11.0 Biology

11.1 Summary

11.1.1 Freshwater Sawfish

A survey of freshwater fishes particularly targeting the Freshwater Sawfish (*Pristis microdon*) was undertaken in May 2006 in the McArthur River to provide additional data on the distribution and abundance of this species. The survey sampled the three permanent waterholes upstream of McArthur River mine (Djirrinmini, Eight Mile and Bessie Springs), and tidal and non-tidal reaches of the river downstream. From a regional perspective, the upper reaches of the McArthur River may be described as marginal habitat for *P. microdon* in comparison to other Gulf rivers. The section of the river to be diverted is unlikely to represent a significant refuge or resting habitat for *P. microdon* other than providing a relatively unobstructed transitory route to upstream habitats such as Eight Mile Waterhole.

It is recognised that in the short term, the diversion channel will not provide optimal habitat for fish exploitation or migration. However the rehabilitation strategy will be to stabilise the channel and to maintain/restore ecological function as quickly as possible. On the basis of the proposed rehabilitation design, adequate passage for fish species currently using the river will be maintained. To confirm this, a comprehensive monitoring program is proposed which will include the monitoring of fish populations in seasonal and refuge pools and tidal reaches, metals levels in fish, and fish passage through the diversion.

11.1.2 White-Browed Robin

The White-Browed Robin (*Poecilodryas superciliosa)*, which is listed as a migratory species under the EPBC Act, is a common species within riparian vegetation along the main McArthur River channel. The primary impact that the Open Cut Project may have on this species is habitat fragmentation brought about by partial clearing of the existing McArthur River channel. However, fragmentation of fauna populations along the riparian corridor will not be as sudden or significant as if the entire existing channel was cleared at once. Given the phased clearing proposed for the existing channel and the gradual establishment of vegetation along the realigned channel, there will be a transition over 10 years from the functionality of the existing river channel as a fauna movement corridor, to that of the diversion acting as a fauna movement corridor. Because of this, no significant impacts on the White-Browed Robin and other riparian species are expected.

11.1.3 Migratory Birds at Bong Bong

The nature and extent of the existing operations at Bing Bong will not change as a result of the Open Cut Project. To minimise the risk of spills to the marine environment, strict operational procedures are followed. Since operations commenced at Bing Bong in 1996, there has been no major spills of concentrate into the sea, and the minor amount of spillage that has occurred has not resulted in any significant impacts on water quality, sediment or marine biota.

Metal contamination in food sources has the potential to affect migratory birds, as they are relatively long-lived organisms at the top of the food chain. However, identifying the source of contamination is difficult due to the migratory nature of these birds, some of which travel seasonally to northern hemisphere countries.

A two-stage monitoring program of migratory birds is proposed. The first stage will include surveys of migratory birds to identify species present, and their abundance, in the area of potential impact from Bing Bong operations. The regional significance of this area could then be determined, and the chief food sources of the birds identified. The value of undertaking a second stage of the program to monitor food species for heavy metals would be assessed, based on the first stage results.

11.1.4 Monitoring Programs

Monitoring programs for aquatic ecology, riparian birds and migratory birds are presented in this section. All programs are currently in draft form as detailed information such as sampling size and frequency, sample sites, and data collection/analysis methods cannot be finalised until preliminary field survey trials are undertaken. Following initial field surveys, the programs will be refined and presented to the Northern Territory Government for comment, after which agreed commitments will be made.

Initially, the aim of the programs will be to establish levels of natural variability, after which threshold values for change may be set. Should future remedial responses be required, these will be managed according to the type, level and extent of the problem as it arises.

11.2 Aquatic Ecology

11.2.1 Aquatic Biodiversity and Ecology

Surveys of freshwaters of the McArthur River indicate that at least 43 fish species (including brackish water species) are present. Of these, about 31 use the reach of the McArthur River proposed to be diverted for seasonal migration or habitat. Macroinvertebrates are present in riffles, edge habitats and permanent pools along the main river channel and in tributaries such as Barney Creek.

The abundance of macroinvertebrates in the proposed diversion reach is lower due to reduced habitat diversity and the transience of the habitat. Aquatic reptiles that use this reach include freshwater crocodile, Worrell's Turtle and Arafura File Snake.

Virtually all of the fish species inhabiting the McArthur River are wide ranging and none are known to be restricted to that catchment. The McArthur River is a highly seasonal system which, unlike other southern Gulf systems such as the Roper, Towns and Gregory Rivers, ceases to flow for much of the year.

The reach of the McArthur River to be diverted has no permanent refuge pools. As such all fishes currently using this area must retreat to permanent pools in other sections of the river by the end of the wet season in order to survive till the following year.

