assigned an impact magnitude rating of "low".

Table 7-4 Residual impacts of waste management on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	N/A	N/A
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Gathering Line and Pipeline Trenching

The following constraints have been placed on gathering line and pipeline trenching under the constraints analysis outlined in section 6:

- No trenching activities will be undertaken within designated “No go” zones. This eliminates these impacts on Lake Broadwater
- Trenching within highly constrained areas will be minimised and will comply with the specific guidelines provided in section 6.3, as well as the generic guidelines in section 6.2. The magnitude of impacts to Oakey Creek and the Lake Broadwater buffer zone will remain “low”.
- Within buffer zones in moderately constrained parts of the project area, trenching will be minimised and will comply with the specific guidelines in section 6 as well as the generic guidelines in section 6.2. Other specific mitigation measures described in section 6 will result in the impact magnitude rating remaining “low”.

Table 7-5 Residual impacts of gathering line and pipeline trenching on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	Low	Moderate
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Pipeline/access road creek crossings

The following constraints have been placed on pipeline and access road creek crossings under the constraints analysis outlined in section 6:

- No tracks or pipelines will be constructed within designated “No go” zones. This effectively eliminates these impacts on Lake Broadwater.
- No creek crossings will be undertaken within highly constrained areas, eliminating impacts to Oakey Creek and the Lake Broadwater buffer zone.

- No specific mitigation (in addition to the generic mitigation strategies in section 6.2) is proposed for moderately constrained areas, hence the impact magnitude rating for these areas is unchanged from the baseline scenario.

Table 7-6 Residual impacts of pipeline/access road creek crossings on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	N/A	N/A
Permanent Waterways	Moderate	Moderate	Moderate
Ephemeral Waterways	Low	Moderate	Low

Drilling operations – sumps for waste water/ drilling product management

The following constraints have been placed on drilling operations under the constraints analysis outlined in section 6:

- No drilling will occur within designated “No go” zones. This effectively eliminates drilling impacts on Lake Broadwater.
- No drilling will be undertaken within highly constrained areas, eliminating impacts to Oakey Creek and the Lake Broadwater buffer zone.
- Within moderately constrained zones, no drilling will occur within 50m of 1st or 2nd order streams, within 100m of 3rd or 4th order streams or within 200m of 5th order streams.
- The Regional Vegetation Management Code for Brigalow Belt and New England Tableland Bioregions has been adopted as the basis for defining appropriate offsets to watercourses. Table 2 of the code, which applies to terrestrial ecosystems, prescribes offsets (buffers) to watercourses based on stream order. The intent of Table 2 is to protect riparian vegetation, a key factor in stream health and biodiversity. Aquateco notes that this is inconsistent with Arrow’s current EA conditions which specify a 100 m offset (buffer) to all watercourses. The magnitude of potential impacts and identified risks assessed as part of this study do not support a blanket 100 m buffer for all watercourses. Aquateco notes that Arrow Energy is engaged in discussions with DERM regarding consistency of buffer distances between activities and waterways. The distances outlined herein may changes pending the outcomes of these discussions.

Table 7-7 Residual impacts of drilling operations on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	N/A	N/A
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Altered surface water hydrology – emergency water releases

The following constraints have been placed on emergency releases of high quality, treated water under the constraints analysis outlined in section 6:

- Current dam safety regulations require that treated and untreated water, and brine dams are operated and maintained to avoid overtopping and possible consequential failure.
- Emergency releases will occur only when unforseen conditions (eg extended periods of heavy rain or flooding) reduce the demand for beneficial use. Releases would only occur when the capacity of the dam had been reached and the discharge of water is required to maintain dam integrity. In these situations, discharges would occur at the time of high flows in the receiving watercourses, including those draining to Lake Broadwater
- The water released would be high quality and would comply with water quality standards outlined in Arrow's Environmental Authority for their current operations, including the receiving watercourse, volume, flow, duration and water quality.

As the release of water is likely to only occur during periods of high natural river flow, the impacts of emergency releases would be significantly lower (impact magnitude "moderate") than would occur during dry season conditions (impact magnitude "high").

By controlling the timing and manner in which release occurs, the downstream effects are likely to be minimal due to the dilution effect attributable to the high flow rates associated with the unusual/ or potentially unseasonal rainfall event. Therefore, the significance of the residual impact of emergency releases to watercourses draining to Lake Broadwater is moderate.

Table 7-8 Residual impacts of altered surface water hydrology on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	Moderate	Moderate
Oakey Creek	High	High	N/A
Permanent Waterways	Moderate	Moderate	High
Ephemeral Waterways	Low	High	Moderate

Operation and maintenance activities

The following constraints have been placed on operational and maintenance activities under the constraints analysis outlined in section 6:

- No activities will occur within designated “No go” zones. This effectively eliminates drilling impacts on Lake Broadwater.
- Activities undertaken within highly constrained areas will be restricted to inspection and maintenance of access tracks and pipelines. The impact magnitude rating will therefore be low.
- No specific provision has been made for operational activities within moderately constrained parts of the study area, However, generic environmental controls and the nature of the operation and maintenance activities result in a low impact magnitude rating.

Table 7-9 Residual impacts of operation and maintenance activities on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	N/A	N/A
Oakey Creek	High	Low	Moderate
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Low

Maintenance of access tracks and overhead power lines

The following constraints have been placed on access track and overhead power line maintenance activities under the constraints analysis outlined in section 6:

- No activities will occur within designated “No go” zones. This effectively eliminates drilling impacts on Lake Broadwater.
- Access tracks and overhead power lines within highly constrained areas will be kept to a minimum. The impact magnitude rating will be low.

- No specific provision has been made for operational activities within moderately constrained parts of the study area, However, generic environmental controls and the nature of the operation and maintenance activities result in a low impact magnitude rating.

Table 7-10 Residual impacts of maintenance of access tracks and overhead power lines on aquatic ecosystems.

Environmental Value	Sensitivity	Magnitude	Significance of Impact
Lake Broadwater	High	Low	Moderate
Oakey Creek	High	Low	Moderate
Permanent Waterways	Moderate	Low	Low
Ephemeral Waterways	Low	Low	Negligible

Table 7-11 Summary of residual impact magnitude.

7.2 Activity	Lake Broadwater		Oakey Creek		Permanent waterways		Ephemeral waterways	
Site clearing and levelling	High	N/A	High	N/A	Moderate	Low	Negligible	Negligible
Construction of access tracks	High	N/A	High	Moderate	Moderate	Low	Negligible	Negligible
Use of vehicles and machinery near waterways	High	N/A	High	Moderate	Moderate	Low	Negligible	Negligible
Waste management	High	N/A	High	N/A	Moderate	Low	Negligible	Negligible
Gathering line and pipeline trenching	High	N/A	High	Low	Moderate	Low	Negligible	Negligible
Pipeline/access road creek crossings	High	N/A	High	N/A	Moderate	Moderate	Negligible	Negligible
Drilling operations	Moderate	N/A	Moderate	N/A	Low	Low	Negligible	Negligible
Altered hydrology	Major	Moderate	Major	High	High	Moderate	Moderate	Moderate
Operation and maintenance	High	N/A	High	Low	Moderate	Low	Negligible	Negligible
Maintenance of access tracks and overhead powerline easements	Moderate	N/A	Moderate	Low	Low	Low	Negligible	Negligible

8 Cumulative Impact Assessment

The industries most likely to potentially cumulatively impact on the Surat project area can broadly be classified into four distinct components:

- LNG projects.
- Resource development projects.
- Infrastructure and energy projects.
- Transport infrastructure projects.
- The cumulative impacts associated with each of these distinct components are discussed below. A review of the expected cumulative impacts on aquatic ecosystems of these four key components within and adjacent to the study area is summarised in Five resource development projects (Table 8.1) have the potential to add to cumulative impacts within the project area and include:
-
- Spring Gully Power Station; an approved but not yet constructed power station, including 30 coal seam gas wells for provision of base load power.
- Nathan Dam; an 888,000 ML dam for the provision of irrigation water.
- Nathan Dam Pipeline; pipeline to transport water from Nathan Dam to Surat Basin
- Emu Swamp Dam Project; either a 5000 ML urban water supply dam or a 10,500 ML urban and irrigation water supply dam, with an associated pipeline linking the dam to MT Marlay Water Treatment Plant and a number of irrigators in Stanthorpe Shire.
- Bloodwood Creek Queensland – Stage 2; a syngas power station, including carbon dioxide separation and assessment into alternative CO2 sequestration.

All of the infrastructure and energy projects involve relatively similar infrastructure and production requirements. In terms of impacts on aquatic ecosystems, this has the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.
- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Altered surface water hydrology and geomorphological processes as a result of emergency water and/or chemical releases.

- Altered surface water hydrology as a result of operational processes (Nathan Dam, Emu Swamp Dam and associated pipelines only).
- Spread or introduction of pest aquatic organisms.

The degree to which these impacts are likely to occur will vary between projects, depending on the location of infrastructure, operational processes and proximity to watercourses.

To date only the Spring Gully Power Station has received formal State and Federal EIS approval. The Nathan Dam and associated pipeline are in the final stages of approval.

Arrow Surat Gas Project Contribution to Cumulative Impacts of Infrastructure Projects

The combined impacts of the two of major infrastructure projects in the region (Spring Gully Power Station and Bloodwood Creek Queensland – Stage 2) are expected to have negligible impact on aquatic ecosystems.

The combined impacts of the three of major infrastructure projects in the region (Emu Swamp Dam Project, Nathan Dam and Nathan Dam Pipeline) and their potential impact on aquatic ecosystems is more difficult to assess.

The Nathan Dam and associated pipeline is being constructed primarily to deliver water to end users in the Surat Coal Basin. The volume, duration and timing of water delivery to the Basin is currently unknown, including whether water will be transported entirely through a constructed pipeline network, or whether options exist to discharge water into waterways as part of a water transport strategy. In addition, the project, while primarily designed to transport water from Nathan Dam, also has an option to receive and distribute coal seam water as part of its operational activities.

While the relative proportion of coal seam water distributed through the pipeline cannot be quantified, it is assumed that is will represent a small percentage. However, distribution of beneficial use of water in general, and coal seam water in particular, falls outside of the scope of the EIS and therefore has not been assessed further.

Taking these exclusions into account, the assessment broadly indicates that the impact of the infrastructure and operational components of the project on local and regional aquatic values is expected to range between **moderate** and **negligible** for values identified in Table 8-1, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

These impacts are therefore considered **moderate** to **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of all infrastructure and energy projects considered.

