RED HILL
MINING LEASE

ENVIRONMENTAL IMPACT STATEMENT

Section 10
Aquatic Ecology

Section 10 Aquatic Ecology

10.1 Evaluation of Aquatic Ecological Values

10.1.1 Introduction

The Red Hill Mining Lease is located adjacent to the existing Goonyella, Riverside and Broadmeadow (GRB) mine complex in the Bowen Basin, approximately 20 kilometres north of Moranbah and 135 kilometres south-west from Mackay, Queensland.

BHP Billiton Mitsubishi Alliance (BMA), through its joint venture manager, BM Alliance Coal Operations Pty Ltd, proposes to convert the existing Red Hill Mining Lease Application (MLA) 70421 to enable the continuation of existing mining operations associated with the GRB mine complex. Specifically, the mining lease conversion will allow for:

- An extension of three longwall panels (14, 15 and 16) of the existing Broadmeadow underground mine (BRM).
- A future incremental expansion option of the existing Goonyella Riverside Mine (GRM).
- A future Red Hill Mine (RHM) underground expansion option located to the east of the GRM.

The three project elements described above are collectively referred to as 'the project'.

An assessment of the aquatic ecology within the environmental impact statement (EIS) study area was undertaken as part of the project EIS. The aquatic ecological values of the proposed project were defined with reference to:

- species of conservation significance as listed under relevant legislation (*Nature Conservation Act 1992* (NC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- declared pest species as listed under relevant legislation (i.e. *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act)); and
- general habitat values, including contributions to faunal movement corridors.

10.1.2 Methodology

The methodology adopted to describe the status of the aquatic ecological values included:

- literature review of relevant databases, including the Department of Sustainability Environment, Water, Population and Communities (DSEWPaC) Online Protected Matters Search Tool, the Department of Environment and Heritage Protection (EHP) Wildlife Online database, and Queensland Museum's fauna database;
- review of previous aquatic ecology survey results in and adjacent to the EIS study area (WBM Oceanics 2001 and 2005; URS 2009);
- review of aerial photography;
- ground survey conducted in May 2011 which allowed for the description of fish, macroinvertebrates, and water quality (**Appendix K3**); and
- a stygofauna ground survey conducted during June 2011 (**Appendix K4**).

The results of these investigations were consolidated in order to compile a description of aquatic ecological and environmental values within the EIS study area.

10.1.3 Field Surveys

To provide clarity, the area covering the aquatic ecology sampling sites is referred to as the survey area. The survey area covers a wider area than the EIS study area. The survey of macroinvertebrates and fish was conducted between 24 and 27 May 2011. This allowed for an assessment of the aquatic ecology after the high rainfall (flood) events of 2010/2011. Survey at or near the cessation of wet seasons flows is generally considered optimal in terms of highest biodiversity being present.

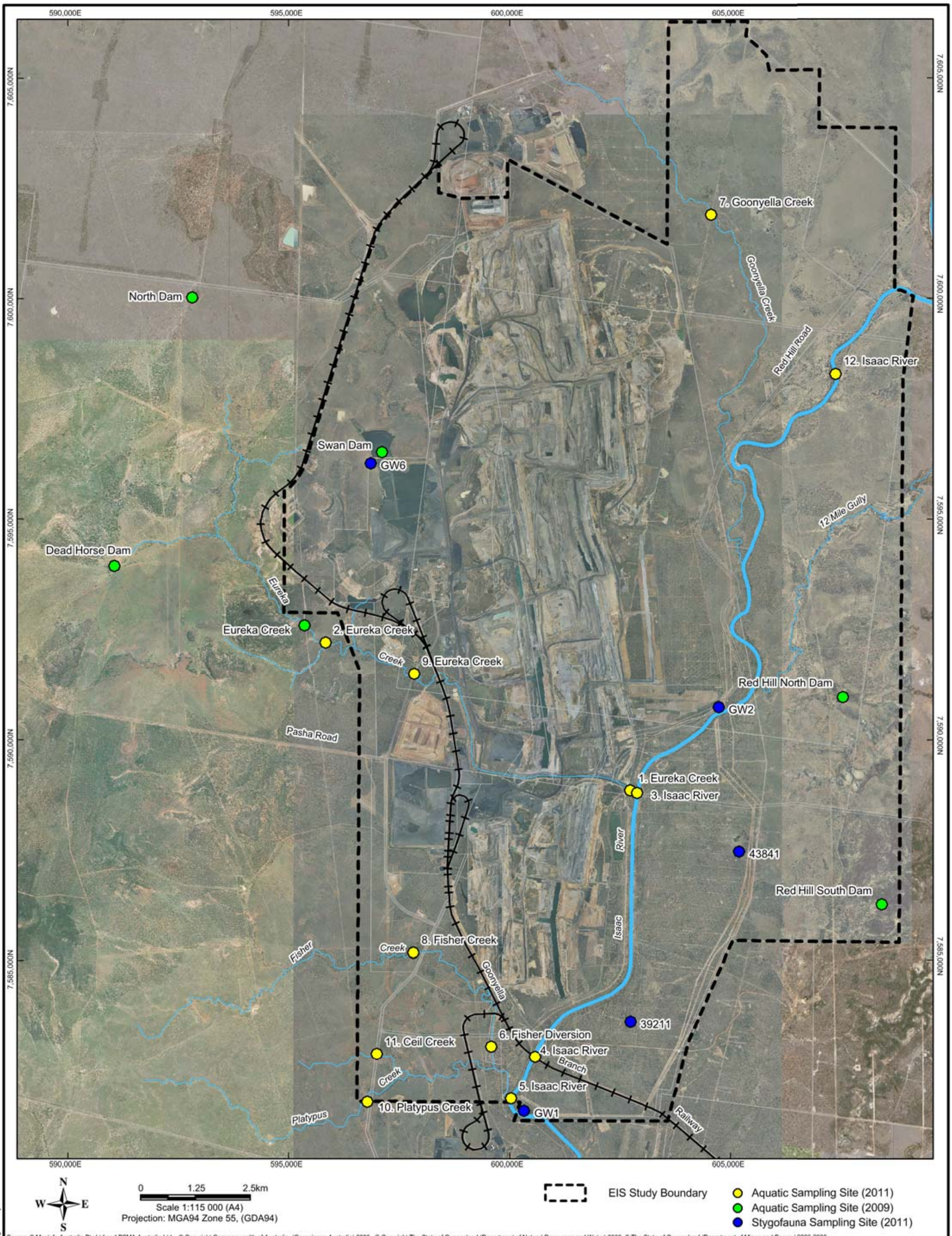
The majority of ephemeral rivers and creeks within the survey area contained water at the time of the survey, and the area was sufficiently dry to allow access across the entire area. All macroinvertebrates, fish, and stygofauna sampling sites are included on **Figure 10-1**. Macroinvertebrates and fish sampling sites are listed in **Table 10-1**.