Upstream, there are several permanent pools, the largest and most important of which is Eight Mile Waterhole, about 5 km upstream of the proposed diversion. Other permanent pools include Djirrinmini Waterhole (1 km upstream) and Bessie Springs (20 km upstream). A number of permanent pools are also present in the Glyde River, a major tributary of the McArthur which enters at a point about 1 km downstream of the proposed diversion channel.

Below the mine area, there are no permanent freshwater pools until well downstream of the Bukalara Range towards Borroloola. Below the Burketown Crossing at Borroloola, the river forms into an estuarine complex, debouching into the southern Gulf via a mangrove delta.

A literature review of the ecology of major components of the fish fauna inhabiting the McArthur River is summarised in Appendix K. This information has been compiled from Allen *et. al.,* (2002), Bishop *et. al.,* (2001), Merrick and Schmida (1984) and Pusey *et. al.,* (2004) and is summarised below.

Nine species grow to 20 to 50 cm in length, seven are between 10 and 20 cm, and two species are generally less than 10 cm (Glassfish *Ambassis spp.* and Fly-specked Hardyhead *Craterocephalus stercusmuscarum*). Three species that commonly attain lengths of over 100 cm are found in the river. They are Barramundi (*Lates calcarifer),* Freshwater Sawfish (*Pristis microdon)* and Ox-eye Herring *(Megalops cyprinoides)*. These three fishes are considered migratory and likely to breed in marine waters only.

Data on longevity and age at sexual maturity are available for 14 species. Most species live for 2 to 5 years, two are relatively short-lived (less than 2 years), two live up to 7 years, and one species (Barramundi) is a long-lived species (up to 20 years) although only about 3 to 4 years of that are spent in freshwater rivers. Eight species reach sexual maturity in their first year, four species mature between one and two years of age, one species matures between two and three years of age, and Barramundi take three or more years to reach sexual maturity.

There is a wide range in the temperature tolerances of most species, due in part to their wide distributions. Ten species tolerated cool water below 20^{o}C, whilst all species have been found in waters of 21^{o}C or more. Fifteen species can tolerate water with temperatures over 30^{o}C, nine of which can tolerate water over 35^{o}C. Flat-head Goby *Glossogobius spp* and Sleepy Cod *Oxyeleotris spp.* have been found in the most restricted temperature range with the lowest maxima (20 to 30^{o}C).

All 17 species for which data are available on habitat water chemistry have been found in water with a pH range of 5 to 7.7. Of these, 11 species tolerate more acidic water below pH 5, 10 species live in alkaline waters between pH 8 and 9, and 3 species tolerate a pH over 9.

Dissolved oxygen (DO) levels below 2 mg/L and down to 0.1 mg/L have been recorded in the habitats of 12 species, whilst 4 species have been found in water with DO between 2 and 3 mg/L and 1 species (Sooty Grunter *Hephaestus fuliginosus*) occurs in water with DO over 4 mg/L. All species are found in water with a wide range of conductivity and turbidity measurements.

Eight species are generalists using two or three of the available river habitats for feeding. Five species are benthic feeders, five feed in the water column and two feed on the surface of the water. Most species are omnivorous and eight species are generally carnivorous, consuming aquatic macroinvertebrates and fish. Omnivores also eat algae, detritus and aquatic macrophytes.

Most species breed from the early to mid wet season (September to December). Mouth Almighty (*Glossamia aprion*), Flathead Goby and Barred Grunter (*Amniataba percoides*) also breed in the late dry season, and Bony Bream can breed year-round. Most of the species breed in lentic areas of freshwater, except Sawfish, Ox-eye Herring, Barramundi and Flathead Goby, which breed in the marine environment. Young of these four latter species migrate upstream to spend their juvenile years in freshwater reaches of rivers, while mature/maturing individuals move downstream to saltwater to breed.

Most obligate freshwater species show movement of young and adults up and downstream to and from dry season refugia, and movement of adults to suitable breeding areas within the river or connected waterbodies. Forktail Catfishes (*Arius spp.)* and Eel Tail Catfishes *(Neosilurus/Porochilus spp.)* migrate upstream mostly at night, Glassfish at dusk and dawn, and other species mostly during the day.

In the light of the above biological information on fish species that occur in the McArthur River, the proposed diversion channel area of the river is of importance for fish movements rather than for feeding or breeding. All species are tolerant of a range of water chemistry and temperature parameters, making them well adapted to the dramatic seasonal changes of the wet/dry tropics. Furthermore, the dynamic nature of tropical rivers, variations in channel structure between monsoonal seasons, and the opportunistic foraging habits of many northern fishes suggest these species will be capable of travelling through the proposed diversion channel.

