15

SURFACE WATER

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15 Surface Water

15.1 Introduction

This chapter presents the environmental values of surface waters in the vicinity of the proposed Project, the potential impacts to these values from development of the Project, and the proposed mitigation measures to minimise these impacts. Further detail on the surface water assessment is provided in the Surface Water Technical Report (Appendix N) of this EIS.

A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

15.2 Methodology

An assessment of the potential impacts of the development of the proposed Project on surface water resources was undertaken in the context of environmental values, as defined by the Queensland *Environmental Protection (Water) Policy 2009* (EPP Water).

A baseline water quality and geomorphology assessment was conducted at 22 locations and is further discussed in the Surface Water Technical Report (Appendix N) of this EIS. Relevant water quality objectives for the CSG field were identified from the Fitzroy River Sub-Basin Environmental Values and Water Quality Objectives (2011) and the Queensland Water Quality Guidelines (2009).

A fluvial geomorphology assessment was undertaken at 22 locations from 20 to 24 May 2012. The assessment included field observations based on the AusRivAS (**Aus**tralian **Riv**er **A**ssessment **S**ystem) Physical assessment protocol, combined with desktop analysis of aerial photography and GIS data to determine stream order; sinuosity; floodplain and valley characteristics, and channel planform at each location.

Rainfall, pan evaporation and other climate data from the Queensland Climate Change Centre of Excellence SILO database and bureau of meteorology (BOM) Climate Data Online resource were analysed to determine climate characteristics within the study area. Six BOM stations were located within and in close proximity to the study area. Stream flow, rainfall trends and flow duration curves were developed for each study catchment based on data available from BOM stations and NRM stream gauges.

Major planned activities through the different stages of construction, commissioning, operation, and decommissioning phases of development have been assessed. This chapter discusses the scope of the surface water assessment undertaken, provides an overview of the surface water management regulatory framework, a description of the existing environmental values, potential impacts of the Project and proposed management measures to be adopted to minimise those impacts.

A detailed description of the existing surface water environment within the Project area, including hydrology, water quality and fluvial geomorphology, the potential impact of the Project and proposed mitigation measures, is provided in the Surface Water Technical Report (Appendix N) of this EIS.

15.3 Legislative Context, Policies and Standards

The following legislation, policies and guidelines are relevant to identifying values and to providing guidance on mitigating and managing impacts on surface water.

15.3.1 Environment Protection and Biodiversity Conservation Act 1999

This Commonwealth act provides for the protection of matters of national environmental significance, including listed aquatic species and Ramsar sites. Changes to surface water systems due to CSG projects have the potential to impact aquatic species and Ramsar sites. Any action with the potential for a significant impact on these must be referred to the Minister for the SEWPaC and may require approval under this Act.

15.3.2 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) aims to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (being ecologically sustainable development. The EP Act governs the management of surface water with regards to CSG fields.

15.3.3 Environmental Protection (Water) Policy 2009

The EPP (Water) sits under the EP Act. Amongst other functions EPP (Water) governs the discharge of wastewater to land, surface water, and groundwater, aims to protect environmental values and sets water quality objectives to provide guidance to protect environmental values.

15.3.4 Environmental Protection Regulation 2008, Environmental Protection (Waste Management) Policy 2000 and Environmental Protection (Waste Management) Regulation 2000.

These pieces of legislation are supported by the former Department of Environment and Resource Management's Environmental Protection Agency's 2010 Coal Seam Gas Water Management Policy[1].

15.3.5 Water Act 2000

The *Water Act 2000* (Water Act) provides a framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. The Project is located within the areas covered by the Water Resources (Fitzroy Basin) Plan (2011) and the Water Resources (Burdekin Basin) Plan (2007), which sit under the Water Act. These plans set requirements for the taking of or interfering with overflow flow; therefore such activities need an operational works approval under Schedule 3, Table 4 of Sustainable Planning Regulation 2009.

[1] The DERM *Coal Seam Gas Water Management Policy 2010* was superseded by the EHP *Coal Seam Gas Water Management Policy 2012* on the 21/12/2012, subsequent to the compilation of the draft Bowen Gas Project EIS. Arrow are reviewing the updated policy at the time of the Bowen Gas Project EIS being published, and may undertake further amendments to the Arrow CSG Water and Salt Management Strategy (Appendix AA) in keeping with the updated EHP policy, as part of a supplementary report to the EIS.

15.3.6 Water Supply (Safety and Reliability) Act 2008

This legislation provides a regulatory framework for water service providers, recycled water management schemes, referable dams and flood mitigation responsibilities.

15.3.7 Fisheries Act 1994 (Qld)

The *Fisheries Act 1994* (Qld) is the Act for the management, use, development and protection of fisheries resources and fish habitats in Queensland. In the event that Arrow needs to establish waterway barriers during watercourse crossings, approval must be sought under the *Fisheries Act 1994*.

15.3.8 Coal Seam Gas Water Management Policy 2010[2]

This policy was developed to give direction for the treatment and disposal of CSG water and to the role the government wishes to play in facilitating greater beneficial use.

15.3.9 Queensland Water Quality Guidelines (DERM, 2009)

These guidelines provide a framework for assessing water quality in Queensland through the setting of water quality objectives.

15.3.10 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)

These guidelines provide a method for assessing water quality through comparison with guidelines derived from local reference values.

15.4 Existing Environmental Values

EPP (Water) seeks to protect and/or enhance the suitability of Queensland's waters for a variety of beneficial uses.

The Environmental Values (EVs) and Water Quality Objectives (WQOs) for receiving waters within the Fitzroy Basin were specified in Schedule 1 of EPP (Water) in September 2011. Although EVs for the Burdekin Basin study area have not been previously specified by the Department of Environment and Resource Management (DERM; now EHP), EVs and pertinent water quality objectives for the Burdekin Basin have been identified in studies carried out for the Queensland Department of Natural Resources, Mines and Water (Greiner and Hall, 2006).

[2] The DERM *Coal Seam Gas Water Management Policy 2010* was superseded by the EHP *Coal Seam Gas Water Management Policy 2012* on the 21/12/2012, subsequent to the compilation of the draft Bowen Gas Project EIS. Arrow are reviewing the updated policy at the time of the Bowen Gas Project EIS being published, and may undertake further amendments to the Arrow CSG Water and Salt Management Strategy (Appendix AA) in keeping with the updated EHP policy, as part of a supplementary report to the EIS.

A summary of the EVs associated with surface waters that are potentially impacted by the Project is provided in Section 15.5.3 (further details are provided in the Surface Water Technical Report (Appendix N) of this EIS).