Table 10-1 Location of Aquatic Ecology Sampling Sites May 2011 Survey

Site #	Type[1]	Waterway	Notes	Easting[2]	Northing[2]
1	I	Eureka Creek	Downstream of Causeway	602615	7588680
2	C	Eureka Creek	Upstream control	595839	7592209
3	B	Isaac River	Upstream of Eureka Creek	602885	7588802
4	I	Isaac River	Rail Crossing	600580	7582824
5	I	Isaac River	Near Platypus confluence	600031	7581875
6	B	Fisher Creek	Fisher Diversion	599473	7582873
7	R	Goonyella Creek	Broadmeadow	604563	7601899
8	R	Fisher Creek	Upstream of Main Road	597822	7585183
9	B	Eureka Creek	Middle Reach	597837	7591499
10	R	Platypus Creek	Goonyella Road	596778	7581804
11	R	Ceil Creek	Goonyella Road	596997	7582886
12	C	Isaac River	Riverside Station	607390	7598290

Note 1: Site Type: I potential impact from existing mine, B background - other impacts in catchment apart from existing mine, R reference condition - typical land use, C control site (further details given in **Appendix K3**).
Note 2: Coordinates given in Universal Transverse Mercator (UTM) Geodetic Datum Australia (GDA94, Projection MGA (Map Grid Australia) Zone 55.

In addition to survey sites studied on the Isaac River, five tributaries of the Isaac River (Eureka, Goonyella, Platypus, Fisher, and Ceil creeks) were also examined. Sites were selected taking into account historical aquatic ecology surveys to allow for temporal comparisons, and to ensure reference conditions were sampled. In a limited number of cases, site selection was constrained by the absence of water, as was the case for 12 Mile Gully, a small tributary to the Isaac River, which drains through the RHM footprint.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

AQUATIC ECOLOGY SURVEY POINTS

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AQUATIC ECOLOGY

Figure: **10-1**

File No: **42627136-g-1044.wor** Drawn: **VH** Approved: **CT** Date: **11-06-2013** Rev.**A** A4

Eureka Creek is the largest tributary of the Isaac River, within the survey area, which drains in a north-south direction joining the Isaac River in the southern portion of the EIS study area. The majority of this creek is upstream of any potential mine impacts and has been extensively impacted by cattle grazing. The development of GRM necessitated the diversion of part of Eureka Creek. The diversion is located in a corridor within the active GRB mine complex operation and is used to transport mine water to the GS4A dam on Eureka Creek. Releases from the GS4A dam operations occur when the environmental authority release criteria are satisfied. Mine water management is addressed in detail in **Section 7.3.2** of this EIS.

The reaches of the Isaac River immediately downstream of the Eureka Creek confluence also consist of an excavated diversion channel which diverts around the GRB mine complex operations (the Isaac River diversion).

Platypus, Fisher, and Ceil creeks are situated in the southern end of the EIS study area. These creeks have historically received intermittent volumes of mine affected water through diversions and are also disturbed through cattle grazing.

Goonyella Creek is in the north of the EIS study area and is potentially affected by Goonyella North Mine; 12 Mile Gully is located in the east of the site.

Stygofauna sampling was undertaken in 2011 from existing bores. Sites were chosen to ensure representative samples from geological units, which may be impacted by mine dewatering (refer to **Section 8**) and provide adequate coverage of the survey area. The ALS 2011 sampling sites for the stygofauna survey are listed in **Table 10-2** and located on **Figure 10-1**.