11.2.2 Freshwater Sawfish

A survey of freshwater fishes particularly targeting the Freshwater Sawfish (*Pristis microdon*) was undertaken in May 2006 in the McArthur River to provide additional data on the distribution and abundance of this species. The survey sampled the three permanent waterholes upstream of McArthur River mine (Djirrinmini, Eight Mile and Bessie Springs), and tidal and non-tidal reaches of the river downstream. A total of 29 species of freshwater or brackish water fish species were recorded in the survey, including the capture of one sawfish at Eight Mile Waterhole. Full results of the surveys are presented in Appendix L.

The decline of sawfish populations throughout the world has resulted in the listing of the Freshwater Sawfish as Vulnerable in Australia under the EPBC Act 1999, and internationally as Critically Endangered under the IUCN Red List (IUCN, 2006).

Freshwater Sawfish migrations occur at both the early juvenile stage and again prior to attaining maturity (Thorburn *et. al*., 2004, submitted). Juvenile Freshwater Sawfish migrate upstream into freshwater habitats from their estuarine birth site, presumably to take advantage of waters that have fewer large predators and offer favourable feeding conditions (Thorburn *et. al*., 2004). This was indeed the case of the individual that was captured from Eight Mile Waterhole in May 2006.

Individuals have been found up to 400 km inland in the Fitzroy River in Western Australia (Morgan *et. al*., 2004). At approximately four years of age (and 2.8 m in length) individuals migrate downstream to the estuary and marine environment where they attain maturity and reproduce. Here they can attain a maximum length of 6 m (Thorburn *et. al*., 2004, Last and Stevens, 1994). Thus, individuals of the species which utilise upstream reaches require habitats that facilitate both upstream and downstream migrations.

Results of ichthyological surveys of northern Australian rivers suggest those that contain permanent deeper waters, attributable to a large catchment area or spring/groundwater feeding etc, and which maintain a comparatively high level of interconnectedness between dry season pools, may contain higher numbers of sawfishes than those systems that have limited permanent waters or disjunct pools (Thorburn *et. al*., 2003).

From a regional perspective, the upper reaches of the McArthur River may be described as marginal habitat for *P. microdon* in comparison to other Gulf rivers, such as the Roper River. It is possible that the permanent nature of estuarine waters and complex tidal delta of the lower McArthur River is more likely to hold higher numbers of *P. microdon* throughout the year than upper freshwater reaches.

The section of river proposed for diversion shows a high degree of homogeneity in the channel, a consistently shallow depth (and high flow rate), the absence of deeper and wider sections, a lack of permanent water, and no evidence of bank undercutting. Based on these characteristics, it is unlikely to represent a significant refuge or resting habitat for *P. microdon* other than providing a relatively unobstructed transitory route to upstream habitats such as Eight Mile Waterhole.

11.2.3 Management and Mitigation of Fish Passage throughout the Diversion Channel

It is recognised that in the short term, the diversion channel will not provide optimal habitat for fish exploitation or migration. The aquatic habitats of the existing McArthur River reach to be diverted are described in Section 4.4. Key features of the reach important to aquatic biology are:

- A sandy, low-flow run channel with no permanent refuge pools
- An absence of significant riffles, rock-bars or undercut banks
- A high level of shading, notably through large tree cover (especially *Melaleuca argentea* and *Casuarina cunninghamiana*) and a semi-continuous edge cover of *Barringtonia acutangula* which offers protection from heat and predators
- Primary in-stream habitats, which include large woody debris accumulations and large in-stream trees, that create quiet areas suitable as fish resting sites.

The results of the preliminary ichthyological survey (Appendix L) confirmed that Freshwater Sawfish, in addition to other migratory fish species, transit the section of river proposed for diversion. While a visual inspection of that section did not reveal any habitat that would be considered to be significant for Freshwater Sawfish (or any other species), its function as a relatively unobstructed passage to upstream habitat remains important.

A key design objective of the diversion is to ensure that the channel does not create a barrier that:

- Restricts or impedes the upstream or downstream migration of fish species
- Reduces the length of the potential migration period

- Results in the biological segregation of upstream and downstream populations of non-migrating species.

One of the principal management considerations in relation to the design and construction of the diversion channel is to stabilise the channel rapidly, and to maintain/restore ecological function. In this respect a priority in constructing and managing the channel will be the re-establishment of riparian vegetation, particularly key edge and in-stream habitat species such as *Barringtonia* and *Melaleuca*. A description of the proposed rehabilitation program is detailed in Section 4.6.

The 'randomness' of a naturally occurring riverine channel is important for the passage of fishes. All physical characters of the channel such as the degree of sinuosity, riverbed contour, in-stream debris, aquatic vegetation, root mats and riparian vegetation draped in water etc, are important in creating slower moving, still waters and eddies that facilitate the migration of fishes.