15.4.1 Study Area

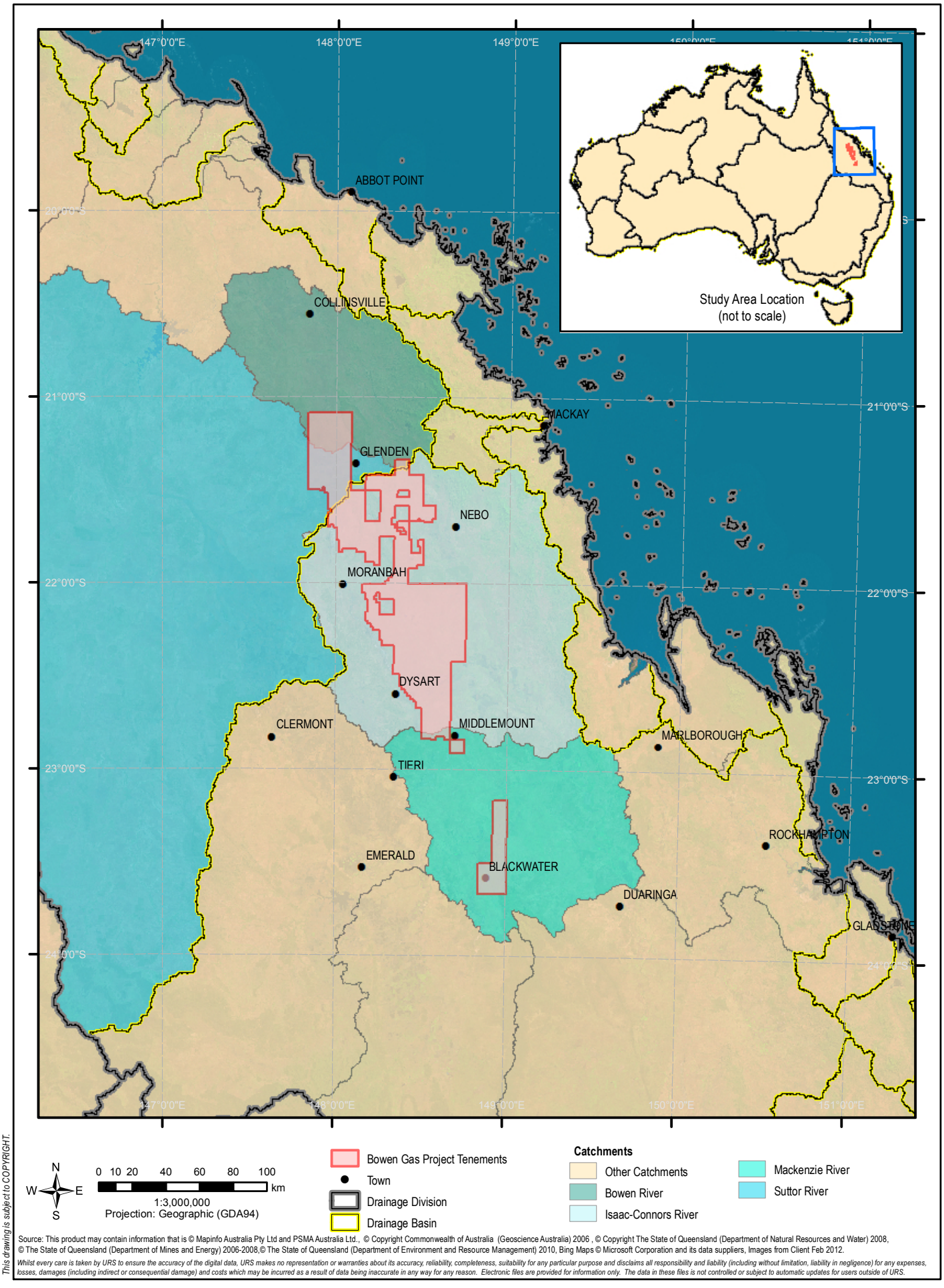
The study area encompasses entire catchments within the CSG fields, and consists of four main catchments throughout the Burdekin and Fitzroy Basins, as illustrated in Figure 15-1.

The northern basin, Burdekin, is approximately 131,000 km^2 in area and comprises the Bowen, Suttor and Burdekin Rivers and their tributaries. This river network discharges into the Coral Sea approximately halfway along the Great Barrier Reef, near Ayr.

The Fitzroy Basin is the largest coastal catchment in eastern Australia, covering an area of approximately 142,600 km^2 and encompassing the Isaac-Connors, Dawson, Comet, Nogoa, Mackenzie, and Fitzroy River systems. The Fitzroy Basin drains to the southern end of the Great Barrier Reef, just east of Rockhampton.

The majority of the study area is located in the Isaac-Connors catchment, within the Fitzroy basin, with the remainder split between the Mackenzie River catchment (Fitzroy) and the Suttor and Bowen catchments (Burdekin).

Figure 15-2 illustrates the surface water monitoring locations and main catchment watercourses within the study area.