Table 10-2 Location of Stygofauna Sampling Sites in the June 2011 Survey

Bore ID	Aquifer	Easting [1]	Northing [1]
GW1	Moranbah Coal Measures	600214	7581417
GW2	Tertiary Sediments	604622	7590557
GW6	Back Creek Group	596744	7596096
39211	Moranbah Coal Measures	602622	7583440
43841	Quaternary	605082	7587287

Note 1: Coordinates given in Universal Transverse Mercator (UTM) Geodetic Datum Australia (GDA94, Projection MGA (Map Grid Australia) Zone 55.

10.1.4 Aquatic Habitat

The survey area is situated in the upper reaches of the Isaac River catchment within the geological Bowen Basin in east-central Queensland. The Isaac River is a major tributary of the Fitzroy River, which discharges into the Coral Sea near Rockhampton. At the Department of Natural Resources and Mines (NRM) stream gauge located at Goonyella Rail Bridge, the Isaac River drains a sub-catchment area of 1,215 square kilometres (km^2).

The sub-catchment falls within the subtropical, distinctly dry winter climatic zone (**Section 4**). The Isaac River and its tributaries are seasonally intermittent (ephemeral). The mean annual rainfall at Moranbah is approximately 600 millimetres, of which approximately 80 per cent is received between the months of November through March.

The survey area contains several ephemeral streams that form a series of discontinuous pools during low flow periods and which generally dry up completely in the dry season.

10.1.4.1 Aquatic Habitat Assessment

At the time of the aquatic survey (May 2011) *in situ* water quality was measured at all survey sites. The field measurements included water temperature, electrical conductivity, dissolved oxygen concentrations, and turbidity readings. These data provided context for the survey results (please note a full assessment of surface water quality is provided in **Section 7.2.6**).

Water temperature was recorded to vary across the survey area, from 12.2 degrees Celsius (°C) at Platypus Creek to 22.3°C at Fisher Diversion. Variation in water temperature was largely attributed to the time of day the temperature was recorded, the depth of the water, flowing or stagnant water, and the extent of shading by banks and / or overhanging riparian vegetation. For example, the Platypus Creek site was sampled in the morning, prior to peak temperatures; the mean depth of the creek was 0.3 metres though a pool with water deeper than one metre was present; and the stream was flowing with extensive riparian vegetation present. In Fisher Creek, the water flow was limited and shallow, running over boulders that would aid in warming the water.

Single ‘snap shot’ records of electrical conductivity (EC) values varied from a relatively low 280 microSiemens per centimetre (µS/cm) at the upstream control site on Eureka Creek to a relatively high 5,521 µS/cm at Eureka Creek downstream of the causeway. Releases from the GRB water management system via Eureka Creek had not occurred in the week prior to the survey (Ben Stewart of BMA, *pers. comm*). It is noted that repeat measurements are required to assess the validity / representativeness of these readings.

Electrical conductivities of 2,521 µS/cm and 3,706 µS/cm were recorded at Eureka Creek Middle Reach (site 9) and Fisher Diversion (site 6), each of which are recognised not to be affected by mining activity. This indicates that locally elevated surface water salinities are not uncommon in the area. Ceil, Fisher, and Platypus creeks (sites 11, 8, and 10) displayed a similar range of electrical conductivity readings. Variations in EC are expected to be partially attributed to the degree of evaporation within the isolated pools, and the subsequent increase in salt concentration.

Monitoring results for sites 3, 4, and 5 on the Isaac River were similar to the upstream Isaac River control site (site 12). Goonyella Creek exhibited a relatively high reading of 2,062 µS/cm suggesting effects of evaporation, possible discharges from the Moranbah North Mine, and/or localised erosion of sodic soils.

GRM operates under EA No. EPML00853413, September 2013 (formerly EA No. MIN100921609). This details compliance requirements for GRB in relation to discharges of mine water. This EA permits the release of mine affected water from the GS4A dam into the Isaac River when the following criteria are satisfied:

- Natural flow rate measured at the upstream Isaac River gauging station (upstream of confluence with Goonyella Creek) > 3 m^3/s.
- Release criteria under flow conditions:
  - the salinity of mine affected water released from GS4A must not exceed an EC of 10,000 µS/cm; and

– the salinity in the Isaac River at the downstream release point must not exceed an EC of 2,000 µS/cm.

The water quality objective for the protection of aquatic ecosystems in the area is pH 6.5 – 8.5. Median recorded pH is consistent with this objective (refer to **Appendix I8**). Measurements taken during the aquatic ecology study are consistent with historic data, but tend to exceed the nominated range (pH>8.5) including at upstream control sites. This suggests that the Isaac River contains naturally alkaline water under low flows.

The NRM (2011) dissolved oxygen water quality objective for the protection of the aquatic ecosystem is 85 to 110 per cent. Only water within the Fisher Diversion was consistent with this objective. Given that records from the control sites lie outside the recommended range it is suggested that impacts from grazing, decomposition of organic material, and the low flows evident at the time of sampling are contributing to the lower dissolved oxygen readings.