The current design includes large woody debris randomly distributed throughout the river channel, anchored in place. The addition of woody debris of varying sizes is essential in off-setting riverine flow, and can also lead to the creation of naturally occurring log jams and deposition of island forming sediments. Furthermore, drag created by a non-homogenous bank can promote undercutting and the formation of back-waters which can favour cryptic and bottom dwelling species.

Bank vegetation is important not only in terms of providing in-stream habitat, but also in providing shade. A lack of shading can result in variations in water surface temperatures and light attenuation, which may affect fish foraging behaviours and predation. While shading is difficult to replicate in the short term, it can be achieved with the rapid establishment of bank vegetation, in particular species that grow along the water's edge, such as *Barringtonia acutangula*. The use of bank vegetation and shading can subsequently aid in the migration of prey species and, alternatively, provide cover for ambush predators.

Two engineered rock riffles are proposed to be placed in the upstream alluvial section of the diversion channel. The purpose of these riffles is to reduce flow velocities and stream power and to reduce the risk of erosion of young bank-side vegetation. The design of these riffles has been developed to ensure that disruptions to fish passage is minimised.

The sloped design (of both up and downstream sides), relatively low height (approximately 1.5 m), and construction using natural rock (hence variability in form) should not hinder migration of fishes during peak migration periods when water levels will be higher than the riffle. Furthermore, the 20:1 down-river slope ratio is consistent with the slope incorporated into rock ramp fish ways (Morgan and Beatty, 2004a and 2004b; Morgan *et. al.,* 2005), and should function in a similar fashion when water levels are retreating.

It is important to note that a number of naturally formed rock bars already exist in the McArthur River upstream and downstream of the diversion reach. The rock bar that forms the downstream end of Djirrinmini Waterhole is an example. It is clear that these rock bars do not hinder the existing migration of fish up and down the river.

Small pools will also be created in the bed of the new channel, and minor pools will also form upstream of the rock riffles. These pools will be no more than 1 m deep at low flow. Small pools within the channel

have the potential to trap migrating fishes early in the dry season. This is a natural occurrence in the monsoonal tropics, and the small fish in drying pools provide food for other fauna, such as birds. Development of large pools will not occur as depths will be no more than approximately 1 m. This will ensure that larger species (e.g. Barramundi, crocodiles) do not remain and become trapped in the drying channel.

The proposed ongoing monitoring of fish distribution, abundance and migration data will provide an indication of the utilisation of the diversion channel, and the ability of the channel to function in an ecological sense. If, in subsequent years, the particular features of the channel prove to be a barrier to fish passage, a review of the design would be undertaken.

11.2.4 Proposed Aquatic Monitoring Program

One of the commitments made in both the Draft and Supplementary EIS documents (URS, 2005a; 2005b) was for an ongoing monitoring program to assess the condition of aquatic biota along the McArthur River, to identify potential impacts, and to use the data in formulating mitigation and contingency plans.

To reaffirm this commitment, and following further discussions with the EPA and other Northern Territory Government agencies, the proposed monitoring program is outlined in greater detail in this section. Further details will be developed following additional Northern Territory Government discussions and further field surveys to identify the optimal locations for sampling sites.

The program is proposed to have a number of components, which are described below.

Monitoring Fish Populations in Refuge Pools and Tidal Reaches

This program is proposed to involve annual late dry season sampling of fish populations in the known refuge pools both upstream and downstream of the proposed river diversion. Upstream pools targeted for study will include Djirrinmini Waterhole, Eight Mile Waterhole (2 sites), and possibly as yet unsurveyed sites in the Balbarini area. Downstream sites will include one site near the tidal limit and one site below the Burketown Crossing. Additionally, it may be advantageous to sample within a permanent pool in the Glyde River.

Sampling methods will be standardised, and will include gill netting, seine netting and electrofishing. Fishes caught will be counted, identified, measured and released into the water. Information on the Freshwater Sawfish populations in the river will be collected as part of this study.

Monitoring Fish and Macroinvertebrate Populations in Seasonal Pool/riffle Habitats

The monitoring program for seasonal pools will involve an annual early dry season survey of habitats while they are still available. Potential sites to be investigated include Barney Creek, an upstream site such as Djirrinmini Waterhole (rock-bar), and one downstream site below the Glyde River confluence. Additionally, sites within the diversion channel, probably located at the rock riffles, could be sampled.

Sampling methods will include macroinvertebrate collection using AUSRIVAS protocols, and seine netting or electrofishing for fish. Habitat parameters will be recorded at all sites.

Monitoring for Heavy Metals in Aquatic Biota

Fish tissue and liver samples will be collected annually during the course of the monitoring program from every site and for heavy metals analysis. If mussels or crustaceans are encountered they will be collected also, although based on previous observations, these groups are not abundant in the river.