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BOWEN GAS PROJECT EIS

CATCHMENT CONTEXT

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SURFACE WATER

Figure: **15-1**

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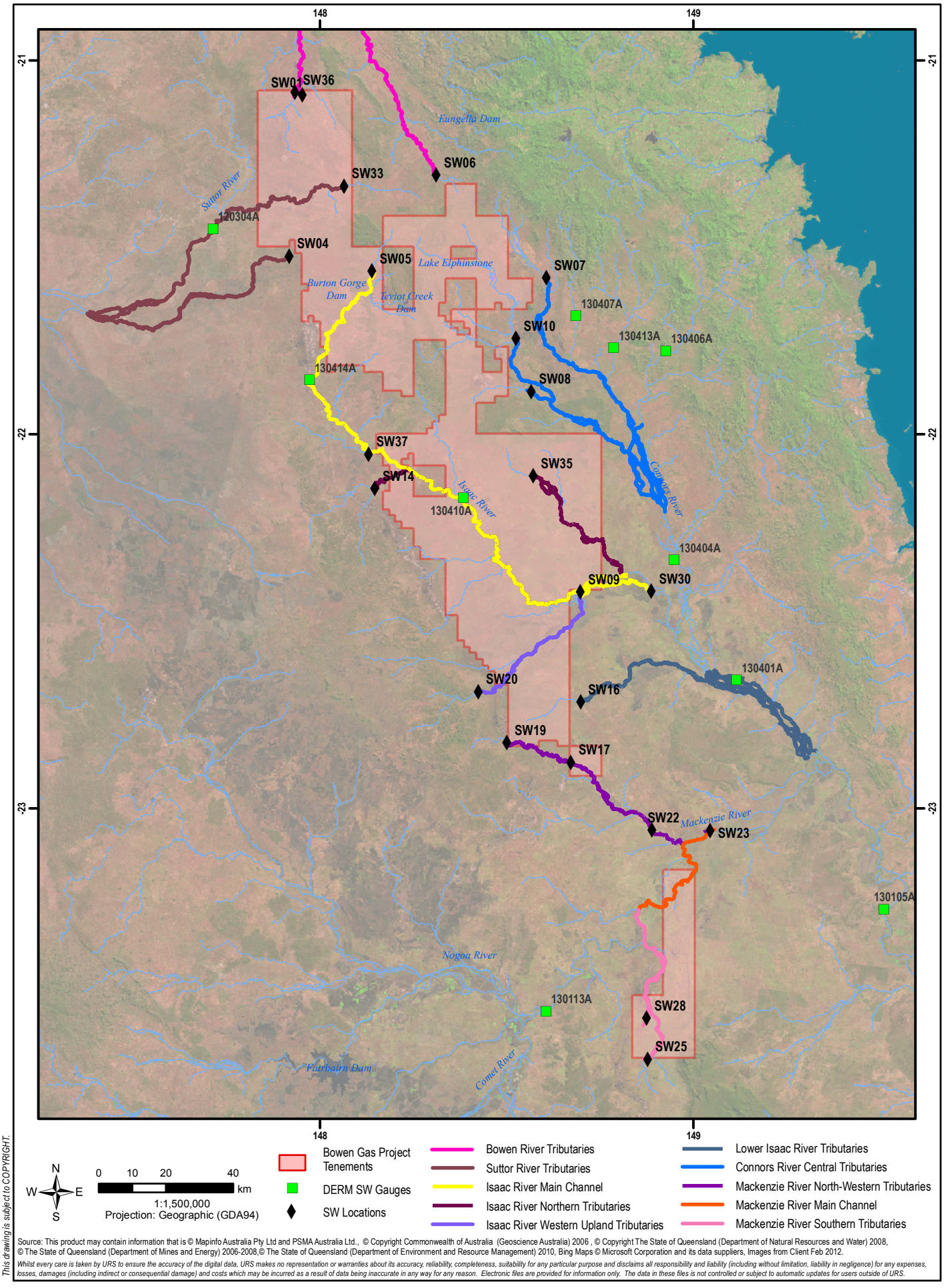

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BOWEN GAS PROJECT EIS

BOWEN LEASE AREA, SURFACE WATER MONIORING LOCATIONS AND STUDY CATCHMENTS

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SURFACE WATER

Figure: 15-2

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15.4.2 Catchment Overview

15.4.2.1 Burdekin Basin

Bowen River Catchment

The Bowen River is a major tributary of the Burdekin River, and its catchment is predominantly impacted by agriculture. The upper tributaries of the Bowen River are set within broad valleys with both incised and anabranching channels approximately 20 m wide on average.

Suttor River Catchment

The Suttor River and its tributaries are ephemeral with waterholes supplied by groundwater. The tributaries in the vicinity of the study area (Suttor Creek and Eaglefield Creek) are set within broad, shallow valleys.

Extensive land clearance and agricultural land uses are the likely sources of significant volumes of sediment deposited in channels throughout the catchment.

15.4.2.2 Fitzroy Basin

The waterways within the portion of the study area located within the Fitzroy Basin are ephemeral in nature and provide seasonal habitat for aquatic fauna and flora.

Isaac River Catchment

The Isaac River is a major tributary of the Fitzroy River. Historic clearing of land for agricultural uses and the development of numerous open-cut and underground coal mines in recent decades has significantly affected the characteristics of the catchment's drainage system. Channel diversions, subsidence, and increased sediment loads have all lead to aggradation of the channel bed and replacement of a former pool system with a much more uniform sand sheet bed. Furthermore, the Burton Gorge Dam, a major water storage dam in the upper reaches of the Isaac River, impacts on the flood hydrology regime downstream.

The upland tributaries and upstream reaches of the Isaac River typically consist of a mixture of alluvial and bedrock controlled reaches constrained within small valleys and with subsequently small floodplains, if any. The northern tributaries and mid-catchment reaches of the Isaac River contain broad valleys with extensive low angle floodplains through which the rivers run in a generally sinuous multi-thread channel pattern. Close to the junction of the Isaac and Connors Rivers, the floodplain is wide and contains several anastomosing channels. Downstream of this, the lower Isaac River tributaries were found to contain variable channel and floodplain characteristics.

Connors River Catchment

The Connors River central tributaries are set within wide, shallow valleys and typically have single thread channels. One of the study sub-catchments, Cooper Creek, is part of an anabranching channel system. The surrounding landscape is predominantly native grassland, with some grazing.

Mackenzie River Catchment

The Mackenzie River is a large anabranching system in a shallow valley setting, and contains Bingegang Weir, a major water storage facility for the surrounding region. Mature forest with pockets of shrubs and grassland exists in a relatively natural state, with limited land clearance activities (compared with the Isaac River catchment).

Roper Creek is a major tributary of Mackenzie River, which flows south-east to join the main channel, and is also set within a shallow valley. The upper 45 km of Roper Creek are confined by bedrock associated with the Peak Range (east of Clermont). The majority of the catchment appears to be native grassland, with some grazing activity observed in the lower portion of the sub-catchment.

The southern tributaries of Mackenzie River (namely Sagittarius Creek and Taurus Creek) flow north to converge into Blackwater Creek, which is a major tributary of Mackenzie River. Blackwater Creek flows to the east of Blackwater town, and passes through the open-cut Curragh North Coal Mine before joining the Mackenzie River. Both tributaries are set within shallow valleys, where the channels are incised below the floodplain.

The Black Water Conservation Park is situated within the Project area, in the lower Mackenzie River catchment.

15.4.3 Catchment Environmental Values

Environmental values that are relevant to the Project include the biological integrity of the aquatic ecosystems, as well as human values such as water supply, cultural / spiritual, recreational, agricultural and industrial purposes, as summarised in Table 15-1. Details regarding surface water users and associated licences are provided in Table 4-3 of the Surface Water Technical Report (Appendix N) of this EIS.