The NRM (2011) water quality objective for turbidity is less than 50 NTU. The median values for turbidity do not meet this objective at Fisher Creek, Platypus Creek, Upper Eureka Creek, Upper Isaac River and Lower Isaac River (refer to **Appendix I8**). Turbidity measurements met the objective at Isaac River upstream of Eureka Creek, at the Rail Crossing, and near the confluence with Platypus Creek. The mid reach of Eureka Creek also met the objective; however, control sites did not meet this water quality objective, indicating that catchment runoff may be contributing to turbidity. The water quality assessment (refer to **Appendix I8**) found that median turbidity exceeded water quality guidelines at all sites.

In-stream habitat in the study area was limited. This was attributed to scouring by high flow events and sand dominated unstable sediments. No aquatic macrophytes were recorded. However, riparian vegetation does provide some habitat, either in the form of trailing bank vegetation or by providing root mats. Undercut banks were also present in the Isaac River and Platypus Creek.

10.1.5 Macroinvertebrates and Stream Health

A total of 40,231 individuals from 48 taxa were collected from the 12 sites sampled in the survey area (**Appendix K3**). Diptera (true flies) was the most abundant order, followed by Ephemeroptera (mayflies), Trichoptera (caddisflies), Coleoptera (beetles) and Hemiptera (true bugs). Chironominae (Diptera) were the dominant taxa, representing 27 per cent of the total number of macroinvertebrates, and were present at all sites examined. Baetidae (Ephemeroptera) were the next most abundant taxa representing 27 per cent of the total number. Other abundant taxa included Tanypodinae (Diptera) with 10.3 per cent, Caenidae (Ephemeroptera) with 10.3 per cent and Leptoceridae (Trichoptera), with 6.3 per cent). Water mites, Mollusca (snails) and Crustacea were in low abundances. Diptera were the most diverse family with 13 taxa recorded, followed by Hemiptera and Coleoptera with eight taxa.

The highest abundances and taxa richness were recorded from Isaac River near the confluence with Platypus Creek (site 5). Ceil Creek (site 11) and Isaac River at Rail Crossing (site 4) also had high taxa richness with 28 taxa. The least abundant site was Goonyella Creek (site 7) with 195 individuals although this included 17 taxa. Fisher Diversion (site 6) contained the least number of taxa with 13, probably reflecting the impacts of channelisation and removal of natural habitat.

The biotic index SIGNAL (Stream Invertebrate Grade Number – Average Level) (Chessman 1995 and 2003) was determined for the families at each site. Families of aquatic invertebrates have been assigned pollution sensitivity grades based on their known sensitivity to a variety of pollution types. The resulting average value, or SIGNAL, can vary between 1 and 10, and can be used to assess a site's status in terms of water quality. For SIGNAL 95 a site with typically high water quality will have a high SIGNAL value (greater than six) and a site with probable severe pollution would have a low value (smaller than 4). The health grades produced using SIGNAL 95 do not apply to the average site score produced for SIGNAL 2. SIGNAL 95 and SIGNAL 2 (Chessman 2003) provide different views of the data and together provide for an interpretation of water quality from observed biota.

SIGNAL 95 scores were calculated for each site. The scores were relatively consistent across all sites with an average of 5.1. Eureka Creek Causeway (site 1) showed the most impact with the lowest SIGNAL score of 4.8. This site, along with Eureka Creek control site (site 2) and Fisher Creek upstream of Main Road (site 8) produced scores between 4 and 5 indicating probable moderate pollution. Isaac River, upstream of Eureka Creek (site 3), had the highest SIGNAL score of 5.5.

The Stream Invertebrate Grade Number – average level – 2 (SIGNAL 2) index uses a simple scoring system to provide an indication of water quality and ecosystem health (Chessman 2003). When used in conjunction with taxa richness, SIGNAL 2 can provide an indication of the types of pollution and other physico-chemical factors that are influencing macroinvertebrate community structure and function. SIGNAL 2 scores were calculated for each site and it was established that the 'health' rating of sites changes order. All sites ranged between 3.2 and 3.9. Fisher Diversion (site 6) and the Isaac River at the railway crossing (site 4) exhibit the highest average score and the least impacts with a score of 3.9. Eureka Creek Causeway (site 1) and Fisher Creek (site 8) exhibited the most impact with a SIGNAL 2 score of 3.2.

Based on the SIGNAL 2 characterisation plot developed by Chessman (2003) where SIGNAL 2 score is plotted against taxa richness, Fisher Diversion (sites 6), Isaac River upstream of Eureka Creek (site 2) and Goonyella Creek (site 7) may fall into Chessman's (2003) 'industrial or agricultural pollution category'. In this case these results are expected to reflect potential mining and/or grazing activity on water quality. All other sites may have high salinity level impacts. Refer to **Appendix K3**, Section 2.6.1 for a definition of the indices.