The activities associated with the project may result in impacts on waterways adjacent to and downstream of infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

8.1 Transport Infrastructure Projects

One transport infrastructure project (Table 8.1) has the potential to add to cumulative impacts within the project area and includes:

- Surat Basin Rail; a proposed 210km multi-user, open access railway track with up to eight passing loops and a railway corridor of approximately 60m.

In terms of impacts on aquatic ecosystems, Surat Basin Rail project has the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.
- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Spread or introduction of pest aquatic organisms.

The Surat Basin Rail Project has received formal State and Federal EIS approval and construction is expected between the 2011/2012 and 2014-2015 financial year.

The Surat Basin Rail EIS (Surat Basin Rail Pty Ltd Joint Venture 2009) states that the waterway crossings are confined to tributaries of the Dawson River, a drainage system that the Surat Gas Project will have a negligible impact on.

Surat Gas Project Contribution to Cumulative Impacts of Transport Infrastructure Projects

This assessment indicates that the impact of the infrastructure components of the project on local and regional aquatic values is expected to be **negligible** for values identified in table 8-1, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

These impacts are therefore considered **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of rail infrastructure projects considered.

The activities associated with the project may result in minimal impacts on waterways adjacent to and downstream of the rail infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

8.2 Summary of Cumulative Impact Assessment on Aquatic Environments

The projects considered during the cumulative impacts assessment are expected to potentially impact on freshwater aquatic ecosystems, communities or processes at **moderate** to **negligible** levels, dependent on infrastructure and operational requirements and their proximity to watercourses, assuming mitigation measures (such as those outlines in Section 6) relevant to each project are adopted throughout the life of the project.

The overall effect of all projects is also expected to be **moderate** to **negligible** and spread across a number of watercourses within or adjacent to the study area. This outcome is reliant on effective environmental controls placed on each of these projects to ensure potential impacts to freshwater systems and associated freshwater aquatic communities, habitat or processes of high conservation value are minimised.

The Surat Gas Project project is expected to contribute **moderate** to **negligible** impacts on freshwater aquatic ecosystems in the study area.

8.3 LNG Projects

Five resource development projects (Table 8.1) have the potential to add to cumulative impacts within the project area and include:

- Queensland Curtis LNG Project (QCLNG); a proposed coal seam gas field, 380 km pipeline and 12 Mtpa LNG facility on Curtis Island, near Gladstone.
- Gladstone Liquefied Natural Gas (GLNG); a possible proposed coal seam gas field development, 435 km pipeline and 10 Mtpa LNG facility on Curtis Island, near Gladstone.
- Australia Pacific LNG; a proposed coal seam gas field development, 450 km pipeline and 18 Mtpa LNG facility on Curtis Island, near Gladstone.
- Arrow Surat Pipeline; a proposed 467km pipeline to transport LNG gas from the Surat gas fields to a port facility on Curtis Island, near Gladstone.
- Queensland Hunter Gas Pipeline; a proposed 831km pipeline to transport LNG gas from Wallumbilla Gas Hub in Queensland to Newcastle, New South Wales.

All of the LNG projects outlined in Table 8-1 involve production wells and associated infrastructure (similar to that outlined in Section 1.4 for the Surat Gas Project), as well as a linear (feed gas pipeline) component and the construction of an LNG plant and supporting infrastructure. All of the stand-alone pipeline projects involve a pipeline component.

In terms of impacts on aquatic ecosystems, the production wells and associated infrastructure, and the feed gas pipeline component of all of the LNG projects have the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.
- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Altered surface water hydrology and geomorphological processes as a result of emergency releases
- Spread or introduction of pest aquatic organisms.

The degree to which these impacts are likely to occur will vary between projects, depending on the location of production wells and associated infrastructure, the route to be taken by the feed gas pipeline and any ancillary infrastructure associated with it (e.g., access tracks).

Production and infrastructures plans for each LNG project have not been released, therefore it is not currently possible to determine exact impacts. However, it is considered likely that the impacts of each of these individual projects will be comparable to those expected for the Surat Gas Project.

Arrow Surat Gas Project Contribution to Cumulative Impacts of LNG Projects

This assessment indicates that the impact of the infrastructure and operational components of the project on local and regional aquatic values is expected to range between **moderat**e and **negligibl**e, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

It is therefore the case that the contribution of the project in these areas can also be expected to be moderate to negligible.

The activities associated with the project may result in impacts on waterways adjacent to and downstream of infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

These impacts are considered **moderate** to **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of all LNG projects considered.

Coal Seam Water

The Surat Gas Project's water strategy has not yet been finalised, but will broadly consider different options for the management of coal seam water. Given the assessment of any potential impacts associated with these management options fall outside the Terms of Reference for this component of the Environmental Impact Statement, water strategy options for the beneficial use of coal seam water have not been considered further. It is also therefore not possible to assess any potential Surat Gas Project impacts within the broader framework of project-wide cumulative impacts.

Additionally, given other LNG proponents have similarly not yet finalised their coal seam water strategies, it is not possible to consider any potential cumulative impacts associated with any LNG projects in the study area.

Nonetheless, it is still recognised that the beneficial use of coal seam water, at both a project-specific and cumulative project level, has the potential to impact on aquatic systems within the project area, although this cannot currently be qualified or quantified.

8.4 Resource Development Projects

Five resource development projects (Table 8.1) have the potential to add to cumulative impacts within the project area and include:

- Cameby Downs Expansion Project; an existing open cut coal mine seeking approval for expansion of its existing operations tp produce approximately 15-20Mtpa, with water demand estimated at 8,000 – 10,000ML per annum.
- Elimatta Coal Project; a new open cut coal mine (approximately 2500 hectares) seeking approval, including approximately 42 kilometers of rail line to connect into the Surat Basin Rail.
- AmbreCTL Coal to Liquids Plant; a new open cut coal mine seeking approval, including an associated syngas electricity generation plan, with estimated production of 3.8 Mtpa after Stage 2 implementation.
- New Acland Coal Mine Stage 3 Expansion Project; an existing open cut coal mine seeking approval for expansion of its existing operations.
- Wandoan Coal Project; approved open cut coal mine currently operational but not yet meeting production of approximately 30Mtpa.

All of the resource development projects involve similar infrastructure and production requirements. In terms of impacts on aquatic ecosystems, this has the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.
- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Altered surface water hydrology and geomorphological processes as a result of emergency water and/or chemical releases
- Spread or introduction of pest aquatic organisms.

The degree to which these impacts are likely to occur will vary between projects, depending on the location of infrastructure, operational processes and proximity to watercourses.

To date only the Wandoan Coal Project has received formal State and Federal EIS approval. It is assumed for the purposes of the cumulative impacts assessment that all coal mine are likely to have similar impacts, although these impacts are currently unquantifiable.

Surat Gas Project Contribution to Cumulative Impacts of Resource Development Projects

This assessment indicates that the impact of the infrastructure components of the project on local and regional aquatic values is expected to range between **moderat**e and **negligible** for values identified in table 8-1, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

These impacts are therefore considered **moderate** to **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of all resource development projects considered.

The activities associated with the project may result in impacts on waterways adjacent to and downstream of infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

8.5 Infrastructure and Energy Projects

Five resource development projects (Table 8.1) have the potential to add to cumulative impacts within the project area and include:

- Spring Gully Power Station; an approved but not yet constructed power station, including 30 coal seam gas wells for provision of base load power.
- Nathan Dam; an 888,000 ML dam for the provision of irrigation water.
- Nathan Dam Pipeline; pipeline to transport water from Nathan Dam to Surat Basin
- Emu Swamp Dam Project; either a 5000 ML urban water supply dam or a 10,500 ML urban and irrigation water supply dam, with an associated pipeline linking the dam to MT Marlay Water Treatment Plant and a number of irrigators in Stanthorpe Shire.
- Bloodwood Creek Queensland – Stage 2; a syngas power station, including carbon dioxide separation and assessment into alternative CO2 sequestration.

All of the infrastructure and energy projects involve relatively similar infrastructure and production requirements. In terms of impacts on aquatic ecosystems, this has the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.

- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Altered surface water hydrology and geomorphological processes as a result of emergency water and/or chemical releases.
- Altered surface water hydrology as a result of operational processes (Nathan Dam, Emu Swamp Dam and associated pipelines only).
- Spread or introduction of pest aquatic organisms.

The degree to which these impacts are likely to occur will vary between projects, depending on the location of infrastructure, operational processes and proximity to watercourses.

To date only the Spring Gully Power Station has received formal State and Federal EIS approval. The Nathan Dam and associated pipeline are in the final stages of approval.

Arrow Surat Gas Project Contribution to Cumulative Impacts of Infrastructure Projects

The combined impacts of the two of major infrastructure projects in the region (Spring Gully Power Station and Bloodwood Creek Queensland – Stage 2) are expected to have negligible impact on aquatic ecosystems.

The combined impacts of the three of major infrastructure projects in the region (Emu Swamp Dam Project, Nathan Dam and Nathan Dam Pipeline) and their potential impact on aquatic ecosystems is more difficult to assess.

The Nathan Dam and associated pipeline is being constructed primarily to deliver water to end users in the Surat Coal Basin. The volume, duration and timing of water delivery to the Basin is currently unknown, including whether water will be transported entirely through a constructed pipeline network, or whether options exist to discharge water into waterways as part of a water transport strategy. In addition, the project, while primarily designed to transport water from Nathan Dam, also has an option to receive and distribute coal seam water as part of its operational activities.

While the relative proportion of coal seam water distributed through the pipeline cannot be quantified, it is assumed that is will represent a small percentage. However, distribution of beneficial use of water in general, and coal seam water in particular, falls outside of the scope of the EIS and therefore has not been assessed further.

Taking these exclusions into account, the assessment broadly indicates that the impact of the infrastructure and operational components of the project on local and regional aquatic values is expected to range between **moderat**e and **negligible** for values identified in Table 8-1, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

These impacts are therefore considered **moderate** to **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of all infrastructure and energy projects considered.

The activities associated with the project may result in impacts on waterways adjacent to and downstream of infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

8.6 Transport Infrastructure Projects

One transport infrastructure project (Table 8.1) has the potential to add to cumulative impacts within the project area and includes:

- Surat Basin Rail; a proposed 210km multi-user, open access railway track with up to eight passing loops and a railway corridor of approximately 60m.

In terms of impacts on aquatic ecosystems, Surat Basin Rail project has the potential to alter aquatic communities, values or processes as a result of:

- The loss or decline of riparian and/or aquatic vegetation in the vicinity of stream pipeline and/or road access crossings.
- Disturbance of stream beds or banks at stream crossings.
- Fragmentation of aquatic habitat and impedance to the movement of aquatic biota as a result of physical or velocity barriers.
- Impacts on water quality and/or increased erosion/sediment transport.
- Spread or introduction of pest aquatic organisms.