Table 15-1 Ecological (Habitat) and Human Environmental Values for the EIS Study Area

Receiving Environment	Applicable Environmental Values											
	Protection of slightly to moderately disturbed aquatic ecosystems	Irrigation	Farm Supply	Stock Water	Aqua-culture	Human Consumer	Primary Recreation	Secondary Recreation	Visual Recreation	Drinking Water	Industrial	Cultural / Spiritual
Burdekin Basin												
Bowen River, unknown creek	✓	×	×	✓	×	×	×	×	×	×	×	✓
Bowen River, Kangaroo Creek	✓	×	×	✓	×	×	×	×	×	×	×	✓
Bowen River, Exe Creek	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓
Fitzroy Basin												
Suttor River (Suttor Creek)	✓	×	×	✓	×	×	✓	✓	✓	✓	✓	✓
Isaac River main channel	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Isaac River northern tributaries (Devlin Creek, Cherwell Creek, Lake Elphinstone)	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Isaac River western upland tributaries (Roper Creek)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Isaac River eastern tributaries	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓
Isaac River fresh waters in undeveloped areas	✓	×	×	✓	×	×	✓	✓	✓	✓	×	✓
Connors River central tributaries (Cooper Creek, Bee Creek, Harrybrant Creek)	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓
Connors River freshwaters in undeveloped sites	✓	×	×	✓	×	✓	✓	✓	✓	✓	×	✓
Northern Connors range tributaries (Homevale National Park)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mackenzie River north-western tributaries (Roper Creek)	✓	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓
Mackenzie River main channel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mackenzie River southern tributaries (Taurus Creek, Sagittarius Creek and Blackwater Conservation Park)	✓	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Mackenzie River eastern tributaries	✓	×	×	✓	×	✓	✓	✓	✓	×	×	✓
Mackenzie River fresh waters in undeveloped areas	✓	×	×	✓	×	✓	✓	✓	✓	✓	×	✓

15.4.3.1 Burdekin Basin

Bowen River

The north eastern portion of the Project area is located within the upper catchment of the Bowen River. The aquatic ecosystem values are considered to be slightly to moderately disturbed as a consequence of the surrounding land use.

The human use environmental values which are applicable to the upper catchment waterways comprise stock watering and cultural and spiritual values. Downstream in the Bowen River itself the human use environmental values comprise recreation (swimming, fishing and visual appreciation), irrigation, industrial, stock watering, human consumption, and the cultural and spiritual values.

The Newlands, Newlands East and South Coal Mines (Mining Leases 4748, 4774, and 4771), are located in the upper portion of the Kangaroo Creek tributary, and operated by Xstrata Coal Queensland Pty Ltd. Xstrata have obtained a licensed to extract water from Cerito Creek (a tributary of Kangaroo Creek) for mining operations (license numbers 139700 and 150431).

Suttor River

The aquatic ecosystem values in the upper Suttor River catchment are considered to be slightly to moderately disturbed as a consequence of the disturbance from existing and past land uses, such as grazing and land clearance for extractive industries. The human use environmental values which are applicable to the upper Suttor River catchment include recreation (swimming, boating and visual appreciation), stock watering, human consumption, industrial use (mining), and the cultural and spiritual values.

The Upper Suttor River flows into Burdekin Falls Dam, which provides drinking water for Thuringowa and Townsville and also supplies a large irrigation scheme for a range of crops including sugar cane, cotton and rice. Industrial use is prevalent throughout the catchment. A mine at Suttor Creek (Mining Lease 4761) is operated by Xstrata Coal Queensland Pty Ltd, and the mining lease is currently awaiting renewal (expired June 2011). Wards Well mine (Mining Lease 1790; BHP Billiton Mitsui Coal Pty Ltd) is located in the upper reaches of Eaglefield Creek, which flows into the Suttor River. Permits for irrigation (license numbers 104711, 118642, 119010, 143620, 150499, 184814, 46163F, and 52668F) and diversion around a rail development (Queensland Rail; license number 604448) have also been issued for surface water extraction from Eaglefield Creek and its tributaries.

15.4.3.2 Fitzroy Basin

Isaac River

The upper catchment of the Isaac River is home to Lake Elphinstone, an Environmentally Significant Area (ESA) and one of the Important Wetlands in Australia. The lake is the largest natural fresh water body in Central Queensland and provides breeding grounds and an important refuge during drought for a wide array of bird species.

The Ungie Waterhole is located at the confluence of Devlin Creek and the Isaac River main channel, in the lower portion of the Isaac River Northern Tributaries catchment and is a source of water for irrigation. The Ungie Waterhole consists of two oxbow lakes, and was listed as a waterway of ecological value by participants in a public workshop on environmental values for the Fitzroy Basin, facilitated by DERM (2011).

The Isaac River Northern Tributaries catchment (namely Cherwell Creek and Devlin Creek) are mining-intensive regions. Olive Downs mine (Mining Lease 70354, Peabody Coppabella Pty Ltd) is located in the northern portion of the Isaac River main channel catchment, while Devlin Creek flows through Moorvale mine (Mining Lease 70290, Peabody Coppabella Pty Ltd) further downstream. Further south, in the Lower Isaac river catchment, large coal mines such as Peak Downs and Saraji (Mining Lease 1775 and 1784 respectively; operated by BHP Coal Pty Ltd) and Vermont (Bowen Basin Coal Pty Ltd) draw water from Ripstone Creek, Phillips Creek, and Stephens Creek. All of these watercourses are major contributors to Isaac River.

Connors River

Surface water is extracted within the lower portion of the Connors River catchment for use in stock watering and irrigation activities; licenses to impound sections of Connors River and tributaries such as Bee Creek have been issued to private landholders for such purposes.

Pink Lagoon, located near the South Walker Creek mine in the lowest portion of the Connors River Central Tributaries catchment, was identified by DERM (2011) as a surface water feature with significant ecological value for local communities. It is a large oxbow lake of Bee Creek. A similar feature was identified in Lake Plattaway, a large oxbow lake between the Isaac and Connors Rivers.

Eungy Waterhole, near the confluence of Clark Creek and Isaac River (in the lower portion of the Connors River catchment) was also listed by DERM (2011) as a feature of potential ecological significance. A permit for riparian access and extraction for irrigation has been granted to private landholders for water extraction from Eungy Waterhole (license numbers 109695, 139132, and 41200U).

Surface water users for domestic water supply are located directly below the confluence of Connors and Isaac Rivers, including two licenses issued for extraction from Two Mile Creek (license numbers 57401U, 57417U, 57449U, and 129889) which is a tributary flowing south-west into the Isaac-Connors River junction.

Mackenzie River

Key users of surface water within the Mackenzie River catchment primarily utilise fresh water resources for irrigation and water harvesting. A particularly large surface water source is Lake Mary; a privately owned lake in the upper Mackenzie River catchment. Lake Mary is primarily used for cropping (namely sorghum, wheat, mungbean, chickpea, and peanuts) (Ward, 2003).

Surface water is extracted from Roper Creek for use in mining activities at Foxleigh East mine (Mining Lease 70309, CAML Resources Pty Ltd) north of Wilpeena Park and the confluence with Mackenzie River. Private landholders south of Wilpeena Park (License numbers 111211, 137528, 38974F and

057826F) have been licensed to extract water from Mackenzie River for domestic supply. These license holders are also located near the Bingegang Weir (8,060 ML capacity) and Bedford Weir (22,900 ML capacity) (SunWater, 2012). Both of these storages supply water for irrigation, industrial and domestic use throughout the catchment (ANRA, 2009).