Plecoptera Ephemeroptera Trichoptera (PET) scores is another index based on the pollution sensitivity of macroinvertebrates. Three insect orders, Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are known to be more sensitive to pollution. The number of families within each order observed at a site is summed to provide the PET score. Generally, the higher the PET scores the higher the habitat and water quality rating. PET scores, which indicate the presence of sensitive taxa, were highest at Isaac River railway crossing (site 4) where seven taxa were collected. The lowest PET score was recorded from Platypus Creek at Goonyella Road (site 10) with two taxa.

The results indicate that there was a general increase in the health of the sites as evidenced through higher SIGNAL and PET scores compared to previous monitoring events collected in 2009 (FRC Environmental 2009) and in 2004 and 2005 (WBM Oceanics 2005). This is largely expected to be due to the increase in the time the sites were inundated and, therefore, the time mobile species have to colonise.

The macroinvertebrate community structures were typical of seasonal streams in central Queensland. Although taxa were not identified to species level, no freshwater macroinvertebrates within the study area are listed under the EPBC Act. Additionally, no taxa are listed under NC Act's endangered fauna of Queensland.

10.1.6 Fish

A total of 2,909 fish from seven species were collected across the survey area (**Appendix K3**). No exotic species were collected in the survey. All fish were examined for lesions, ectoparasites, and deformities. No fish examined exhibited any signs of disease.

The most abundant site was Goonyella Creek (site 7) where 1,010 individuals were collected. This site, along with Platypus Creek (site 4) and Eureka Creek at the Causeway (site 1), contained the highest species richness, with six of the seven species recorded. Within the Isaac River (site 5), the fish richness varied between two and five species. Sleepy Cod (*Oxyeleotris lineolata*) were restricted to the Isaac River at Railway Crossing (site 4). Glassy Perchlet (*Ambassis agaassizi*) with 1,229 individuals was the most abundant species in the survey area and was recorded at all sites except the Isaac River near Platypus Creek confluence (site 5). Eastern Rainbowfish (*Melanotaenia splendida*) was the next most abundant taxa with 858 individuals, followed by Spangled Perch (*Leiopotherapon unicolour*) with 325 individuals. Both species were recorded from all sites except the Isaac River near Platypus Creek confluence.

Five species were collected from the control site, Isaac River at Riverside (site 12). The absence or presence of taxa downstream is largely expected to be attributed to habitat structure. The control site on Eureka Creek contained four species and all species remained present downstream of mining activities. Abundances of Eastern Rainbowfish (*Melanotaenia splendida*) were higher in the downstream site than the control site.

Comparisons of fish community structure between sampling years is compromised by the more efficient sampling methods used in 2011. In 2001, the only equivalent site examined is from Eureka Creek where one Western Carp Gudgeon (*Hypseleotris klunzingeri*) and one Eastern Rainbowfish (*Melanotaenia splendida)* were collected (FRC Environmental 2009). Eastern Rainbowfish were abundant while Western Carp Gudgeon were not collected in the current survey.

In 2005 seven species were collected that included Western Carp Gudgeon, Midgley's Gudgeon (*Hypseleotris sp1*), and Leathery Grunter (*Scortium hilli*) that were not collected in 2011. In 2005 Western Carp Gudgeon were present at all sites examined except from a control site on Isaac River. In 2001 Western Carp Gudgeon were collected in higher abundances in the North Dam and Red Hill Dam. The species is known to be more common in areas of low water velocity and their spawning sites are known to be vulnerable to erratic fluctuations in water level (Pusey *et al*. 2004). Their absence in the 2011 survey may reflect high flow levels in the catchment and subsequent loss of suitable breeding habitat that includes aquatic and submerged vegetation, woody debris and backwaters. Only four individuals of Midgley's Gudgeon were recorded across 10 sites in 2005, although the species has been reported as widespread across coastal drainages of eastern Queensland. The species may still be found in vegetated backwaters or dams in the area. Leathery Grunter is considered an estuarine species and they migrate upstream with summer rainfall to spawn (Allen *et al.* 2002). The single juvenile individual may represent a stranded individual that was unable to return downstream before stream flow ceased.

None of the fish species collected within the survey area are listed under the EPBC Act. Additionally, no taxa are listed under the NC Act endangered fauna of Queensland. The Queensland *Fisheries Act 1974* and the Queensland *Fishing Industry Organisation and Marketing Act 1982* provide legislation for the management of fishes and invertebrates in marine and fresh waters. Presently, the only freshwater species listed is the lungfish *(Neoceratodus forsteri*). The Red-finned Blue-Eye (*Scaturiginichthys vermeilipinnis*) is currently being considered for listing. Neither species are known to exist within the study area (Pusey *et al.* 2004). While Morris *et al.* (2000) recommended listing Purple-spotted Gudgeon (*Morgurnda adspersa)* as rare in southern inland waters of southern Queensland, the species is common and widely distributed in coastal Queensland and the populations are not listed (Pusey *et al.* 2004).

10.1.7 Stygofauna

The presence of stygofauna within the region has been established, with recorded findings in the Clermont and Collinsville regions, and to south of Nebo (ALS, unpublished data). The groundwater quality, as discussed in **Section 8**, within the alluvial and Tertiary sediment aquifers is considered as potentially conducive to the presence of stygofauna.