The Surat Basin Rail Project has received formal State and Federal EIS approval and construction is expected between the 2011/2012 and 2014-2015 financial year.

The Surat Basin Rail EIS (Surat Basin Rail Pty Ltd Joint Venture 2009) states that the waterway crossings are confined to tributaries of the Dawson River, a drainage system that the Surat Gas Project will have a negligible impact on.

Surat Gas Project Contribution to Cumulative Impacts of Transport Infrastructure Projects

This assessment indicates that the impact of the infrastructure components of the project on local and regional aquatic values is expected to be **negligible** for values identified in table 8-

1, based on their proximity to environmental areas with sensitivities ranging from High to Low, and associated magnitude of impacts (Section 7 – Residual Impact Assessment).

These impacts are therefore considered **negligible** in the context of contribution to the combined impacts (outlined in table 8-1) of rail infrastructure projects considered.

The activities associated with the project may result in minimal impacts on waterways adjacent to and downstream of the rail infrastructure. It is anticipated that implementing the environmental mitigation measures outlined in Section 6 will minimise potential deleterious effects to the Project area and associated aquatic communities.

8.7 Summary of Cumulative Impact Assessment on Aquatic Environments

The projects considered during the cumulative impacts assessment are expected to potentially impact on freshwater aquatic ecosystems, communities or processes at **moderate** to **negligible** levels, dependent on infrastructure and operational requirements and their proximity to watercourses, assuming mitigation measures (such as those outlines in Section 6) relevant to each project are adopted throughout the life of the project.

The overall effect of all projects is also expected to be **moderate** to **negligible** and spread across a number of watercourses within or adjacent to the study area. This outcome is reliant on effective environmental controls placed on each of these projects to ensure potential impacts to freshwater systems and associated freshwater aquatic communities, habitat or processes of high conservation value are minimised.

The Surat Gas Project project is expected to contribute **moderate** to **negligible** impacts on freshwater aquatic ecosystems in the study area.

Table 8-1 Potential impacts of significant projects within and adjacent to the study area.

Projects	Potential Impact									
	Site Clearing and levelling	Construction of access tracks	Use of machinery near waterways	Waste management	Trenching for pipelines and gathering lines	Pipeline/access road creek crossings	Drilling operations	Surface water hydrology – emergency release	Operation and maintenance activities	Maintenance of access tracks and easements
LNG Projects										
Queensland LNG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gladstone LNG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Australia Pacific LNG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Central Queensland Pipeline	✓	✓	✓	✓	✓	✓	✓	-	✓	✓
Arrow Surat Pipeline	✓	✓	✓	✓	✓	✓	✓	-	✓	✓
Queensland Hunter Gas Pipeline	✓	✓	✓	✓	✓	✓	✓	-	✓	✓
Transport Infrastructure Projects										
Surat Basin Rail	-	-	-	-	✓	-	✓	-	✓	✓
Resource Development										

Projects	Potential Impact: Site Clearing and levelling	Construction of access tracks	Use of machinery near waterways	Waste management	Trenching for pipelines and gathering lines	Pipeline/access road creek crossings	Drilling operations	Surface water hydrology – emergency release	Operation and maintenance activities	Maintenance of access tracks and easements
Projects										
Cameby Downs Expansion Project	✓	✓	✓	✓	✓	✓	-	✓	✓	✓
Elimatta Coal Project	✓	-	-	-	-	-	-	✓	-	-
Felton Clean Coal Demonstration Project	✓	✓	✓	✓	✓	✓	-	-	✓	✓
New Acland Coal Mine Stage 3 Expansion Project	✓	✓	✓	✓	✓	✓	-	✓	✓	✓
Wandoan Coal Project	✓	✓	✓	✓	✓	✓	-	✓	✓	✓
Infrastructure and Energy Projects										
Nathan Dam	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Natham Dam Pipeline	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emu Swamp Dam Project	✓	✓	✓	✓	✓	✓	-	✓	✓	✓

Projects	Potential Impact									
	Site Clearing and levelling	**Construction of access tracks**	**Use of machinery near waterways**	**Waste management**	**Trenching for pipelines and gathering lines**	**Pipeline/access road creek crossings**	**Drilling operations**	**Surface water hydrology – emergency release**	**Operation and maintenance activities**	**Maintenance of access tracks and easements**
Spring Gully Power Station	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Kogan Creek Solar Boost Project	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Bloodwood Creek Queensland – Stage	✓	✓	✓	✓	✓	✓	✓	-	✓	✓

9 Inspection and Monitoring

This assessment has indicated that freshwater aquatic ecosystem values within the study area for the Surat Gas Project are diverse and intrinsically linked in terms of the availability and quality of aquatic habitat present.

The residual impact assessment has revealed that many of the potential impacts of the project would be reduced to moderate to low following the implementation of the specific impact avoidance (constraints) framework and specific mitigation strategies outlined in section 6.

Moderate impacts may occur in the following areas:

- Oakey Creek if access tracks are constructed or vehicles/plant/machinery are operated within the highly constrained buffer zone.
- Within permanent waterways as a result of:
- Site levelling and clearing
- Access track construction
- Waste generation and management
- Gathering line/pipeline trenching
- Creek crossings for pipelines/access tracks
- Operational and maintenance activities, particularly where these involve excavating the pipeline.
- Within ephemeral waterways if/when emergency releases of treated coal seam gas water occur during dry season conditions.

All other impacts are expected to be low, with the exception of the emergency release of treated coal seam gas water into permanent or semi-permanent streams, which may have relatively high impacts if/when occurs during the dry season.

9.1 Monitoring

Despite the generally low to moderate residual impacts of the project, monitoring of the ongoing health of aquatic ecosystems is expected to be a compliance requirement. This will be particularly important:

- in watercourses that may eventually be subjected to emergency water releases
- in sensitive areas or areas of higher ecological value, such as waterways within the highly constrained zones.

Bi-annual monitoring, following the methodology outlined in Section 3, and including water and sediment quality, aquatic macroinvertebrates, fish, macrophytes and other aquatic/semi-aquatic fauna, is recommended. The methodology should include sampling of all existing baseline monitoring sites at a minimum, and should include any other sampling sites deemed necessary as project-specific details are finalised.

Care should be taken to properly design the sampling program, including:

- the selection of adequate reference sites within and adjacent to the study area
- selection of representative and strategically located sampling sites to ensure that any impacts associated with the Arrow project can be distinguished from normal ecological cycles/processes and or other activities within the catchment.
- That the analysis of data is statistically valid and defensible and that the frequency and timing of sampling events is optimal for the purpose.

Reporting analysis should include both standalone and cumulative interpretation to provide for a comprehensive understanding of significant change, if any, over time.

In addition, during construction and operation of the project, mandatory implementation of the general and specific mitigations measures outlined in Section 6, combined with rigorous environmental audits of compliance with the project Environmental Management System are considered necessary to protect the freshwater aquatic systems within the study area.

Environmental auditing processes should include both internal and external audit components to ensure consistency and compliance with the regulatory framework.

9.2 Inspection

In addition to biannual monitoring, inspections are recommended on an incident basis to determine potential impacts to aquatic environments resulting from pollution events, or potential pollution events, that may occur as a consequence of any event defined as a “Reportable/Notifiable Incident” under an approved Environmental Management System, including, but not limited to, discharge of, or potential discharge of substances into waterways.

Where a discharge of a defined substance and/or quantity triggers a mandatory incident procedure that includes the need for point-source assessment, at a minimum, water and sediment quality should be assessed at the point source, as well as downstream of that point to the estimated downstream limit of impact.

In addition, where additional incident procedures are triggered (such as those associated with a predetermined volume or substance) then aquatic macroinvertebrate and/or fish communities should be sampled for comparison against baseline monitoring results to more fully determine potential impacts to aquatic ecology.

Reporting protocols must be developed and incorporated into the EMS procedures to ensure an iterative approach towards ongoing best-practice is maintained by learning from, and minimising the potential for subsequent incidents to occur.

10 Conclusions

The intensive preliminary review of existing data and information for the study area, field reconnaissance and rigorous selection of representative, highly targeted sampling sites enabled the aquatic assessment to be completed with an appropriate field effort given the large project development area. Relatively uniform aquatic communities and habitat across the study area also assisted in this regard. The resulting risk-based framework approach outcomes were very efficient and provide controls and constraints that will ensure a high degree of protection for aquatic values in the study area.

Field surveys included physico-chemical water quality, sediment sampling and analysis, fish and macroinvertebrate studies, aquatic vegetation audits, rapid assessment techniques for riparian health and geomorphological processes. Data interpretation included modelling, univariate and multivariate statistical analysis.

Watercourses within the study area have been impacted upon over many decades by highly modified terrestrial environments, altered catchment processes and regulation. Despite the degree of catchment disturbance, the health of aquatic communities within the study area is considered moderate with the exception of some localised areas (e.g. Myall Creek) which are considered to be in poor health.

Two fish species of conservation interest, *Gadopsis mamoratus* (freshwater blackfish) and *Mogurnda adspersa* (purple spotted gudgeon) were recorded at a site just outside of the study area. A third species *Maccullochella peelii peelii* (Murray cod) was not recorded in the surveys but is known to exist within the area both as a remnant population of wild fish and as a stocked recreational species. *M. peelii peelii* is listed under Commonwealth environmental legislation.

Statistical analyses of the field data confirm that the ecological communities (fish, macroinvertebrates and aquatic flora) were similar at most sites within the study area. Habitat type and quality was also relatively uniform across the study area. No pockets of endemism or habitat of unusual quality of composition were identified.

On the basis of this assessment, the aquatic ecology values within the study area were assigned a sensitivity ranking. Subsequently, the degree of sensitivity defined the degree to which the project should be constrained by aquatic ecosystem values was determined:

- Lake Broadwater is defined as highly sensitive. Potential impacts to this feature of the project development area can be mitigated by avoidance only. It is therefore designated a “no go” zone. No disturbance of this area is permissible.
- A section of Oakey Creek upstream of sampling site C is defined as highly sensitive. It is an area containing significant aquatic ecosystems that may be impacted upon by some aspects of the construction and operations or operational activities. Lower impact activities may be undertaken in these areas, under strict environmental controls.

- Remaining aquatic ecosystems associated with ephemeral, semi-permanent and permanent waterways are moderately sensitive. Higher impact activities (e.g. construction of water treatment facilities) may be undertaken in these areas provided strict environmental controls are in place.
- Construction and operations in all remaining areas is permissible in compliance with standard environmental procedures.