Collected samples will be frozen and forwarded to a certified laboratory for analysis, most likely by ICP-MS scan.

Monitoring Fish Passage through the Diversion Channel

From an aquatic ecological perspective, it is important that the diversions do not compromise key aspects of the river's ability to provide fish passage and micro-habitats for fishes and invertebrates. The diversion has been designed to allow passage for both diadromous and potamodromous fishes.

To determine whether or not the diversion is successful in enabling fish passage, the following monitoring options are being considered. The preferred option(s) will depend on a range of factors including logistics, efficacy, cost, and resource availability.

Tagging Program of Key Species

It is important to assess the extent to which Freshwater Sawfish will utilise the diversion. Tagging Freshwater Sawfish would allow the assessment of whether the diversion is successful in providing species access to sites upstream of the diversion, while also enabling the downstream movements of larger individuals.

One option available for tagging is acoustic telemetry with the use of listening stations (hydrophones). This allows the study of real-time behaviour and habitat utilisation including the extent to which the individuals utilise the diversion. For example, Freshwater Sawfish could be tagged both upstream and downstream of the diversion, and hydrophones strategically placed throughout the diversion and the river in general.

In addition, the use of a cattle style tag placed in the first dorsal fin, which has a call-in contact number and a specific tag number, would be used to report the location of the individual upon recapture.

Barramundi is an iconic species that utilises the freshwaters as nursery and feeding grounds, and then migrates downstream to the sea/estuary to breed. From a public and ecological perspective, it is important that Barramundi are shown to use the diversion to reach upstream parts of the river. A tagging program will be implemented with conventional tags and recapture methods used to assess migrations.

Assessing Temporal Migration Patterns of the Fishes Within the River and Determining Habitat Associations and Utilisation of the Diversion

A sampling program will be implemented to determine the extent to which other fishes utilise the diversion during critical migratory periods. For example, fyke nets may be strategically placed throughout the diversion (and in other riverine/tributary sections) to determine both the temporal upstream and downstream movements of the different species. This would allow an assessment of not only spawning migrations of potamodromous fishes, but also the level of recruitment.

The habitat associations and diversity of fishes within the diversion would also be assessed and compared to unmodified sections of the river.

Sampling of Key Sites both within the Diversion and Upstream and Downstream

Sampling of fishes within the diversion and sites immediately upstream and downstream will be used to provide an indication of the success of the diversion in facilitating fish passage. Ideally, sampling of this nature would be conducted early in the wet season when the river becomes interconnected, however it should avoid peak flows. Sampling would be undertaken with the use of quantified seine netting and electofishing, and successive annual samples should indicate the success of establishing suitable habitat in the diversion area.

11.3 White-Browed Robin

11.3.1 Conservation Status

The White-Browed Robin (*Poecilodryas superciliosa*) consists of two subspecies: *P. s. cerviniventris* which occurs in Western Australia and the Northern Territory; and *P. s. superciliosa*, which occurs in north-eastern Queensland. The north-western race is known as the Derby White-Browed, or Buff-sided Robin and is recognised by some authorities as a distinct species (Schodde and Mason, 1999). This is the race that occurs in the McArthur River area.

The species is not listed in any threatened category under Northern Territory or Commonwealth legislation, nor is it listed in the most recent IUCN Red Data list revised in May 2006 (IUCN, 2006). It is listed under the Commonwealth EPBC Act as a 'migratory' species. The reasons for this listing are unclear, as literature review indicates the species to be sedentary, rarely moving more that 10 km (Higgins *et. al.*, 2002).

However, the White-Browed Robin has been identified as a species that is strongly associated with riparian habitats and monsoon vine thickets, and has declined in the Northern Territory in these habitats due to the impacts of grazing and fire (Woinarski *et. al.*, 2000). For this reason it can be considered as an indicator species of habitat fragmentation and hence is of interest irrespective of the reason for its Commonwealth listing.

11.3.2 Status at McArthur River

Within the McArthur River area the White-Browed Robin is common in riparian vegetation along the main McArthur River channel, and in the riparian vegetation and small monsoon vine thickets associated with side gorges in the Bukalara Range/Glyde River area (P. Barden, unpublished records). Elsewhere on McArthur River Station, this species has also been observed in isolated monsoon vine forest in the Abner Range in habitat that is distant from contiguous riparian habitats.

During timed area searches (20 min/2 ha) undertaken in riparian habitats along the McArthur River (adjacent to the existing mine) and along the Glyde River during 2003, the White-Browed Robin was a relatively common species, with a mean number of observations per 20-minute sample of 0.45 individuals (19th most common of 51 species). The White-Browed Robin was detected in 27.3% of surveys within riparian habitats. Most observations were associated with denser vegetation on the banks of the river on the main McArthur River channel, in small patches of monsoon vine forest and in *Melaleuca* species in the Glyde River gorge. Birds were recorded singly or in pairs (Appendix J).