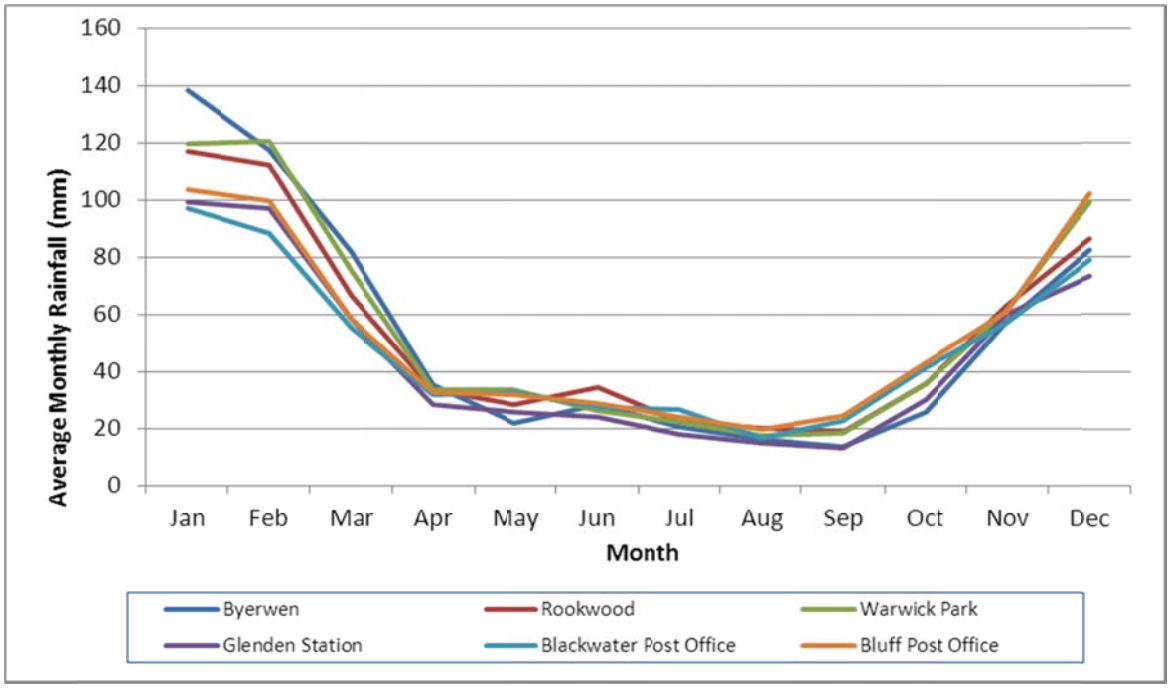
Surface water is commonly used for irrigation, intensive stock watering, and industrial activities along the Mackenzie River main channel. Two licenses to extract surface water from Mackenzie River for domestic water supply have been issued.

Mining is the primary land use activity utilising surface water resources from the southern tributaries of the Mackenzie River. Taurus Creek flows through the Eldorado Hill mining lease (Mining Lease 1779, Cook Resource Mining Pty Ltd) while Blackwater Creek flows through the Minyango mine, operated by Blackwater Coal Pty Ltd (Mining Lease 80173). The Curragh mine, operated by Wesfarmers Curragh Pty Ltd (Mining Lease 1878 and 1990) is situated north of Blackwater township. A license for extraction of surface water for industrial use has been granted to Wesfarmers Curragh Pty Ltd (interim water allocation). The majority of mines surrounding Blackwater township are supplied via the Blackwater pipeline scheme.

15.4.4 Hydrology

All five catchments traversed by the Project contain extensive ephemeral stream networks with flow periods generally restricted to the wet season period. The Mackenzie River at Riley's Crossing is the exception as it exhibits perennial characteristics with flows persisting during the dry season period. Seasonal rainfall patterns for the study area are provided in Figure 15-3.

Figure 15-3 Seasonal Rainfall in the Vicinity of the Study Area



Stream gauge data was sourced for EHP stream gauges which were located within or in close proximity to the Project area. The stream gauge data which is provided in the Surface Water Technical Report (Appendix N) of this EIS shows that stream flows within the Project area are characterised by large annual variations due to the seasonal and highly variable nature of rainfall. Stream flows generally occur during the wet season between November and March when the majority of rainfall occurs across the study area. During the prolonged dry season between April and October, flows ceased at the majority of the stream gauging locations, which is indicative of the ephemeral nature of many of the waterways within the study area.

15.4.5 Geomorphology

Bedload dominated systems are common in the upper portions of catchments within the study area, particularly in the headwaters of the Isaac River, and north-western tributaries of the Mackenzie River. These systems source sediment from high relief and bedrock in the headwaters, such as the Carborough Range in the upper portion of Isaac River, and Peak Range in the headwaters of Roper Creek. These areas represent the “source zone” within their respective catchments (Brierley and Fryirs, 2005).

Systems tend to become suspended load dominated in the middle and lower portions of each catchment, and sediment storage becomes the dominant fluvial process. This is known as the “transfer zone” (Brierley and Fryirs, 2005). This is particularly evident in study reaches where in-channel benches were observed; for example, upper reaches of Exe Creek (upper tributary of Bowen River), mid- to lower portions of the Isaac River main channel; middle portions of the Isaac River

northern tributaries, and middle portions of the Connors River central tributaries. Sediment is stored in continuous pockets along these channels, particularly after flood events erode the upper catchment and transport sediment 'slugs' downstream. The sediment drops out of suspension as flow recedes, and is stored as in-channel benches and bar deposits during dry periods.

Riparian vegetation is highly impacted by agricultural activities throughout the study area, particularly as a result of grazing pressures. This has accelerated erosion in the source and transfer zones of the majority of the study catchments, and contributed to increased volumes of sediment transported to the lower portions of the catchments. As a result, the lower portions of the Isaac River and Connors River are anastomosing, where multiple channel threads meander freely across a floodplain that is over 2 km wide in places.

The high sediment loads throughout the study catchments, including large volumes of sediment stored within channels, makes the study area susceptible to changes in sediment supply and catchment flow regimes, particularly during high flow and flood events. The localised erosion impacts observed around existing structures (such as road and rail bridges) with foundations placed within channels and the reaction of watercourses to the placement of sand and rip rap along banks and floodplains, have highlighted the sensitivity of the fluvial environment to external influences.