In accordance with the risk-based framework approach two areas that should be subjected to development constraints have been identified within the study envelope:

- Lake Broadwater, though dry at the time of the November surveys, is a gazetted conservation park and may provide refuge or foraging/spawning habitat for a number of aquatic species including *M peelii peelii* during periods when it is connected to other regional waterways. This area has been designated “No Go”.
- A buffer zone of 1 kilometre around the Lake Broadwater Conservation Park has been designated as “Highly Constrained” to further protect aquatic values associated with this area. It is noted that Arrow Energy is currently engaged in discussions with DERM regarding appropriate buffer distances for project activities and that this requirement may change pending the outcomes of these discussions.
- Whilst considered unlikely, Oakey Creek between Cecil Plains Road and the study area boundary has some potential to support populations of *G. Mamoratus* and *M. adspersa*, both of which are species whose distribution in the region is now extremely limited.

Based on the precautionary principle Oakey Creek between Cecil Plains Road and the study area boundary has been designated “Highly constrained”. It is likely that the area can be readily avoided by the project due to its relatively small area and location on the eastern boundary of the study area. All activities within this area should be highly cognizant of the requirement to avoid disturbance of the streambanks and beds, aquatic habitat and riparian vegetation. Particular care should be taken to avoid impacts on water quality in the area, particularly as a result of sediment loading. It is suggested that a buffer of 200m, measured from the bank edge, is adopted during all phases of the project, although this buffer distance may change pending the outcomes of discussions between Arrow Energy and DERM

As construction activities will require small scale clearing of vegetation to facilitate well or pipeline (including subsurface pipeline) installation across waterways, the adoption of appropriate riparian buffer zones along all watercourses is essential. The Regional Vegetation Management Code for Brigalow Belt and New England Tablelands encompasses the Project development area and provides guidelines for appropriate riparian buffer strip width. These are intended to protect water quality, aquatic habitat and riparian habitat values and have been designated “moderately constrained” for the purposes of this assessment.

- A riparian buffer of 50m either side of first and second order streams.
- A riparian buffer of 100m width on either side of third and fourth order streams.

- A riparian buffer of 200m width on either side of fifth and higher order streams.

Although these buffer distances are considered appropriate at the time of preparing this report, it is understood that Arrow Energy and DERM are currently engaged in discussions regarding appropriate buffer distances, and the above recommendations may change pending the outcomes of these discussions.

Aquatic ecosystems across the remainder of the study area are unlikely to be significantly impacted by most of the construction and operations associated with the Surat Gas Project provided normal environmental best practice is implemented, hence have been designated as having a “low constraint” outside of riparian buffer zones, and moderate constraints within riparian buffer zones as outlined in table 4.2.

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12 Appendix A – Macroinvertebrate Assemblages

Table 12-1 Abundance of macroinvertebrate taxa recorded at the sampling sites, November 2009

Taxa	Family	Site C		Site 1		Site 3		Site 69		Site 6	Site 23	Site 62		Site 71	Site 40		Site E	Site D
		Edge	Pool	Riffle	Pool	Pool	Edge	Edge	Pool	Pool	Pool	Edge	Riffle	Pool	Edge	Pool	Edge	Pool
Amphibia	Tadpole					1												
Annelida	Oligochaeta		16	4		9	1			1		1	2		1	1	1	
	Hirudinea											2						
Platyhelminthes	Temnocephalidae							2					4	19				
Aracihnida	Acarina	15													1			
	Ancylidae											1			5	2		
Gastropoda	Bithyniidae												3					
	Physidae	14	5															
	Planorbidae					2	5					4	3		3			
	Thariaridae											17						
Bivalvia	Corbiculidae											2						
	Spaeridae											2						
Cladocera	Chydoridae												3					
	Daphnidae					1												
	Moinidae			8							1					4	28	1
Calanoida			2						1					4				1

Taxa	Family	Site C		Site 1		Site 3		Site 69		Site 6	Site 23	Site 62		Site 71	Site 40		Site E	Site D
		Edge	**Pool**	**Riffle**	**Pool**	**Pool**	**Edge**	**Edge**	**Pool**	**Pool**	**Pool**	**Edge**	**Riffle**	**Pool**	**Edge**	**Pool**	**Edge**	**Pool**
Coleoptera (beetles)	Dyticidae	4	6	2		4					1							
	Dyticidae (larvae)	3	2															
	Elmidae (larvae)	1																
	Gyrinidae	1																
	Hydraenidae	1	4					3									1	
	Hydrophilidae											1					1	
	Hydrophilidae (larvae)	1		1							1						1	
Cyclopoida			1										14			7		1
Decapoda	Atyidae	3		22	3	5	14	1	5	4		3	3	9			10	22
	Parastacidae	1				1						3					1	
	Ceratopoginae	3																
Diptera	cf. Athericidae														10	1		
	Chironomidae (Chironominae)	7	10	5	1	9		7			17		5	1	7	22		
	Chironomidae (Orthocladinae)			2			6					1						
	Chrironomidae (Tanypodinae)	1	3		1	3						2						

Taxa	*Family*	Site C		Site 1		Site 3		Site 69		Site 6	Site 23	Site 62		Site 71	Site 40		Site E	Site D
		Edge	Pool	Riffle	Pool	Pool	Edge	Edge	Pool	Pool	Pool	Edge	Riffle	Pool	Edge	Pool	Edge	Pool
	Culicidae		1				7				1	1			3			
	Physcodidiae											1						
	Tabanidae						2											
Ephemoroptera	Baetidae	5	1	1	1	7	8	1			1				1		16	
	Caenidae	1	1	23		18		39										
Epiproctophora (dragonflies)	Aeshnidae	4					1											
	Hemicordulidae	1	1			2				1			1				1	
Hemiptera (bugs)	Corixidae	9	14	9	31	16	3				4			6			9	19
	Naurcoridae						1											
	Nepidae													1				
	Notonectidae	2	3	4	2	4			1	5	1							2
Tricoptera	Ecnomidae																1	
	Hydropsychidae											34						
	Leptoceridae	14	2					1					1					
Zygoptera (damselflies)	cf Protoneuridae					1		1										
	Coenagrionidae	11	1				17								1			
	Diphlebiidae	2																

13 Appendix B – Fish Assemblages

Table 13-1 Abundance of fish taxa across the Surat Basin study area, November 2009.

ScientificNname	Common Name	Site 1	Site 3	Site 6	Site 23	Site 40	Site 62	Site 69	Site 71	Site C	Site D	Site E	Totals
Carassius auratus	Goldfish			1		1		1		1	15		19
Cyprinus carpio	Common carp		2	1	1			1	3	2	389	1	400
Gadopsis marmoratus	Freshwater blackfish						1						1
Gambusia holbrooki	Mosquito fish		219	2		28	152	22		23	30	34	510
Hypseleotris klunzingeri	Western carp gudgeon	3	5					6	3	1			18
Hypseleotris Sp. 1	Midgely's carp gudgeon	1	6	2		2			12		2		25
Hypseleotris spp.	Carp gudgeon species	10	66	6		4		36	68	31		59	280
Leiopotherapon unicolor	Spangled perch		1	1					1	5		1	9
Macquaria ambigua	Golden perch		2					8	3	2			15
Melanotaenia fluviatilus	Murray Rainbowfish	1	28				10		5				44
Mogurnda adspersa	Purple-spotted gudgeon						1						1
Nemetalosa erebi	Bony bream		62	3				83	20	15		2	185
Neosilurus hyrtlii	Hyrtl's Tandan							44		4		4	52
Retropinna semoni	Australian smelt		5				5						10
Tandanus tandanus	Eel-tailed catfish											8	8

Table 13-2 Abundance of fish taxa across the Surat Basin study area, May 2010.

Scientific name	Common name	Site 1	Site 3	Site 6	Site 23	Site 40	Site 62	Site 69	Site 71	Site C	Site D	Site E	Totals
Carassius auratus	Goldfish		3	5				4	3	27	14	7	63
Craterocephalus stercusmuscarum fulvus	Un-specked Hardyhead						2			31			33
Cyprinus carpio	Common carp			1			1	6		1090	2	23	1123
Gambusia holbrooki	Mosquito fish	3	3	77	2	49	2	124		209	21	261	751
Hypseleotris klunzingeri	Western carp gudgeon			5									5
Hypseleotris spp.	Carp gudgeon species		15	3		12		5	41	62	113		251
Hypseleotris Sp. 1	Midgley's carp gudgeon		1	4		1		1			5	4	16
Hypseleotris Sp. 3	Murray-Darling carp gudgeon					2		5	1				8
Leiopotherapon unicolor	Spangled perch	7	17		12	1	4	44	5	70	19	19	198
Macquaria ambigua	Golden perch	1	2			1	1	12		42			59
Melanotaenia fluviatilus	Murray Rainbowfish		1				6		7				14
Nemetalosa erebi	Bony bream		18	3		1		77	160	2	12	20	293
Neosilurus hyrtlii	Hyrtl's Tandan							6			2	5	13
Porochilus rendahli	Rendahl's tandan											2	2
Retropinna semoni	Australian smelt	1	15						4	5			25
Tandanus tandanus	Eel-tailed catfish	1					2						3

14 Appendix C – Ecological characteristics of fish species recorded from the Surat sites

***Ambassis agassizii* (Olive perchlet)**

A. agassizii has previously been recorded as locally abundant in parts of the Condamine catchment. The species was previously abundant throughout much of the Murray-Darling Basin, but populations have undergone significant declines in recent decades (Lintermans 2007). The species is still relatively abundant in coastal streams from northern NSW through to north Queensland. *A. agassizii* inhabits the vegetated margins of lakes, creeks, wetlands and rivers and feeds predominantly on microcrustaceans as well as aquatic and terrestrial insects (Pusey et al. 2004).

While *A. agassizii* is not considered threatened as a species, the significant reduction of populations in the Murray-Darling Basin is of some concern (Lintermans 2007).

***Anguilla reinhardtii* (Long-finned Eel)**

A. reinhardtii is generally only recorded from coastal streams along the eastern seaboard of Australia where it is widespread and abundant. In the Murray-Darling Basin the only records have come from the lower Condamine catchment and from the lakes near the mouth of the Murray in South Australia (Lintermans 2007). These records may represent translocated individuals from coastal populations.

A. reinhardtii is not considered to be threatened or a species of concern.

***Bidyanus bidyanus* (Silver perch)**

Once widespread throughout the Murray-Darling Basin numbers of *B. bidyanus* has declined dramatically over its range, including throughout the study area (Lintermans 2007). The species is still abundant in isolated areas within the mid-Murray River.