The ability of this species to disperse and move within the landscape remains poorly known, and while it is thought to be relatively sedentary, local movements (<10 km) have been reported (Higgins *et.al*., 2002). The presence of this species in relatively isolated patches of suitable habitat, such as monsoon vine forest in the Abner Range and small patches of habitat separated for some distance by apparently unsuitable habitat in the Glyde River/Bukalara range, suggests that the White-Browed Robin is able to move across areas of unsuitable habitat.

11.3.3 Impacts and Proposed Monitoring Program

The primary impact that the project may have on the White-Browed Robin is of habitat fragmentation brought about by partial clearing of the existing McArthur River channel to make way for the Open Cut Project. However, as discussed in Section 4.7, fragmentation of fauna populations along the riparian corridor will not be as sudden or significant as if the entire existing channel was cleared at once.

Most studies focusing on the use of corridors by wildlife have examined corridors that have been left in a fragmented landscape, rather than restored corridors or projects that aim to re-establish riparian corridors (Jansen, 2005). Many of the studies associated with restoration of mined areas in northern Australia have concentrated on the rehabilitation of areas of habitat within an undisturbed surrounding landscape, rather than the re-establishment of a narrow band of a specific habitat within a wider habitat matrix.

However Jansen (2005), in a study of the restoration of riparian vegetation linking remnant rainforest patches in the wet tropics of Queensland, found that a riparian restoration project could re-establish connectivity for forest birds and provide habitat for closed forest specialists.

As discussed in Section 4.7, it is expected that the extensive revegetation program proposed for the diversion channel will, in time, result in the re-establishment of the riparian corridor. Given the phased clearing proposed for the existing channel and the gradual establishment of vegetation along the realigned channel, there will be a transition over 10 years from the functionality of the existing river channel as a

fauna movement corridor, to that of the diversion acting as a fauna movement corridor. In this way the corridor function of the McArthur River will be maintained.

The comprehensive bird monitoring program presented in Appendix J is proposed to confirm the success of the rehabilitation program in providing a fauna movement corridor along the diversion channel.

11.4 Migratory Birds

11.4.1 Migratory Bird Fauna at Bing Bong and McArthur River Estuary

The estuarine complex at the mouth of the McArthur River, 60 to 100 km downstream of the mine site, is of conservation value as it forms part of the Port McArthur Tidal Wetlands System as listed in the Directory of Important Wetlands (Jaensch, 1993).

This wetland system comprises 119,000 ha of tidal wetland at and around Port McArthur and the Sir Edward Pellew Group of islands. It is the only substantial area of mangrove swamp, and the largest area of inter-tidal mudflats, in the south-west of the Gulf. It is described as 'a major migration stop-over area and possibly a major over-wintering area for shorebirds' as well as 'an important seabird (tern) breeding area'.

Bird species listed as migratory under the EPBC Act are recognised as significant and include species listed in three international agreements to which Australia is a signatory nation. These agreements are as follows:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

A list of all migratory sea and shorebird species included in the EPBC Act that have been recorded or could potentially occur in the Bing Bong/McArthur River area is presented in Appendix M. Twenty six of these have been recorded in the Bing Bong/McArthur River area previously (Chatto, 2000; 2001; 2003).

Four additional species have been recorded in Barrett *et. al.*, (2003), and an EPBC data search of a 5,844 km^2 area including 110 km of Gulf coastline and the Pellew islands identified two additional shorebird species and an additional seabird. The remaining 25 species are uncommon to rare species that have been recorded in other areas of the Top End infrequently and in low numbers.

The migratory status and feeding habits of species recorded in the region are summarised from existing literature in Appendix M.

Forty one of the migratory species listed are northern hemisphere breeding species that arrive in northern Australia from August. Many of these species disperse throughout much of Australia, but large numbers remain in coastal areas of northern Australia until departing in March and April. They mainly forage on the inter-tidal sand and mudflats, and roost on sandy beaches and promontories at high tide. It is possible that some shorebirds over-winter in the area.

Two birds of prey, White-Breasted Sea-Eagle (*Haliaeetus leucogaster*) and Osprey (*Pandion haliaetus*), have both been recorded in the vicinity of Bing Bong. While listed in international migratory treaties, Australian populations of these species are mostly sedentary, although they may forage over wide areas (Marchant and Higgins, 1993).

Most of the larger seabirds probably forage away from the shallow waters near the coastline, although the smaller terns utilise the shallow near-shore and island waters. The four waterbird species forage in a variety of habitats along the coastline and islands, including inter-tidal mudflats, mangroves, saline coastal flats and rocky shores.