A survey was conducted to assess stygofauna presence within the EIS study area. During this survey, samples were collected from five monitoring bores in the Quaternary alluvium material, coal seam aquifers of the Moranbah Coal Measures, units of the Back Creek Group, and Tertiary sediments within the EIS study area (ALS 2011). Laboratory analysis found no stygofauna presence within any of the samples.

The absence of stygofauna from any of the groundwater samples may be due to unsuitable local geological conditions (low porosity, low hydraulic conductivity), limited groundwater availability throughout the year, or unsuitable groundwater quality. It is, therefore, considered that the EIS study area itself offers very low opportunities for stygofauna. Refer to **Appendix K4** for further details.

10.1.8 Other vertebrates

The Fitzroy River turtle (*Rheodytes leukops*) is listed as 'vulnerable' both in Queensland and nationally (refer to the NC Act and EPBC Act). While not observed during the current survey or past surveys of the study area, the species may occur in the wider area and is listed by EHP (DERM 2007) as occurring in the Isaac River. The species prefers well oxygenated flowing streams and permanent water bodies, and as the Isaac River is ephemeral, this may not provide habitat of preference to the turtle. Nesting habitat is also not present.

10.2 Potential Impacts and Mitigation Measures

No aquatic fauna of special conservation significance were recorded during current or previous surveys of the survey area.

Impacts on the aquatic environment may occur during the construction and operational phases of the project and relate both to direct loss or alteration of aquatic habitat and impacts on aquatic organisms from degraded water quality.

10.2.1 Construction Earthworks and Clearance of Vegetation

There will be selective clearance of vegetation and earthworks at the mine industrial area (MIA), the Red Hill accommodation village, the road to the accommodation village, the conveyor route, the coal handling and preparation plant (CHPP), and across the underground mining footprint for the incidental mine gas (IMG) network. These works will expose soils, which can potentially lead to erosion and increased sediment loads into local streams.

Control of erosion and sediment loading in the waterways is essential to ensure the maintenance of aquatic ecological habitat structure. Controls will be implemented for all development, including construction of bridges, roads, tracks and the IMG pipelines, which impinge on waterways.

The following principles of erosion and sediment control will be applied:

- where practical, clean water flows will be diverted around disturbed areas;
- measures will be taken to minimise exposure of soils to erosive forces; and
- where erosion is unavoidable, devices will be installed to minimise release of sediment laden water from disturbed areas.

Erosion and sediment control plans will be developed prior to surface disturbance in any particular area. These plans will include an assessment of erosion risk at each location, and selection of appropriate diversion, erosion prevention and sediment capture methods. Current relevant erosion and sediment control guidelines will be utilised in preparation and implementation of erosion and sediment control measures.

Normal control measures will include limitation of vegetation clearance, use of sediment fences, and construction of stormwater diversion and containment structures prior to any substantial earthworks. Adjacent to sensitive areas such as stream lines, multiple levels of sediment control may be required to minimise sediment movement into water ways. Regular inspection and maintenance of sediment control works will be undertaken to ensure ongoing effectiveness. More details on erosion and sediment control is provided in **Section 5.3.3.4**.

If check dams or other sediment capture structures are installed on streams or drainage lines, these will be installed in accordance with the EHP (DERM 2010) *Guideline - activities in a watercourse, lake or spring associated with mining operations*.

The protection of the riparian zone outside of the intensive development zones is important to controlling bank erosion, and for the provision of allochthonous material that is expected to contribute to the function of the aquatic ecosystem. The main surface facilities of the MIA, accommodation village and CHPP do not require clearing in riparian zones. Management of disturbance arising from construction of the bridge, associated pipelines and IMG drainage infrastructure, is discussed further in **Sections 10.2.2** and **10.2.3**.

Interference with aquatic passage through the EIS study area will be minimised wherever possible to allow migration and breeding of fishes during flow periods.

With these measures in place, marked changes in habitat structures and aquatic ecosystem characteristics are not expected to arise from vegetation clearing and earthworks activities.

10.2.2 Construction of Isaac River Crossings (Bridgeworks and Other Infrastructure)

A road bridge is to be constructed across the Isaac River above the main drive of the RHM that will also carry water pipelines and gas pipelines associated with the IMG management system. As is typical with bridge construction on ephemeral rivers, construction will take place in the dry season if possible. The bridge is to be designed so that it does not markedly impede river flows or increase flood risk and, hence, will have minimal impact on fish passage (refer to **Section 3.7.2**). However, there may be some disturbance to the bed and banks of the river during construction which will need to be reinstated and stabilised.

Pipelines for gas and water and power lines may need to be buried under the river at one or two locations to be determined in the detailed design phase. Construction works would most likely be undertaken by open trench during the no-flow conditions, with the bed and banks stabilised and restored post-construction. Fish passage would, therefore, not be impacted.

There is a risk that should a flow event occur before stabilisation is complete, local erosion and increased sediment releases may occur. These impacts are likely to be temporary and are considered to have a minor (cumulative) impact on water quality and downstream habitat as the volume of sediment that might be released is relatively small. No mitigation measures are proposed other than to complete stabilisation works or make good any local erosion in the event that a flow does occur before stabilisation is finalised.