B. bidyanus are typically found in turbid, slow-flowing lowland rivers. The species is omnivorous with diet containing aquatic plants, snails, shrimp and aquatic insects (McDowall 1996).

B. bidyanus is considered to be a highly threatened species, with few viable natural populations remaining (Clunie & Koehn 2001).

***Carassius auratus* (Goldfish)**

C. auratus are native to eastern Asia and were first introduced into Australia in the 1860s. *C. auratus* are widely distributed throughout the Murray-Darling Basin as well as coastal drainages of south-eastern Australia (Allen et al. 2002). It is a tolerant species capable of tolerating high water temperatures and low oxygen concentrations (McDowall 1996).

C. auratus is typically associated with warm slow-flowing lowland rivers and lakes and is not known to migrate. Spawning occurs in summer amongst freshwater plants (McDowell et al. 1996). This species is generally regarded as benign, with few or no adverse impacts documented (Lintermans 2007).

C. auratus are an introduced species and are not considered threatened within their native distribution.

***Craterocephalus stercusmuscarum fulvus (*Un-specked Hardyhead)**

C. stercusmuscarum fulvus was formerly widespread in the Murray-Darling Basin but has undergone significant reduction in abundance, particularly in the southern part of its range (Lintermans 2007). It is still common in the north eastern portion of the basin of New South Wales.

C. stercusmuscarum fulvus is typically found around the margins of large, slow-flowing lowland river, lakes and billabongs. It prefers habitats with aquatic vegetation and sand, gravel or mud substrates (Allen et al. 2002). The species is carnivorous, usually feeding on small insects and microcrustaceans (McDowall 1996).

While *C. stercusmuscarum fulvus* is not considered threatened as a species, the significant reduction of populations in the Murray-Darling Basin is of some concern (Lintermans 2007).

***Cyprinus carpio* (Common carp)**

C. carpio are native to central Asia although have been widely translocated, and been successful invaders in parts of Europe, Asia, Africa, North, Central and South America, Australia and Oceania (Lever 1996). *C. carpio* are considered a major pest threatening native fish, due to environmental degredation. *C. carpio* have been declared noxious fish in most Australian States. *C. carpio* are common in the Murray-Darling river system and several coastal streams in NSW, Victoria, southern Queensland and southern Western Australia (Koehn 2004).

C. carpio inhabit a variety of habitats though are less common in clear, cool, swift-flowing waters (Driver et al. 2005), although Koehn & Nicol (1998) showed a preference for slow flowing waters, including billabongs and backwaters. *C. carpio* spawn in spring and summer, laying sticky eggs in shallow vegetation. The maximum reported age for *C. carpio* is 20 years (Froese 2009). *C. carpio* is omnivorous, feeding mainly on aquatic insects, crustaceans, annelids, molluscs, weed and tree seeds, aquatic plants and algae; mainly by foraging in sediments (Allen et al. 2002).

C. carpio are an introduced species and are considered a noxious pest.

***Gadopsis marmoratus* (River blackfish)**

G. marmoratus is widespread and common throughout Victoria, northern coastal drainages of Tasmania and southern sections of the Murray-Darling Basin (Allen et al. 2002). 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 extreme of the species' range (Lintermans 2007).

G. marmoratus prefers habitats with good instream cover such as structural woody habitat, aquatic vegetation or boulders (Lintermans 2007). *G. marmoratus* is an opportunistic carnivore feeding on insect larvae, crustaceans, terrestrial insects and occasionally other fish (Lintermans 2007). Movements of adults are largely restricted to small home ranges typically less than 20 metres (Khan et al. 2004).

Numbers of *G. marmoratus* in the Murray-Darling Basin have declined, although abundance in some locations seems to fluctuate from year to year (Lintermans 2007). The major threat to the species is the smothering of eggs and spawning sites by sediment. Habitat modifications such as cold-water pollution, desnagging and altered flows through river regulation are also likely to impact on this species.

While *G. marmoratus* is not considered threatened as a species, the significant reduction of some populations in the Murray-Darling Basin is of some concern (Lintermans 2007).

***Galaxias olidus* (Mountain galaxias)**

G. olidus are widely distributed through-out south-eastern Australia from southern Queensland to South Australia (Allen et al. 2002). Within the northern section of their distribution (i.e. Queensland) they are largely restricted to higher altitudes (Lintermans 2007). *G. olidus* are typically found in slower flowing or pool habitats. The species is not thought to migrate and their diet consists of aquatic insect larvae and terrestrial insects (Allen et al. 2002).

G. olidus is not a threatened species across its distribution; however, it is locally threatened in some areas (Raadik 2001, Lintermans 2007).

***Gambusia holbrooki* (Mosquitofish, Gambusia)**

G. holbrooki are native to rivers draining the Gulf of Mexico, but have been widely translocated throughout Australia, Europe, Asia, and Africa (Froese & Pauly 2007). *G. holbrooki* are widespread and abundant throughout Victoria, New South Wales, South Australia, coastal drainages of Queensland and parts of Western Australia and Northern Territory. *G. holbrooki* is a tolerant species capable of handling a wide range of temperature and salinity extremes. An aggressive species, *G. holbrooki* chase and fin-nip fish much larger than themselves as well as prey on the eggs of native fish and frogs. They have been implicated in the decline of nine fish species Australia-wide and more than 10 species of frog in Australia.

G. holbrooki is found in a variety of habitats including still or slow-moving aquatic habitats in large lowland floodplain rivers, upland rivers and streams, small coastal streams (Allen et al. 2002). *G. holbrooki* prefers warm still areas and are typically seen shoaling along the edges of aquatic vegetation beds in streams and lakes (Allen et al. 2002).

G. holbrooki are ovoviviparous fishes, capable of releasing broods of well-developed offspring at approximately monthly intervals during the warmer months (Milton & Arthington 1983). Peak spawning activity begins in spring and continuing through summer (Penn & Potter 1991).

G. holbrooki is an adaptable generalist carnivore (Penn & Potter 1991) feeding at the water surface and throughout the water column on a wide range of both terrestrial insects and aquatic invertebrates.

G. holbrooki is an introduced species and are considered a noxious pest.

Hypseleotris klunzingeri **(Western carp gudgeon),** ***Hypseleotris*** **Sp. 1 (Midgley's carp gudgeon),** ***Hypseleotris*** **Sp. 3** ***(*****Murray-Darling carp gudgeon*****), Hypseleotris spp.*** **(Carp gudgeons)**

As a group, *Hypseleotris* are widespread and common throughout the Murray-Darling Basin (Lintermans 2007). This group of species is found in slow-flowing or still waters, normally associated with aquatic vegetation. Although experimental data are not available, tolerances for low dissolved oxygen and high turbidity are inferred from distributional studies.

While originally thought to be a relatively sedentary species, recent studies have shown that large numbers of *Hypseleotris* attempt to move through fishways (Baumgartner 2003). Whether these movements reflect local dispersal or foraging movements is unknown.

The *Hypseleotris* species of the Murray-Darling Basin are not considered to be threatened and are highly adaptable and tolerant of a very wide range of environmental conditions.

Leiopotheropon unicolor **(Spangled perch)**

L. unicolor is the second most widespread of Australia's freshwater fish species and is often very abundant when present. In the Murray-Darling Basin it occurs in the north and western portions (Lintermans 2007). *L. unicolor* has been shown to exhibit tolerance to a wide range of salinities within inland systems, with the upper tolerance approaching that of seawater (35%), which is beneficial in enabling the species to survive in pools that evaporate to near dryness (Pusey et al. 2004). Although experimental data are not available, tolerances for low dissolved oxygen and high turbidity are inferred from distributional studies.

L. unicolor is a relatively fast swimming species and is capable of swimming through quite shallow water in order to colonise expanding habitat such as floodplains and ephemeral streams during storm events (Pusey et al. 2004). It appears to undergo spawning migrations, although various studies have suggested that adult fish may move upstream at the start of the wet season in some systems but downstream in others, usually with a return migration following spawning (Pusey et al. 2004). Fishway studies have tended to be uninformative regarding these movements.

The species is not a threatened species and is highly adaptable and tolerant of a very wide range of environmental conditions.

***Maccullochella peelii peelii* (Murray Cod)**

M. peelii peelii was formerly widespread and abundant in the lower and mid-altitude reaches of the Murray-Darling Basin including within the study area (Allen et al. 2002). Numbers have since declined dramatically and the species now has a patchy distribution across its historic range. *M. peelii peelii* was listed nationally threatened in 2003 (Lintermans 2007).

M. peelii peelii is generally associated with deep pools in rivers with associated instream cover such as rocks, undercut banks and structural woody habitat. It is an ambush predator feeding mainly on fish, frogs and crayfish (Allen et al. 2002). *M. peelii peelii* is a long-lived species having been aged up to 48 years old (Lintermans 2007).

The major threats to the species are overfishing, habitat destruction through sedimentation, removal of structural woody habitat and river regulation. The Condamine Alliance regularly stocks *M. peelii peelii* throughout the study area and have done extensive habitat improvement work in the form of reintroducing structural woody habitat (pers. comm).

M. peelii peelii is considered to be nationally threatened and is an EPBC listed species.

***Macquaria ambigua* (Golden perch)**

M. ambigua is widespread throughout the Murray-Darling Basin, although numbers have declined in some areas (Lintermans 2007). They are predominantly found in the lowland warmer, turbid, slow flowing rivers, often in association with structural woody habitat and other cover. The species is an opportunistic carnivore with shrimps, yabbies, small fish and aquatic insects most typically consumed (Allen et al. 2002).

M. ambigua exhibit extensive migratory movements in excess of 1000 kilometres, followed by periods of restricted home ranges (Crook 2004). Upstream movements are stimulated by small rises in streamflow. River regulation has disrupted migrations and spawning behaviour throughout the Murray-Darling Basin, while weirs and dams act as barriers to migration and recolonisation.

At present *M. ambigua* is not considered to be a threatened species.

Melanotaenia fluviatilus (Murray River rainbowfish)

M. fluviatilus was formerly widespread across the Murray-Darling Basin but has declined in recent years (Lintermans 2007). However, in the Condamine catchment it still appears to be relatively common. *M. fluviatilus* is generally found in the lowland slow-flowing rivers, wetlands and billabongs. The species is carnivorous, consuming aquatic and terrestrial invertebrates (Allen et al 2002). Until recently *M. fluviatilus* was considered to be largely sedentary, however recent studies have shown substantial movement through fishways (Baumgartner 2003).

Predation on larvae by *G. holbrooki*, loss of aquatic vegetation and cold water pollution are considered to be the key threats to *M. fluviatilus*.