In the most recent surveys, the most abundant shorebird species in the Bing Bong/McArthur River estuary area were: Great Knot (*Calidris tenuirostris*); Grey-Tailed Tattler (*Tringa brevipes*); Greater Sand-Plover (*Charadrius leschenaultia*); Lesser Sand-Plover (*Charadrius mongolus*); Red-Necked Stint (*Calidris ruficollis*); Black-Tailed Godwit (*Limosa limosa*); Bar-Tailed Godwit (*L. lapponica*); and Curlew Sandpiper (*Calidris ferruginea*) (Chatto, 2003).

In 1990, a high proportion of Sharp-Tailed Sandpiper (*Calidris acuminate*) were recorded at the McArthur River mouth on their northern migration (Garnett and Taplin, 1990). Compared with the inter-tidal mudflats along much of the coast, the extensive saline flats and mangroves around the McArthur River estuary do not support large numbers of shorebirds (Chatto, 2003). Generally, the Bing Bing/McArthur River mouth area supports lower concentrations of shorebirds than the south-east and far south-west of the Gulf.

Six of the local migratory species have been recorded breeding in the area (Appendix M). Great Egrets (*Egretta alba*) breed in two of the five reported waterbird breeding colonies in the area (Chatto, 2000). These are large colonies of 1,000-5,000 birds of 4 and 7 species respectively, located near the McArthur River mouth and on a mangrove island east of the Wearyan River. These colonies can be active from March through to August.

The Osprey and White-Breasted Sea-Eagle are known to breed on several of the Sir Edward Pellew Islands. Three migratory terns (Little Tern *Sterna albifrons*, Bridled Tern *S. anaethetus* and Black-Naped Tern *S. sumatrana*) also breed along the coastline and islands.

Around the Sir Edward Pellew Islands more than 10 breeding colonies of 2 to 60 Little Terns, 9 colonies of 11 to 25 Black-Naped Terns, and 7 breeding colonies of 50 to 500 Bridled Terns have been recorded (Chatto, 2001). Most breeding colonies are active from September to December.

Surveys undertaken from November 1993 to May 1999 have located at least two breeding colonies of 11 to 500 Little Terns and one rookery of 101 to 500 Black-Naped Terns west of Bing Bong, and at least four breeding colonies of 2 to 100 Little Terns well to the east of the McArthur River mouth. Chatto (2001) has recorded two Little Tern colonies approximately 15 km (colony S066) and 35 km (colony S082) to the north-west of Bing Bong.

11.4.2 Current Monitoring Program at Bing Bong

The Environmental Analytical Chemistry Unit of Charles Darwin University has been conducting an annual environmental monitoring program since 1995 to assess whether the Bing Bong loading facility may be having an impact on the coast and islands. Seawater, surface sediment, one oyster (*Sacostrea* sp.), two marine gastropods (*Telescopium telescopium* and *Terebralia semistriata*), and seagrass are sampled for heavy metal concentrations (cadmium, copper, lead and zinc).

Results show that the Bing Bong operation has a low level of localised impact, largely within the dredged access channel. However, concentrations of zinc, cadmium and lead in surface sediments from the beach immediately west of the channel have shown elevated levels since 1996, compared to sites east of the channel and offshore (Munksgaard and Parry, 2006).

Concentrations of zinc, cadmium and lead in oysters have remained within historic ranges, but copper from Rocky Reef, west of Bing Bong had an unexplained increase in 2005. Heavy metals in the two mollusc species from the beach west of the load-out facility have remained elevated, and lead isotope ratios indicate an uptake of ore-concentrate derived lead dispersed from the load-out facility towards the west.

Heavy metals in seagrass fluctuated from 2002-2005 due to natural seasonal effects but there may be occasional dispersion of concentrate-derived lead. However, there is no heavy metal contamination in seawater along the coast or offshore sediments, indicating no regional impacts have occurred as a result of the Bing Bong operations.

11.4.3 Impact Assessment of Migratory Bird Species at Bing Bong

The nature and extent of the existing operations at Bing Bong would not change as a result of the Open Cut Project. To minimise the risk of spills to the marine environment, strict operational procedures are followed. Since operations commenced at Bing Bong in 1996, there has been no major spill of concentrate into the sea, and the minor amount of spillage that has occurred has not resulted in any significant impacts on water quality, sediment or marine biota. The existing concentrate handling procedures and safeguards are proposed to continue to be implemented.

Metal contamination in food sources has the potential to affect migratory birds, as they are relatively long-lived organisms at the top of the food chain. Contaminants can bio-accumulate over time to reach sub-lethal, or even lethal levels in organisms unless they are excreted or detoxified. However, identifying the source of contamination is made difficult due to the migratory nature of these birds, some of which travel seasonally to northern hemisphere countries. Any impacts from food contamination would be more likely to be observed in resident rather than migratory species.