Based on the above assessment, the following environmental values are associated with the study area, in terms of fluvial geomorphology:

- High sediment load systems; significant volumes of sediment stored in channels during dry periods;
- Streams are sensitive to in-channel modifications such as placement of rock riprap; sand; and pile foundations;
- Floodplains are wide and often have one active channel, with additional channels that become active during flood conditions; and
- Anastomosing systems within the study area have unstable channels which may alter their course during high flow and flood events.

15.4.6 Surface Water Quality

The available water quality data showed that for the majority of the analytes measured in the study catchments, the concentrations were consistent with trigger values for slightly to moderately disturbed aquatic ecosystems. However the water quality data also identified a number of contaminants which consistently exceeded the water quality objectives for watercourses within the study area. These were as follows:

- Total suspended solids;
- Dissolved oxygen (in-situ results from the Mackenzie River Southern and North-Western catchments were indicative of marginally depleted oxygen conditions);
- Zinc;
- Uranium (elevated in tributaries of the Suttor River, Bowen River, Isaac River Main Channel and Connors River Central catchments);
- Total dissolved solids and hardness (elevated in the Suttor River catchment);
- pH and total vanadium (elevated in tributaries of the Connors River Central catchment); and

- Electrical conductivity was elevated well above the water quality objective of 720 µS/cm at the majority of sites with the Bowen River Tributaries, Suttor River Tributaries, and Connors River Central Tributaries.

Occasional exceedences of the water quality objective were recorded in samples collected from the Mackenzie River North-Western Tributaries and the Mackenzie River Southern Tributaries.

The reason for these exceedences is unclear but there is anecdotal evidence to suggest that it is most likely due to a combination of naturally elevated background concentrations and the effect of land clearing and land use practices associated with the existing development within the study area.

15.5 Potential Impacts and Mitigation Measures

As the location details within the Project area have not been defined, a generic assessment of potential impacts on surface water resources has been undertaken in this section of the report.

15.5.1 Objectives for Environmental Protection

On the basis of the description of the existing environment presented in the Surface Water Technical Report (Appendix N) of this EIS and the identified environmental protection objectives specified within the EPP (Water) and related documentation for waters in the receiving environment, the environmental protection objectives for the Project are as follows:

- To maintain the physical integrity, fluvial processes and morphology of watercourses and wetlands;
- To maintain sufficient quantities of water within watercourses to protect existing downstream beneficial uses of those waters;
- To maintain the quality of water in streams and pools so that existing and potential environmental values, including biological integrity, are protected;
- To ensure that the quality and quantity of water emissions does not adversely affect environmental values or the health, welfare and amenity of people and land uses and does meet statutory requirements and acceptable standards;
- To ensure water resources used for public water supply are protected in accordance with the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011);
- To maintain the integrity, ecological functions and environmental values of wetlands; and
- Maintenance of sufficient quality of surface waters to protect existing beneficial downstream users of those waters.

15.5.2 Activities with Potential Impacts

The following section details the major planned activities for the Project through the different stages of construction, operation and decommissioning. The potential impacts of each activity on surface water resources are assessed and mitigation measures have been identified to minimise potential impacts.

Project activities that have the potential to result in environmental impacts on surface water are listed below.

- Exploration and drilling activities;
- Watercourse crossings by roads, tracks and pipelines;
- Construction, operation and decommissioning of Project infrastructure including field compression facilities (FCFs),central gas processing facilities (CGPFs), and integrated processing facilities (IPFs) including water treatment facilities and water storage dams;
- Pipeline construction;
- Discharge and storage of hydrotesting water;
- Discharge and storage of treated and untreated CSG water and brine concentrate; and
- Discharges of treated sewage.

15.5.3 Summary of Potential Impacts and Mitigation Measures

For the purpose of the surface water assessment of construction phase impacts, the construction phase is considered to comprise construction of infrastructure to support the Project including installation of wells, gathering lines, dams and construction of processing and compression facilities (see Table 15-2).

Table 15-2 Summary of Potential Impacts and Mitigation Measures

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
Construction			
Erosion and sediment mobilisation	Sediment mobilised during construction activities may enter surface water runoff during rainfall events and discharge to watercourses, leading to adverse effects on water quality. Sediment exposed or generated during construction may also be carried by wind into surface water bodies. Additionally there is the potential for the presence of high levels of metals from soils that may enter watercourses as a consequence of sediment mobilisation.	• Implement best practice erosion and sediment control measures during construction works in accordance with the requirements of the *Best Practice Erosion and Sediment Control* Manual (IECA, 2008) [B337]; • Areas of disturbed or exposed soil will be managed to reduce sediment mobilisation and erosion [B292]. The mitigation measures to be implemented to achieve this are: — topsoil will be stockpiled away from drainage lines to protect it from erosion [B294]; — vegetation clearing will not be carried out during heavy rainfall [B295]; — dust suppression measures will be implemented [B296]; and — vehicle wash-downs will be located away from drainage lines or watercourses [B297]; • Regular inspections of road alignments will be undertaken to ensure that disturbed surfaces are stable and not subject to concentration of flows or erosion. Repair works will be undertaken proactively to prevent erosion from occurring or worsening [B298]; • As soon as practical following pipe laying, the trench should be backfilled with excavated material, compacted and the topsoil replaced and erosion controls implemented [B299]; and • Regular inspections of the pipeline alignment will be undertaken to ensure that disturbed surfaces are stable and not subject to concentration of flows or erosion. Repair works will be undertaken proactively to prevent erosion from occurring or worsening [B298].	Minimise erosion and sediment release.
Alteration of flows and flow paths	Poorly constructed watercourse crossings have the potential to cause both increased scour and sedimentation with potential adverse impacts on geomorphology. Increased bed scour can lead to adverse water quality impacts through increased turbidity.	Minimise potential impacts on surface waters through implementation of the following measures during construction of watercourse crossings [B300]: • Watercourse crossings should be timed to occur during the dry season during periods of low flow, where possible; • Construction of watercourse crossings will be conducted in the shortest possible time and in accordance with the DERM guideline – "*Activities in a watercourse, lake or spring carried out by an entity*" (WAP/2010/4165); • Avoid disrupting overland flow paths and, where avoidance is not practicable, maintain connectivity of flow in watercourses; • Delay clearance of stream banks until the watercourse crossing is due to be	Retain natural flow capacities and watercourse configuration.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
		constructed, to the greatest extent practicable. Implement appropriate erosion and sediment control measures (e.g., silt fences, sediment basins and erosion berms) on watercourse approaches and banks and ensure prompt completion of construction; • Check for flood warnings or subscribe to flood warning services where relevant during construction of watercourse crossings; • Construct watercourse crossings in a manner that minimises sediment release to watercourses, stream bed scouring (e.g., the crossing location will be at low-velocity, straight sections, with the pipeline or road orientated as near to perpendicular to water flow as practicable), obstruction of water flows and disturbance of stream banks and riparian vegetation (i.e., the crossing location will be at a point of low velocity, and straight sections will be targeted, with the pipeline or road orientated as near to perpendicular to water flow as practicable). Avoid, where practicable, the use of rock gabions, as they are unsuited to watercourses of the region; • All crossings should be constructed and reinstated to ensure that flows are not impeded and water is not ponded by the crossing. Where the temporary damming of flows is necessary during construction then flow will be diverted where required to maintain flows and allow for fish movement; • Watercourse crossings should occur at straight sections of channel and bends should be avoided; • Minimise the number of channels to be crossed; • Avoid permanent pools when selecting watercourse crossing points; • Avoid mid-channel alluvial bars and islands; • Stockpile watercourse bed material in the watercourse channel adjacent to the construction RoW only when the watercourse is dry, and site the stockpile to avoid impacts on riparian vegetation and in-stream features; • Retain coarse alluvial material from watercourse crossings for backfill armouring over the finer unconsolidated material; • Stabilise watercourse crossings as soon as possible using bedrock where available;	