While *M. fluviatilus* is not considered threatened as a species, the significant reduction in abundance in the Murray-Darling Basin is of some concern (Lintermans 2007).

Mogurnda adspersa (Purple-spotted gudgeon)

M. adspersa is a relatively common species of coastal drainages of Eastern Australia north of the Clarence River, NSW (Allen et al. 2002). The abundance of *M. adspersa* in the Murray Darling Basin has undergone significant declines; however it is still locally abundant in the Upper Condamine catchment (Lintermans 2007). Recent electrophoretic studies indicate that Murray-Darling populations display considerable genetic divergence from coastal populations and warrant classification as an Evolutionary Significant Unit (ESU) (Faulks et al. 2008). An ESU is a biological unit with a distinct, long-term evolutionary history that should be managed separately (Ryder 1986).

It is found in a range of lentic and lotic habitats, most commonly in slow flowing and weedy areas of rivers, creeks and billabongs. *M. adspersa* is rarely found distant from cover, being highly dependent on root masses and submerged, emergent or trailing vegetation (Pusey et al. 2004). This habitat preference is reflected in the diet of the species, which is comprised largely of aquatic invertebrates, mollusc, micro- and macro-crustaceans (Pusey et al. 2004). Terrestrial insects also make a contribution to the diet of *M. adspersa.*

M. adspersa is able to tolerate low dissolved oxygen concentrations, but appears unable to endure either elevated salinity or turbidity (Pusey et al. 2004).

Little is known about the movement of *M. adspersa*, although very low representation in fishway surveys suggests it does not undertake significant mass migration.

While *M. adspersa* is not considered threatened as a species, populations in the Murray-Darling Basin are considered to be under considerable threat (Lintermans 2007).

***Nematalosa erebi* (Bony bream)**

Nematalosa erebi is the most widespread fish species in Australian freshwater systems and is often the most abundant (Allen et al. 2002). Despite this, there is surprisingly little information available regarding its microhabitat usage. In the Murray-Darling Basin they are most commonly recorded from lowland rivers.

N. erebi is omnivorous, occasionally feeding on molluscs and terrestrial or aquatic invertebrates, however the species largely feeds on detritus and algae (Pusey et al. 2004).

Whilst it is known that *N. erebi* undertakes significant movement within river systems, it is unclear whether mass migration for the purposes of spawning are part of the life history of the species.

N. erebi is not a threatened species and is able to tolerate widely variable water quality and habitat conditions.

***Neosilurus hyrtlii* (Hyrtl's tandan)**

N. hyrtlii is an extremely widely distributed species that is often locally abundant. It is tolerant of a wide range of temperature, oxygen, pH and conductivity and turbidity levels (Pusey et al. 2004). The distribution of *N. hyrtlii* throughout much its range is patchy, however, it is often locally abundant.

N. hyrtlii is capable of occupying a diverse range of habitats from small intermittent streams through large lowland streams, to floodplain lagoons. *N. hyrtlii* is essentially a still-water species, although it is capable of ascending reaches with substantial water velocities. It is a benthic species found over a wide range of depths, usually in close association with the substrate. During the day, adult fish tend to be confined to water depths greater than two metres, except in the presence of abundant cover (such as undercuts and structural woody habitat) (Pusey et al. 2004). Juveniles tend to shoal, and are common amongst leaf litter and macrophytes (Pusey et al 2004). The diet of *N. hyrtlii* is largely composed of aquatic insects (Allen et al. 2002).

Little is known of the reproductive biology of *N. hyrtlii* within the Murray-Darling Basin, although spawning appears to occur during the summer wet season and upstream movement of adults has been observed (Lintermans 2007).

N. hyrtlii is not considered to be threatened given its wide distribution and generally high abundance.

***Philypnodon macrostomas* (Dwarf flathead gudgeon)**

P. macrostomas are relatively common in coastal streams from southern Queensland through to Wilsons Promontory in Victoria (Allen et al. 2002). Populations in the Murray-Darling are patchily distributed and sparse. Specimens have been recorded from the

Condamine River near Chinchilla (Lintermans 2007) and more recently from Louden Weir (Brooks pers comm. 2010).

P. macrostomas are often collected in relatively calm waters over mud or rock substrates or in areas with aquatic macrophytes. The species is a benthic carnivore, feeding mainly on aquatic insects and their larvae (Pusey et al. 2004).

While *P. macrostomas* is not considered threatened as a species, it may be vulnerable in the Murray-Darling Basin due to the restricted distribution of populations (Lintermans 2007).

***Porochilus rendahli* (Rendahl's tandan)**

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). Outside the Murray-Darling Basin this species has a patchy distribution in northern Australia, the Kimberley, Cape York, the Burdekin and coastal streams of the Northern Territory (Allen et al. 2002).

P. rendahli is a benthic feeder consuming mainly aquatic insects, molluscs and some detritus (Pusey et al. 2004). Little is known about its biology within the Murray-Darling Basin.

While *P. rendahli* is not considered threatened as a species, it may be vulnerable in the Murray-Darling Basin due to the restricted distribution of populations (Lintermans 2007). However, there is currently very little understanding of its biology and ecology in the Murray-Darling Basin.

***Retropinna semoni* (Australian smelt)**

R.semoni is a relatively widespread and common species occurring in coastal and inland drainages of eastern and southern Australia (Allen et al. 2002). It occurs from central Queensland south through New South Wales and west through Victoria as far as the Murray River in South Australia.

R. semoni is found in a variety of habitats including still or slow-moving aquatic habitats in large lowland floodplain rivers, upland rivers and streams, small coastal streams, dune systems, lakes and brackish river estuaries (Allen et al. 2002). *R. semoni* is a microphagic carnivore with aquatic insects dominating dietary composition. A substantial proportion of the diet is composed of terrestrial invertebrates and winged adult forms of aquatic insects (Pusey et al. 2004).

R. semoni commences spawning in winter and may continue through to summer, but spawning appears to be concentrated in late winter and spring. Spawning is thought to occur in aquatic vegetation. Facultative potamodromy appears a common feature of the movement biology of *R. semoni* and probably serves as a dispersal mechanism for juveniles and sub-adults. Upstream migrations may occur in low or high flow periods (Pusey et al. 2004).

R. semoni is tolerant of poor water quality and habitat degradation, with specimens caught over a wide range of water quality conditions in a number of studies.

The species is widespread and abundant and is not considered to be threatened.

***Tandanus tandanus* (Eel-tailed catfish)**

T. tandanus is a widespread species occurring in coastal drainages of eastern Australia and throughout the Murray-Darling Basin (Allen et al. 2002). However, the distribution in the Murray-Darling Basin is now largely restricted (Lintermans 2007). There have been many introductions and translocations of specimens within and beyond the natural distribution.

While *T. tandanus* is found in a variety of lotic and lentic environments, it is most abundant in streams with an intact riparian zone. *T. tandanus* is a carnivorous species, with an increase in prey size with growth. The diet of juveniles is dominated by aquatic invertebrates, while adult diets are comprised largely of aquatic invertebrates, molluscs and macrocrustaceans (Pusey et al. 2004).

Adult *T. tandanus* build circular nests in the substrate and defend the nest until juveniles have hatched. There is limited information on the movement patterns of *T. tandanus*, although the species is suggested to be largely sedentary with a small home range.

While *T. tandanus* is not considered threatened as a species, the significant reduction of populations in the Murray-Darling Basin is of some concern (Lintermans 2007).

15 Appendix D – Sediment Analysis Results

LABORATORY REPORT COVERSHEET

Date: 27 May 2010

To: Aquateco Consulting
4/66 Poinciana Avenue
TEWANTIN QLD 4565

Attention: Mark Bantich

Your Reference: Arrow Surat - SE78329
Laboratory Report No: CE67601

Samples Received: 21/05/2010
Samples / Quantity: 8 Soils

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

This Report must not be reproduced, except in full.

Jon Dicker
Manager
CAIRNS

Shey Goddard
Administration Manager
CAIRNS

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Unit 2, 58 Comport Street, Portsmith 4870 QLD Australia
t +61 (0)7 4035 5111 f +61 (0)7 4035 5122

CLIENT: Aquateco Consulting **Laboratory Report No:** CE67601
PROJECT: Arrow Surat - SE78329

LABORATORY REPORT

Sieve Analysis Our Reference Your Reference Type of Sample Date Sampled	Units	CE67601-1 Site 6 Soil 13/05/2010	CE67601-2 Site D Soil 14/05/2010	CE67601-3 Site 40 Soil 15/05/2010
Date Extracted		25/05/2010	25/05/2010	25/05/2010
Date Analysed		27/05/2010	27/05/2010	27/05/2010
2.36mm (Fine Gravel)	% passing	100	77	98
600µm (Medium Sand)	% passing	95	41	95
300µm (Medium Sand)	% passing	87	27	56
212µm (Fine Sand)	% passing	77	19	42
75µm (Clay - Course Silt)	% passing	45	8	21

Sieve Analysis Our Reference Your Reference Type of Sample Date Sampled	Units	CE67601-4 Site 69 Soil 15/05/2010	CE67601-5 Site 3 Soil 16/05/2010	CE67601-6 Site C Soil 16/05/2010
Date Extracted		25/05/2010	25/05/2010	25/05/2010
Date Analysed		27/05/2010	27/05/2010	27/05/2010
2.36mm (Fine Gravel)	% passing	81	81	96
600µm (Medium Sand)	% passing	34	18	90
300µm (Medium Sand)	% passing	7	4	85
212µm (Fine Sand)	% passing	4	3	81
75µm (Clay - Course Silt)	% passing	2	2	72

CLIENT: Aquateco Consulting

PROJECT: Arrow Surat - SE78329

Laboratory Report No: CE67601

LABORATORY REPORT

Sieve Analysis Our Reference Your Reference Type of Sample Date Sampled	Units	CE67601-7 Site 71 Soil 17/05/2010	CE67601-8 QC Soil 16/05/2010
Date Extracted		25/05/2010	25/05/2010
Date Analysed		27/05/2010	27/05/2010
2.36mm (Fine Gravel)	% passing	98	81
600µm (Medium Sand)	% passing	78	21
300µm (Medium Sand)	% passing	48	4
212µm (Fine Sand)	% passing	38	2
75µm (Clay - Course Silt)	% passing	23	1

CLIENT: Aquateco Consulting

PROJECT: Arrow Surat - SE78329

Laboratory Report No: CE67601

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Sieve Analysis			
Date Extracted			
Date Analysed			
2.36mm (Fine Gravel)	% passing	1	AS 1289.3.6.3-1994
600µm (Medium Sand)	% passing	1	AS 1289.3.6.3-1994
300µm (Medium Sand)	% passing	1	AS 1289.3.6.3-1994
212µm (Fine Sand)	% passing	1	AS 1289.3.6.3-1994
75µm (Clay - Course Silt)	% passing	1	AS 1289.3.6.3-1994

CLIENT: Aquateco Consulting **Laboratory Report No:** CE67601
PROJECT: Arrow Surat - SE78329

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.