Minor loss of habitat may occur during bridge construction. The impact would primarily be confined to a narrow corridor across the riparian zone that would need to be cleared and, depending on bridge design, may be replaced with parts of the bridge structure. No effects on macroinvertebrates are expected if construction takes place during low flows.

10.2.3 Incidental Mine Gas Drainage Infrastructure

The project will require extensive surface infrastructure across the underground mine footprint to drain and manage IMG to enable the safe and efficient operation of the underground mine. IMG management will involve a series of gas drainage wells and a second set of wells to remove goaf gas post mining.

The IMG management system will consist of a network of IMG drainage infrastructure comprising pipes, water pipes, access tracks, and wells and well pads. Once mining is complete, goaf gas drainage wells will be required.

There will be numerous crossings across smaller drainage lines by gas infrastructure. These will consist of an access track that will remain in place for the duration of gas drainage activities and the gas and water pipes. The pipes will likely be laid in an open trench and buried. Construction will take place during no flow conditions wherever possible.

Power will either be overhead or buried with the gas and water pipelines. Depending on the streamline crossed it may be necessary to install culverts to allow for vehicle access. Although waterway barrier works approval is not required for works on a mining lease, consideration will be given to the Queensland Government Code for Self Assessable Development, Minor Waterway Barrier Works Approvals – Part 3 (culverts) and Part 4 (bed level crossings) where relevant and practical.

Tracks and trenched crossings will be stabilised and monitored (inspected) and managed.

The gas drainage infrastructure and the gas wells will result in surface disturbance across the RHM footprint which may result in increased erosion and, hence, increase the potential for sediment release to waterways. For details on sediment and erosion control that should be implemented to prevent impact to the watercourse, refer to **Section 5.3.3.4** and **Section 10.2.1**.

As the gas drainage infrastructure will be constructed up to 15 years ahead of mining the main focus during this stage will be to keep the streams as stable as possible, thus minimising habitat changes outside the immediate footprint of disturbance. Provided all stream crossings are managed and stabilised, and fish passage is maintained on major streams, impacts will be localised to the crossing location and significant changes in aquatic ecosystems and fauna assemblages is not expected at a site or sub-catchment level.

10.2.4 Spills and Leaks of Fuels and Chemicals

Construction and operation will require the use of heavy machinery and the establishment of fuel and maintenance workshops and depots containing diesel and oil. Consequently, there is the potential for fuel and oil spills that could contaminate waterways within the EIS study area.

The likelihood of significant waterway contamination is considered to be low since bulk fuel storage areas will be appropriately sited and bunded, and fuel handling procedures will be observed as set out in **Section 5.4**.

Spills and leaks of fuels and chemicals within the MIA, CHPP and accommodation village areas will be contained by stormwater management systems for these facilities. During early construction, before these stormwater systems are installed, erosion and sediment control systems will assist in capturing spills. Prompt containment and clean up of spills to land will minimise likelihood of mobilisation of contaminants to waterways.

There is a risk of fuel or oil spills arising from the use and refuelling of heavy machinery outside of these areas, particularly associated with IMG management activities and also construction of the bridge across the Isaac River. Works in and around waterways have the highest potential to cause contamination, including bridge construction, river crossings, access road construction and riparian zone works. Constraining work in streams to dry periods for stream line and river crossings will further reduce the risk of spread of any contaminant spill within the aquatic ecosystem.

The risk of significant contamination is considered low since leaks are likely to be of small volume and dispersed across the linear infrastructure. During construction and installation of IMG management infrastructure, erosion and sediment control measures will assist in isolating areas of vehicle movement and machinery. Prompt containment and clean up of spills will also reduce the likelihood of mobilisation of contaminants to waterways.

During high flow events, contaminants may be transported into the Isaac River and Fitzroy River systems, although resultant concentrations are likely to be diluted well below the tolerance thresholds of fauna. Overall, with control measures in place, impacts on aquatic ecosystems on the site and downstream are expected to be negligible.

10.2.5 Subsidence

The proposed underground longwall mining is projected to result in subsidence of portions of the overlying ground surface. The degree of subsidence will vary but is predicted to average between three to five metres. A maximum of six metres has been predicted assuming a worst-case scenario. This will result in marked localised changes to surface drainage patterns and topography as described by Alluvium (2011, **Appendix I6**). Changes may include avulsion, where stream channels alter to follow the alignment of the subsidence troughs, as well as bank erosion and upstream and downstream channel deepening. Ponds are expected to form, and some of these may be effectively permanent. Subsidence impacts and management of impacts on geomorphic processes and water quality is discussed in more detail in **Section 7.3.7**.

The introduction of deep pools through subsidence of the river bed will increase habitat availability for aquatic species in the short term. The pools are expected to provide additional and new refuge habitat for both macroinvertebrates and fish compared with current conditions and may therefore be considered a positive outcome of the project. No significant change in water quality is expected from current conditions (refer to **Section 7.3.5** and **Appendix I8**). However, the pools may be more highly stratified than current pool refuges due to the predicted depth.