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
		• Rehabilitate and revegetate banks as soon as possible after construction; • Stabilise watercourse crossings as soon as possible using bedrock where available; and • Watercourse crossings to be designed to minimise impacts on geomorphology and river flows [B288].	
Mobilisation of contaminants from refuelling, chemical storage and wash-down areas	Potentially contaminated drainage generated through these activities could enter into drainage lines, altering the physical and chemical characteristics of the receiving waters. These pollutants can both affect the surrounding environment and have the potential to be a public health and safety issue.	• Temporary and permanent chemical and fuel storage areas to be appropriately bunded in accordance with AS 1940 and AS 3780 [B302]; • All transfers of fuels and chemicals will need to be controlled to prevent spillage outside bunded areas [B303]; • Refuelling to occur in accordance with AS 1940 at a distance of greater than 50 m from any watercourses [B304] • All vehicles, plant and equipment to be checked regularly for fuel tank and line failures [B305]; • Bunds and sumps should be frequently drained and treated / disposed of appropriately [B306]; • Contaminants and spillages to be collected by a licensed waste collection and transport contractor for disposal at licensed facility [B307]; • Contaminated soil should be removed and remediated [B308]; • Spill clean-up kits in accordance with AS 1940 and AS 3780 to be located in appropriate locations, including inside machinery [B309]; • Refuelling to occur within contained areas in accordance with AS 1940 wherever possible [B317]; and • In the event of a spill occurring, ensure it is controlled, contained and cleaned up to prevent the mobilisation of pollutants in drainage lines or watercourses [B310].	Prevent contaminants from entering watercourses.
Flooding	Obstruction to flood flows from infrastructure. Contamination of flood waters from fuels, oils and chemicals stored within construction sites	• Construction activities will be undertaken during the dry season where scheduling allows [B293].	Prevent contaminants from entering watercourses.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
	and soils exposed during construction activities.		
Improper management of drilling wastes	Release of drilling muds and hydraulic stimulation fluids into watercourses may lead to water quality degradation though increased sediment and contaminant loads.	Develop, implement and maintain a drilling procedure [B311]; • Develop, implement and maintain a procedure to minimise the risk of drilling waste (in the form of drilling fluids and hydraulic stimulation fluids) contaminating watercourses during drilling, completion, hydraulic stimulation and workover activities [B288]; • Ensure well sites are selected outside of designated buffers around watercourses; and • In the event of a spill, ensure immediate clean-up of drilling wastes to prevent waste products entering the watercourses.	Prevent contaminants from entering watercourses.
Improper disposal of construction wastes	Fouling of and contamination of surface water resources.	• Develop, implement and maintain a waste management plan [B207].	Prevent contaminants from entering watercourses.
Improper disposal of hydrotest water	Potentially elevated concentrations of contaminants in hydrotest water could have adverse impacts on the receiving surface water environment.	• A hydrostatic testing strategy will be developed to manage hydrotest activities [B312]	Prevent contaminants from entering watercourses.
Lack of water supply	Inadequate dust suppression resulting in windborne dust / sediment and subsequent surface water quality degradation. Excessive use of saline CSG water for dust suppression may increase the salinity in runoff.	• Dust suppression measures will be implemented [B296] • Dust suppression water quality will meet the prescribed specification prior to use and water will be applied in a manner to ensure water does not pool on the surface, or enter surface waterways via surface runoff [B313].	Minimise windborne sediment release. Minimise the risk of saline runoff.
Operation			
Erosion and sediment mobilisation	Permanent structures, minor earthworks, unsealed sites, laydown areas and disturbed	• Develop site-specific Erosion and Sediment Control Plan to include [B290]: — localised erosion and sediment control and energy dissipation structures; and	Minimise erosion and sediment release.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
	(incompletely rehabilitated) areas may result in localised erosion and sediment mobilisation to waterways. Mobilised sediment may enter surface water runoff during rainfall events and discharge to watercourses, leading to adverse effects on water quality.	— stabilise exposed areas; • Operate and maintain appropriate sediment detention measures for overland flow from disturbed areas [B314]; • Undertake routine inspection and maintenance of existing erosion and sediment control devices [B315]; • Design surface flows from unsealed areas to flow to adjacent grassed areas at low velocities [B316]; and • Develop and implement a rehabilitation management plan for decommissioning which includes monitoring and maintenance of rehabilitated areas until rehabilitation is complete [B339].	
Mobilisation of contaminants from refuelling, chemical storage, CSG water spills and wash-down areas	Potentially contaminated drainage generated through these activities could enter into drainage lines, altering the physical and chemical characteristics of the receiving waters. These pollutants can both affect the surrounding environment and have the potential to be a public health and safety issue.	• Refuelling to occur in accordance with AS 1940 at a distance of greater than 50 m from any watercourses [B304]; • Storage and refuelling areas to be designed to minimise the ingress of clean stormwater either from overland flow or incidental rainfall [B291]; • Hazardous chemical bunds and sumps within them should be emptied after each rainfall event to maintain capacity requirements as per AS 1940. Water and oily water from fuel and oil storage areas removed from bunds and sumps should be appropriately treated and/or disposed of appropriately [B318]; • Contaminants and major spills should be collected by a licensed waste collection and transport contractor for disposal at an offsite licensed facility [B319]; • Spill clean-up kits are to be located in appropriate locations, based on the risk of a spill occurring and potential volume of material that might be spilled at the particular location [B320]; • Workers involved in storage, handling and management of fuels and chemicals are to receive training in spill prevention and control [B321]; • Instructions on spill containment and clean-up to be available at refuelling locations and in vehicles where there is a moderate risk associated with spill events [B322]; • Spills are to be contained and cleaned up immediately to prevent the	Prevent contaminants from entering watercourses.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
		mobilisation of pollutants in drainage lines or watercourses [B323]; and • Wastewater from the vehicle wash-down should be treated and recirculated for use in the wash-down facility [B324].	
Failure of regulated water storages and transfer pipelines	Failure of regulated water storages and/or transfer pipelines may lead to adverse water quality impacts for downstream receiving waters, ecosystems and landholders including: • Discharge of poor water quality compared to the water quality of the receiving environment; and • Erosion and sedimentation at failure locations.	• Inspect and maintain dam integrity [B516]; • Establish overflow and operational controls in accordance with the dam operating plan [B515]; • Construction supervision of regulated dams undertaken by a suitably qualified and experienced person (as defined by EHP) [B326]; • Stabilisation of regulated storage embankments through the implementation of suitable erosion controls [B327]; • Annual inspections of regulated storages to be undertaken by a suitably qualified and experienced engineer (as defined by EHP's (2012) *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*) [B363]; and • Develop the construction, design and monitoring requirements for new regulated dams (either raw water, treated water or brine dams) and determine the hazard category of the dam in accordance with the requirements of the most recent version of *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (DERM, 2011b). Construct the dams under the supervision of a suitably qualified and experienced person in accordance with the relevant DERM schedule of conditions relating to dam design, construction, inspection and mandatory reporting requirements [B359];	Prevent contaminants from entering watercourses.
Discharges of CSG water to waterways	The release of CSG water can lead to: • Altered flow regimes by introducing additional flows with potential impacts on geomorphology through altered sediment and erosion patterns within the stream channel.	• Employ beneficial use options for CSG water wherever possible [B347]; • Undertake specific investigations to assess the assimilative capacity of the receiving environment at proposed discharge locations [B348]; • All water for discharged from site will meet approved discharged criteria [B349]; • Ensure that antiscalants or other chemicals used within the reverse osmosis process are captured within the reject waste stream [B350]; • Establish water quality monitoring stations upstream and downstream of discharge points to watercourses to ensure compliance with environmental	Minimise impacts on water quality, hydrology and stream morphology. Minimise erosion due to controlled releases of CSG water