Geneva Legal Comment

ISO 17025

Analysis Date: **Between** 21/05/10 **and** 27/05/10

ANALYTICAL REPORT

27 May 2010

Aquateco Consulting
4/66 Poinciana Avenue
Tewantin
QLD 4565

Attention: **Mark Bantich**

Your Reference: Arrow Surat - Aquateco Consulting

Our Reference: SE78329   Samples: 8 Sediments
Received: 19/5/10

Preliminary Report Sent: Not Issued

These samples were analysed in accordance with your written instructions.

For and on Behalf of:
SGS ENVIRONMENTAL SERVICES

Sample Receipt: Angela Mamalicos AU.SampleReceipt.Sydney@sgs.com
Production Manager: Huong Crawford Huong.Crawford@sgs.com

Results Approved and/or Authorised by:

Edward Ibrahim
Laboratory Manager

Dong Liang
Quality Manager

Ly Kim Ha
Organics Signatory

Huong Crawford
Metals Signatory

TRH in soil with..C6-C9 by P/T Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Extracted (TRH C6-C9 PT)		20/05/2010	20/05/2010	20/05/2010	20/05/2010	20/05/2010
Date Analysed (TRH C6-C9 PT)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20	<20	<20
Date Extracted (TRH C10-C36)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
Date Analysed (TRH C10-C36)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20	<20	<20
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50	<50	<50
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50	<50	<50

TRH in soil with..C6-C9 by P/T Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Extracted (TRH C6-C9 PT)		20/05/2010	20/05/2010	20/05/2010
Date Analysed (TRH C6-C9 PT)		21/05/2010	21/05/2010	21/05/2010
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20
Date Extracted (TRH C10-C36)		21/05/2010	21/05/2010	21/05/2010
Date Analysed (TRH C10-C36)		21/05/2010	21/05/2010	21/05/2010
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Unit 16/33 Maddox Street Alexandria NSW 2015 Australia
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Inorganics Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Extracted (TKN)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
Date Analysed (TKN)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
Total Kjeldahl Nitrogen	mg/kg	420	330	1,500	120	110
Total Nitrogen (by calc.)*	mg/kg	420	330	1,500	120	110
Date Extracted (Ammonia)		20/05/2010	20/05/2010	20/05/2010	20/05/2010	20/05/2010
Date Analysed (Ammonia)		20/05/2010	20/05/2010	20/05/2010	20/05/2010	20/05/2010
Ammonia as N by DA*	mg/kg	7.6	8.3	6.3	3.2	0.76

Inorganics Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Extracted (TKN)		21/05/2010	21/05/2010	21/05/2010
Date Analysed (TKN)		21/05/2010	21/05/2010	21/05/2010
Total Kjeldahl Nitrogen	mg/kg	1,800	360	110
Total Nitrogen (by calc.)*	mg/kg	1,800	360	110
Date Extracted (Ammonia)		20/05/2010	20/05/2010	20/05/2010
Date Analysed (Ammonia)		20/05/2010	20/05/2010	20/05/2010
Ammonia as N by DA*	mg/kg	32	6.3	0.61

Inorganics Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Extracted (Conductivity)		20/05/2010	20/05/2010	20/05/2010	20/05/2010	20/05/2010
Date Analysed (Conductivity)		20/05/2010	20/05/2010	20/05/2010	20/05/2010	20/05/2010
Electrical Conductivity 1:5 soil:water	µS/cm	96	16	21	62	50

Inorganics Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Extracted (Conductivity)		20/05/2010	20/05/2010	20/05/2010
Date Analysed (Conductivity)		20/05/2010	20/05/2010	20/05/2010
Electrical Conductivity 1:5 soil:water	µS/cm	500	35	27

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Anions in soil Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Extracted		24/05/2010	24/05/2010	24/05/2010	24/05/2010	24/05/2010
Date Analysed		25/05/2010	25/05/2010	25/05/2010	25/05/2010	25/05/2010
Nitrite as N 1:5 soil:water	mg/kg	0.11	0.066	0.036	0.043	<0.025
Nitrate as N 1:5 soil:water	mg/kg	0.47	0.18	0.21	0.24	0.99

Anions in soil Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Extracted		24/05/2010	24/05/2010	24/05/2010
Date Analysed		25/05/2010	25/05/2010	25/05/2010
Nitrite as N 1:5 soil:water	mg/kg	0.45	0.073	<0.025
Nitrate as N 1:5 soil:water	mg/kg	0.52	0.37	0.67

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Metals in Soil by ICP-OES Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Extracted (Metals)		25/05/2010	25/05/2010	25/05/2010	25/05/2010	25/05/2010
Date Analysed (Metals)		25/05/2010	25/05/2010	25/05/2010	25/05/2010	25/05/2010
Arsenic	mg/kg	<3	<3	<3	<3	<3
Boron	mg/kg	<3.0	<3.0	<3.0	<3.0	<3.0
Cadmium	mg/kg	<0.3	<0.3	<0.3	<0.3	<0.3
Cobalt	mg/kg	16	2.3	2.8	4.5	2.3
Copper	mg/kg	13	1.2	2.4	1.9	0.92
Lead	mg/kg	5	2	5	1	1
Nickel	mg/kg	28	1.5	1.2	5.2	3.8
Phosphorus*	mg/kg	460	51	63	110	78
Selenium	mg/kg	<3	<3	<3	<3	<3
Vanadium	mg/kg	<0.5	<0.5	4.0	3.2	2.8
Zinc	mg/kg	39	3.6	6.4	5.6	5.0

Metals in Soil by ICP-OES Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Extracted (Metals)		25/05/2010	25/05/2010	25/05/2010
Date Analysed (Metals)		25/05/2010	25/05/2010	25/05/2010
Arsenic	mg/kg	<3	<3	<3
Boron	mg/kg	7.9	<3.0	<3.0
Cadmium	mg/kg	0.4	<0.3	<0.3
Cobalt	mg/kg	24	5.7	3.4
Copper	mg/kg	28	6.5	0.96
Lead	mg/kg	8	7	<1
Nickel	mg/kg	67	4.2	3.6
Phosphorus*	mg/kg	980	130	61
Selenium	mg/kg	<3	<3	<3
Vanadium	mg/kg	<0.5	<0.5	1.4
Zinc	mg/kg	74	16	3.6

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Mercury Cold Vapor/Hg Analyser						
Our Reference:	UNITS	SE78329-1	SE78329-2	SE78329-3	SE78329-4	SE78329-5
Your Reference	-------------	SITE 6	SITE D	SITE 40	SITE 69	SITE 3
Sample Matrix	------------	Sediment	Sediment	Sediment	Sediment	Sediment
Date Sampled		13/05/2010	14/05/2010	15/05/2010	15/05/2010	16/05/2010
Date Extracted (Mercury)		24/05/2010	24/05/2010	24/05/2010	24/05/2010	24/05/2010
Date Analysed (Mercury)		24/05/2010	24/05/2010	24/05/2010	24/05/2010	24/05/2010
Mercury	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05

Mercury Cold Vapor/Hg Analyser				
Our Reference:	UNITS	SE78329-6	SE78329-7	SE78329-8
Your Reference	-------------	SITE C	SITE 71	QC
Sample Matrix	------------	Sediment	Sediment	Sediment
Date Sampled		16/05/2010	17/05/2010	16/05/2010
Date Extracted (Mercury)		24/05/2010	24/05/2010	24/05/2010
Date Analysed (Mercury)		24/05/2010	24/05/2010	24/05/2010
Mercury	mg/kg	<0.05	<0.05	<0.05

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Particle Size Distribution Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Particle Size Distribution		#	#	#	#	#

Particle Size Distribution Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Particle Size Distribution		#	#	#

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Moisture Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-1 SITE 6 Sediment 13/05/2010	SE78329-2 SITE D Sediment 14/05/2010	SE78329-3 SITE 40 Sediment 15/05/2010	SE78329-4 SITE 69 Sediment 15/05/2010	SE78329-5 SITE 3 Sediment 16/05/2010
Date Analysed (moisture)		21/05/2010	21/05/2010	21/05/2010	21/05/2010	21/05/2010
Moisture	%	24	19	37	19	15

Moisture Our Reference: Your Reference Sample Matrix Date Sampled	UNITS ------------- ------------	SE78329-6 SITE C Sediment 16/05/2010	SE78329-7 SITE 71 Sediment 17/05/2010	SE78329-8 QC Sediment 16/05/2010
Date Analysed (moisture)		21/05/2010	21/05/2010	21/05/2010
Moisture	%	63	22	10

Method ID	Methodology Summary
SEO-018	BTEX / C6-C9 Hydrocarbons - Soil samples are extracted with methanol, purged and concentrated by a purge and trap apparatus, and then analysed using GC/MS technique. Water samples undergo the same analysis without the extraction step. Based on USEPA 5030B and 8260B.
SEO-020	Total Recoverable Hydrocarbons - determined by solvent extraction with dichloromethane / acetone for soils and dichloromethane for waters, followed by instrumentation analysis using GC/FID. Where applicable Solid Phase Extraction Manifold technique is used for aliphatic / aromatic fractionation.
AN292	Total Kjeldahl Nitrogen (TKN) - Determined by colourimetric technique using discrete analyser following digestion with Sulphuric Acid, K2SO4 and CuSO4. Based on APHA 21st Edition, 4500-Norg D / USEPA 351.2.
SEI-033	Total Kjeldahl Nitrogen - determined titrimetrically, in accordance with APHA 20th ED, 4500-Norg B.
SEI-037	Ammonia - Determined by salicylate colourimetric method using Discrete Analyser.
AN106	Conductivity and TDS by Calculation (cTDS) - Conductivity is measured using a conductivity cell and dedicated meter, in accordance with APHA 21st Edition, 2510. TDS is calculated by TDS(mg/L)=0.6 x Conductivity(µS/cm).
SEI-038	Water Soluble Chloride Water Soluble Chloride After carrying out a 1:5 soil:water extraction, an aliquot of the extract is reacted with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference NEPM, Schedule B(3), 401 and APHA 4500Cl- Water Soluble Sulphate After carrying out a 1:5 soil:water extraction ,sulphate in the extract is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulphate concentration in the sample. Reference NEPM, Schedule B(3), 401 and APHA 4500-SO42-.
SEM-010	Determination of elements by ICP-OES following appropriate sample preparation / digestion process. Based on USEPA 6010C / APHA 21st Edition, 3120B.
SEM-005	Mercury - determined by Cold-Vapour AAS following appropriate sample preparation or digestion process. Based on APHA 21st Edition, 3112B.
Ext-002	Analysis subcontracted to SGS Environmental Services Cairns, NATA Accreditation No. 2562, Site No. 3146.
AN002	Preparation of soils, sediments and sludges undergo analysis by either air drying, compositing, subsampling and 1:5 soil water extraction where required. Moisture content is determined by drying the sample at 105 ± 5°C.