While, over time, the subsidence voids in the river are predicted to fill up with sediment, numerous deep subsidence voids would act as pools in areas outside of the main river channel if they are not drained. These areas would act as newly created aquatic habitat and provide refuge habitat for aquatic fauna during the dry season.

Ponding along the main Isaac River channel is predicted to infill reasonably quickly due to sediment load in the river system. Ponding along 12 Mile Gully and tributaries may be effectively permanent due to the smaller catchment and lower sediment loads. Destabilisation of the river bank and channel deepening upstream and downstream are also expected as a result of the subsidence. In contrast to the creation of new habitat, these changes would cause readjustment of habitat through sediment movement and potentially the short term loss of riparian habitat and energy inputs such as coarse particulate matter. The loss of energy inputs will be a local phenomenon that may lead to an adjustment of local faunal assemblages or abundances (e.g. in the newly created pools) since taxa dependent on energy inputs will be less favoured and subsequently impact on taxa higher in the food chain. Careful management of erosion and riparian vegetation will be required to minimise long term effects. A subsidence management plan is to be prepared (refer to **Section 7.3.10** and **Appendix I7**).

Subsidence trough ponding extents and volumes outside the Isaac River channel were assessed and indicated a possible 44 ponding areas larger than two hectares, of varying degrees of permanence. The subsidence troughs are estimated to range from less than 10 megalitre capacity up to a maximum of approximately 1,100 megalitres. The average capacity would be approximately 210 megalitres. The largest areas of potential ponding would be up to 40 hectares, and the average area would be approximately 12 hectares. Formation of ponds is discussed further in **Section 7.3.7**.

With the increase in water habitat from subsidence, the macroinvertebrate diversity is expected to be maintained and possibly enhanced through the opportunity for highly mobile taxa to colonise the pools.

Conversely, impacts of erosion, sediment movement and changes in riparian vegetation habitat and inputs may result in a reduction of refuge habitat and diversity of both fish and macroinvertebrates.

The deeper pools that will be created through subsidence may result in an increase in an abundance of Sleepy Cod (*Oxyleotris lineolatus*), a large predator. Sleepy Cod were observed to be restricted to the Isaac River at the Railway Crossing where deep pools existed. Pusey *et al*. (2004) indicate the loss of Purple Spotted Gudgeon (*Morgurnda adspersa*) from Blue Range Station in the Burdekin River occurred within two years of the appearance of Sleepy Cod. Sleepy Cod are known to have a considerably higher fecundity than Purple Spotted Gudgeon (*ibid*) and this can lead to competition for resources as well as higher predation rates by Sleepy Cod. Of note is that subsidence, particularly in 12 Mile Gully, is expected to produce steep walled pools and with the addition of high velocity flows, this may act as a barrier to the movement of Sleepy Cod, which unlike Purple Spotted Gudgeon, are believed to have their dispersion limited by such conditions. For example, Purple Spotted Gudgeon have been found above waterfalls, while Sleepy Cod have been restricted to below such structures. Aquatic ecosystem monitoring will assist in identifying whether imbalances in fish populations are occurring. As discussed in **Section 7.3.6**, provided that stream channel erosion and bank stability is managed, subsidence is not expected to contribute to sediment loads in the Isaac River as sediment will tend to be trapped in the subsidence troughs.

10.2.6 Monitoring

Aquatic macroinvertebrate monitoring will be incorporated into the GRB mine complex receiving environment monitoring program to provide for the assessment of changes in the aquatic ecosystem arising from mining and post-mining subsidence.

Monitoring will be undertaken at or near the cessation of seasonal flow on a regular basis during the life of the future RHM, having regard to access and safety considerations. In the wet-dry tropics Humphrey *et al*. (1990) have shown that this timing represents the period when biological diversity is highest and when the summation of all contaminant runoff effects would be best measured and any effects most pronounced.

Survey design will generally follow ANZECC/ARMCANZ (2000) guidelines including adequate control and impact sites to provide statistically significant comparisons.

Many taxa have shown tolerances to the *in situ* parameters measured beyond that recorded in published material.

Water quality monitoring will be undertaken as part of the receiving environment monitoring program set out in **Section 7.3.9**.

10.2.7 Residual Impacts

Residual impacts associated with the proposed project are likely to be associated with sediment infill of newly formed pools in the river bed caused by subsidence. During the life of the mine monitoring of fauna and water quality associated within these pools will provide information on the likely impacts of these processes and may lead to the need to translocate species away from the pools.

Subsidence is also likely to lead to more permanent refuge habitat on the floodplain. This is considered a positive residual impact that would aid in maintaining biodiversity.

10.2.8 Decommissioning Phase

Rehabilitation of streams and riparian zones will assist in ensuring that impacts from proposed works are managed in such a way that maintains local ecological functionality. As part of the site rehabilitation, snag habitat and overhanging vegetation will be provided as these will add to the habitat quality for aquatic fauna. For further details of site rehabilitation refer to **Section 5.5**. Stabilisation of soil through vegetative control throughout all non-operational zones will be completed to reduce the risk of potential unforeseen erosive events (refer to **Section 5.3.3** for further details).