Most shorebirds and some waterbirds forage on the inter-tidal mudflats, consuming molluscs (such as limpets, snails, chitons, mussels and pipis), crustacean (crabs, barnacles and sandhoppers), marine worms and sea squirts. The migratory seabirds, raptors, and some waterbirds feed on prawns and fish in the open waters of the Gulf.

11.4.4 Proposed Management and Monitoring Program

Monitoring the possible impacts of metal contamination in the food of migratory birds requires a knowledge of the significance of the affected area to particular species, the level of usage, feeding habits of target species, and the level and areal extent of contamination of the food source. Most of this information is currently only available in a general sense and so, in order to effectively monitor and mitigate potential impacts, a staged approach of data acquisition and contingency management is proposed.

Because the metal concentrations in sediments on the coast immediately west of the load-out facility are higher than those to the east, an extension of the existing monitoring program is proposed. This will include surveys of migratory birds to identify species present and their abundance in the area of potential impact from the Bing Bong operations.

The regional significance of this area could then be assessed, and the chief food sources of the shorebirds identified. This would enable future collection and analysis of suitable food species for heavy metal analysis. The first stage of the proposed monitoring program will be to identify what species and numbers are present in the Bing Bong and McArthur River mouth areas. The value of undertaking a second stage of the program to monitor food species would be assessed on the basis of the first stage results.

It is proposed that surveys of feeding flocks at low tide would be carried out three times during the migratory season, as follows:

- Mid to late September, when the bulk of species have arrived form the northern hemisphere on the northern shores of Australia,
- Mid-season in December/January, when many species have migrated south but others remain on northern shores, and
- Early April when large numbers aggregate prior to departure north.

The most practical and economic way to survey the coastal area close to Bing Bong and the MacArthur River mouth is by aerial survey followed by ground counts. More waders have been seen from helicopter than fixed wing surveys in this area by Garnett and Taplin (1990). Aerial surveys would provide an indication of the importance of Bing Bong to migratory birds, compared with other sites in the area.

An ornithologist expert in identification of shorebirds, waterbirds and seabirds will locate concentrations, identify birds and estimate numbers during a general flyover along transects. Ground counts, particularly for shorebird concentrations, would then be conducted using land access from Bing Bong or from suitable helicopter landing sites, noting species presence, abundance and habitat. Land access is preferable, as Garnett and Taplin (1990) noted that helicopter landings often frightened birds away, and, as they took time to return, it lead to a bias in results towards confiding species.

It is proposed that survey methods similar to those employed by Chatto (2003) would be used. Observations would be made into a tape recorder with GPS and time of day regularly logged, which would be later transcribed for data presentation and interpretation. The resulting data on species assemblages would enable assessment of the regional significance of the Bing Bong area to migratory birds.

If surveys were to reveal significant numbers of migratory birds in the Bing Bong area, a program would be developed to monitor the potential impacts of heavy metal contamination of food sources on the migratory birds. This would result in the existing metals monitoring program expanding to include food species as identified from results of the bird surveys. These may include prawns that breed and feed in the seagrass beds, and small crabs and molluscs such as pipis or gastropods collected from the inter-tidal mudflats.

During the initial baseline studies at Bing Bong in 1993, metal contamination levels were analysed from flesh samples in three local bird species: Silver Gull (*Larus novaehollandiae*); Pied Oystercatcher (*Haematopus longirostris*); and Mangrove Heron (*Buteroides striatus*). This approach is not considered suitable for migratory species due to the difficulty in identifying the source of any contamination. In any case, it is not acceptable in a long-term program.

Monitoring of metal concentrations in fledgling bird feathers is a method which can indicate local sources of contamination, since newly formed feathers in young birds represent an exposure to food from the parents (Burger and Gochfield 2000; 2001). Therefore, this technique may be useful for assessing metal contamination in migratory bird species which breed in the area such as the Little Tern. However, sample collection for this method has potential to cause significant disturbance to tern colonies.

The identified tern breeding colony at site S066 (Chatto, 2001) is about 6 km south of Rocky Reef (CDU monitoring site 109), where elevated levels of copper have been detected in oysters, and it is possible that birds from this colony feed in that area. As there are currently no data for that site on metal contamination in their food species (prawns and small fish), the risk to this colony is unknown. Should future monitoring of food species indicate elevated metals, then a decision will be made in consultation with the Northern Territory Government as to whether a fledgling feather monitoring program is necessary.

If significant numbers of migratory birds are found to be using areas identified as having highly elevated metal levels, then methods to deter them from the area, such as use of scaring devices, could be employed until remedial actions are implemented.