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
	• Altered riparian vegetation and aquatic species through changed flow patterns and water quality. • Adverse impacts on water quality and aquatic ecosystems from uncontrolled releases of CSG water. Localised erosion and sedimentation at CSG water release point(s) due to bed scour.	authority conditions and relevant standards [B325]; and • Design discharge structures to minimise erosion of the bed and banks of the receiving waterway by implementing erosion controls, including energy dissipation structures, at discharge outlets at the point of discharge[B346].	
Improper disposal of operational wastes	Fouling of and contamination of surface water resources.	• Develop, implement and maintain a waste management plan [B207].	Prevent contaminants from entering watercourses.
Discharges of treated sewage effluent	Oily or greasy surface waters and depletion of oxygen levels leading to fish kills. Increased pathogens such as faecal coliforms can compromise aquatic ecosystems and human health. Increases in dissolved solids from discharges may alter the salinity of freshwater thereby impacting on the health of existing aquatic flora and fauna and riparian ecosystems. Increased total dissolved solids when applied to land for irrigation can also negatively interfere with soil-water relationships.	• An Effluent Irrigation Management Plan is prepared for any effluent irrigation area [B328]; • Management and maintenance of sewage treatment plants must be carried out by a person(s) with appropriate experience and/or qualifications to ensure the effective operation of that treatment system [B329]; • Monitoring of effluent discharge points and records kept for follow up management [B330]; • Treated effluent from the sewage treatment plant must only be discharged for irrigation in compliance with the requirements for Class C (refer to the DERM (2005) Queensland Water Recycling Guidelines) [B331]; • Releases of effluent must not have any properties nor contain any organisms or other contaminants in concentrations that are capable of causing environmental harm [B332]; • Treated effluent will only be released to any waters or the bed and banks of any waters in accordance with approval conditions [B333]; • Water or storm water contaminated by sewage treatment activities must not be	Prevent contaminants from entering watercourses.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
	Watercourse contamination from increased nitrogen, phosphorus, toxicants (heavy metals and chlorinated organics) and suspended solids. Increased nutrients causing blue-green algal blooms, which have associated biotoxic effects to aquatic ecosystems. Other impacts to watercourses which may impact on recreational values include odour emissions, foul water taste to swimmers and harvested biota i.e. fishing.	released to any waters or the bed and banks of any waters waters (i.e. effluent irrigation must not occur during rainfall events) [B334]; and • When conditions prevent the discharge of the treated effluent for irrigation (such as during or following rain events), the contaminants must be directed to an emergency / wet weather storage or alternative measures must be taken to store or lawfully dispose of effluent (such as wet weather storage or tanking off site to another treatment plant or sewer) [B335].	
Decommissioning			
Pipeline failures	Discharge of poor water quality compared to the water quality of the receiving environment. Erosion and sedimentation at failure locations.	• Regular pipeline inspections and maintenance should be undertaken; • Develop, implement and maintain an appropriate purging procedure; and • Spill containment procedures will be implemented in response to releases of contaminated water as a consequence of pipeline failures [B336].	Prevent contaminants from entering watercourses.
Erosion and sediment mobilisation	Ground disturbance during the removal of above ground infrastructure may result in erosion and sediment mobilisation to watercourses. Mobilised sediment may enter surface water runoff during rainfall events and discharge to watercourses, leading to adverse effects on water quality	• Implement best practice erosion and sediment control measures during decommissioning works in accordance with the requirements of the *Best Practice Erosion and Sediment Control* manual (IECA, 2008) [B337]; and • Separate clean water and impacted water from active and rehabilitated areas [B338].	Minimise erosion and sediment release.

Aspect, Activity	Potential Impacts	Mitigation Measures	Objective
Incomplete rehabilitation	Inadequate rehabilitation of disturbed areas may result in ongoing erosion and sediment mobilisation with subsequent impacts on the downstream receiving environment.	• Develop and implement a rehabilitation management plan for decommissioning which includes monitoring and maintenance of rehabilitated areas until rehabilitation is complete [B339].	Ensure the establishment of a natural environment.

15.6 Summary of Findings

Potential impacts on surface waters from the Project arise from a range of activities associated with the Project including drilling activities, and construction, operation and decommissioning of production wells, pipelines, dams, and processing and compression facilities.

This investigation considers that the impacts associated with the development of the Project could be appropriately managed by implementing a range of mitigation measures during construction, operational and decommissioning phases of the Project.