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QUALITY CONTROL TRH in soil with..C6-C9 by P/T	UNITS	LOR	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted (TRH C6-C9 PT)				20/05/10	SE78329-1	20/05/2010 || 20/05/2010	SE78329-2	20/05/10
Date Analysed (TRH C6-C9 PT)				21/05/10	SE78329-1	21/05/2010 || 21/05/2010	SE78329-2	21/05/10
TRH C_6 - C_9 P&T	mg/kg	20	SEO-018	<20	SE78329-1	<20 || <20	SE78329-2	127%
Date Extracted (TRH C10-C36)				21/05/2010	SE78329-1	21/05/2010 || 21/05/2010	[NR]	[NR]
Date Analysed (TRH C10-C36)				21/05/2010	SE78329-1	21/05/2010 || 21/05/2010	[NR]	[NR]
TRH C_{10} - C_{14}	mg/kg	20	SEO-020	<20	SE78329-1	<20 || <20	[NR]	[NR]
TRH C_{15} - C_{28}	mg/kg	50	SEO-020	<50	SE78329-1	<50 || <50	[NR]	[NR]
TRH C_{29} - C_{36}	mg/kg	50	SEO-020	<50	SE78329-1	<50 || <50	[NR]	[NR]

QUALITY CONTROL Inorganics	UNITS	LOR	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted (TKN)				21/05/2010	SE78329-1	21/05/2010 || 21/05/2010	SE78329-2	21/05/2010
Date Analysed (TKN)				21/05/2010	SE78329-1	21/05/2010 || 21/05/2010	SE78329-2	21/05/2010
Total Kjeldahl Nitrogen	mg/kg	40	AN292	<40	SE78329-1	420 || 390 || RPD: 7	SE78329-2	102%
Total Nitrogen (by calc.)*	mg/kg	20	SEI-033	<20	SE78329-1	420 || [N/T]	[NR]	[NR]
Ammonia as N by DA*	mg/kg	0.15	SEI-037	<0.15	SE78329-1	7.6 || 7.6 || RPD: 0	SE78329-2	98%

QUALITY CONTROL Inorganics	UNITS	LOR	METHOD	Blank
Electrical Conductivity 1:5 soil:water	µS/cm	1	AN106	<1.0

QUALITY CONTROL Anions in soil	UNITS	LOR	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted				24/05/10	[NT]	[NT]	LCS	24/05/10
Date Analysed				25/05/10	[NT]	[NT]	LCS	25/05/10
Nitrite as N 1:5 soil:water	mg/kg	0.025	SEI-038	<0.025	[NT]	[NT]	[NR]	[NR]
Nitrate as N 1:5 soil:water	mg/kg	0.025	SEI-038	<0.025	[NT]	[NT]	LCS	97%

QUALITY CONTROL Metals in Soil by ICP-OES	UNITS	LOR	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted (Metals)				25/05/2010	[NT]	[NT]	LCS	25/05/2010
Date Analysed (Metals)				25/05/2010	[NT]	[NT]	LCS	25/05/2010
Arsenic	mg/kg	3	SEM-010	<3	[NT]	[NT]	LCS	99%
Boron	mg/kg	3	SEM-010	<3.0	[NT]	[NT]	LCS	113%
Cadmium	mg/kg	0.3	SEM-010	<0.3	[NT]	[NT]	LCS	102%
Cobalt	mg/kg	0.3	SEM-010	<0.3	[NT]	[NT]	LCS	101%
Copper	mg/kg	0.5	SEM-010	<0.5	[NT]	[NT]	LCS	102%
Lead	mg/kg	1	SEM-010	<1	[NT]	[NT]	LCS	103%
Nickel	mg/kg	0.5	SEM-010	<0.5	[NT]	[NT]	LCS	103%
Phosphorus*	mg/kg	5	SEM-010	<5	[NT]	[NT]	LCS	100%
Selenium	mg/kg	3	SEM-010	<3	[NT]	[NT]	LCS	102%
Vanadium	mg/kg	0.5	SEM-010	<0.5	[NT]	[NT]	LCS	103%
Zinc	mg/kg	0.5	SEM-010	<0.5	[NT]	[NT]	LCS	99%

QUALITY CONTROL Mercury Cold Vapor/Hg Analyser	UNITS	LOR	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted (Mercury)				24/05/2010	[NT]	[NT]	LCS	24/05/2010
Date Analysed (Mercury)				24/05/2010	[NT]	[NT]	LCS	24/05/2010
Mercury	mg/kg	0.05	SEM-005	<0.05	[NT]	[NT]	LCS	117%

QUALITY CONTROL Particle Size Distribution	UNITS	LOR	METHOD	Blank
Particle Size Distribution			Ext-002	#

QUALITY CONTROL Moisture	UNITS	LOR	METHOD	Blank
Date Analysed (moisture)				[NT]
Moisture	%	1	AN002	<1

QUALITY CONTROL TRH in soil with..C6-C9 by P/T	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Date Extracted (TRH C6-C9 PT)		[NT]	[NT]	[NR]	[NR]
Date Analysed (TRH C6-C9 PT)		[NT]	[NT]	[NR]	[NR]
TRH C_6 - C_9 P&T	mg/kg	[NT]	[NT]	[NR]	[NR]
Date Extracted (TRH C10-C36)		[NT]	[NT]	LCS	21/05/2010
Date Analysed (TRH C10-C36)		[NT]	[NT]	LCS	21/05/2010
TRH C_{10} - C_{14}	mg/kg	[NT]	[NT]	LCS	93%
TRH C_{15} - C_{28}	mg/kg	[NT]	[NT]	LCS	98%
TRH C_{29} - C_{36}	mg/kg	[NT]	[NT]	LCS	73%

Result Codes

[INS] : Insufficient Sample for this test
[NR] : Not Requested
[NT] : Not tested
[LOR] : Limit of reporting
[RPD] : Relative Percentage Difference
* : Not part of NATA Accreditation
[N/A] : Not Applicable

Report Comments

Particle Size Distribution analysed by SGS Cairns, report no. CE67601 (Report attached).
Samples analysed as received. Solid samples expressed on a dry weight basis.
Date Organics extraction commenced:
NATA Corporate Accreditation No. 2562, Site No 4354
Note: Test results are not corrected for recovery (excluding Air-toxics and Dioxins/Furans*)

Quality Control Protocol

Method Blank: An analyte free matrix to which all reagents are added in the same volume or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. A method blank is prepared every 20 samples.
Duplicate: A separate portion of a sample being analysed that is treated the same as the other samples in the batch. One duplicate is processed at least every 10 samples.
Surrogate Spike: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogates are added to samples before extraction to monitor extraction efficiency and percent recovery in each sample.
Internal Standard: Added to all samples requiring analysis for organics (where relevant) or metals by ICP after the extraction/digestion process; the compounds/elements serve to give a standard of retention time and/or response, which is invariant from run-to-run with the instruments.
Laboratory Control Sample: A known matrix spiked with compound(s) representative of the target analytes. It is used to document laboratory performance. When the results of the matrix spike analysis indicates a potential problem due to the sample matrix itself, the LCS results are used to verify that the laboratory can perform the analysis in a clean matrix.
Matrix Spike: An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Quality Acceptance Criteria

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.au.sgs.com/sgs-mp-au-env-qu-022-qa-qc-plan-en-09.pdf

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16 Appendix E – Threatening processes and potential issues

Process/Activity	Wells	Gathering System and Pipelines	Facilities	Issue(s) Identified
Pad clearing and levelling	●		●	Sediment transport and associated water quality and habitat impacts
				Disturbance of sodic soils and associated water quality issues
Construction of access tracks for rigs and vehicles	●	●	●	Disturbance of sodic soils and associated water quality issues
				Transfer of aquatic/riparian weeds on machinery
Use of vehicles/machinery/plant near waterways	●	●	●	Physical damage to banks and riparian zones (soil disturbance or compaction, veg disturbance etc).
				Fuel/chemical spillage results in contamination of waterways
				Transfer of aquatic/riparian weeds on machinery
Waste management	●	●	●	Contamination of waterways through poor management of construction and/or human wastes
Gathering line and pipeline trenching		●	●	Sediment transport during trenching, burying or rehab of pipeline. Poor water quality (turbidity, BOD)

Process/Activity	Wells	Gathering System and Pipelines	Facilities	Issue(s) Identified
				Disturbance of sodic or acid sulphate soils. Poor water quality (pH, BOD, turbidity, metals)
Pipeline or access road creek crossings	●	●	●	Disturbance of banks, riparian zones and substrate
				Sediment transport and poor water quality (turbidity, BOD)
				Altered geomorphic processes. Erosion, bank destabilisation, poor water quality.
				Localised loss of habitat
Drilling operations – sumps for wastewater/drilling product management	●			Sediment transport during excavation. Poor water quality (turbidity, BOD)
				Sump seepage or overflow. Poor water quality (turbidity, BOD), contamination of waterways with drilling products
Construction activities (buildings, treatment facilities)			●	Disturbance of vegetation and soils. Poor water quality (turbidity, BOD)
Operations and maintenance activities	●	●	●	Sediment transport during storms. Poor water quality (turbidity, BOD loads) and smothering of aquatic habitat
				Disturbance of sodic or acid sulphate soils. Poor water quality (pH, BOD, turbidity, metals)
				Release of hazardous materials, including hydrocarbons. Toxic release, degradation of water

Process/Activity	Wells	Gathering System and Pipelines	Facilities	Issue(s) Identified
				quality.
	●	●	●	Transfer of aquatic/riparian weeds on machinery
Maintenance of access tracks and overhead powerline easements	●	●	●	Sediment transport during storms or through construction activities. Poor water quality (turbidity, BOD loads) and smothering of aquatic habitat
				Disturbance of sodic or acid sulphate soils. Poor water quality (pH, BOD, turbidity, metals)
				Transfer of aquatic/riparian weeds on machinery
Maintenance of creek crossings (pipeline or access road)	●	●	●	Disturbance of banks, riparian zones and substrate
				Sediment transport and poor water quality (turbidity, BOD)