

9 Existing environment—aquatic flora and fauna

The proposed development allows for all rivers, streams and natural wetlands in the Project Area to be contained within conservation areas, and to be isolated from land development. This chapter describes the flora and fauna associated with surface water features within and near the Project Area. Other chapters of relevance are Chapter 5, which describes the existing and potential changes to the hydrology and water quality of these surface water features; Chapter 6, which describes the existing and potential groundwater scenarios, and effects that changes in groundwater may have on surface water; and Chapter 10, which describes the conservation strategy for the Project, potential impacts from development, and proposed management measures.

9.1 OVERVIEW

Relative to other areas of Australia there is limited literature available on the aquatic systems of the Kimberley region. Lane and McComb (1988) described the wetlands of the region in broad ecological terms, and Benson (1997) identified the wetlands within the Project Area. Molluscs have been studied by Wilson and Stoddart (1979); fish have been investigated by Allen (1982), Hutchins (1981) and Larson (1995, 1996, 1999); and waterbirds have been studied by Jaensch (1994). A marine biological survey of the eastern Kimberley has been undertaken by the Western Australian Museum and the University of Western Australia (Walker et al. 1996).

As described by Lane and McComb (1988), the types of natural wetland found in the Kimberley region include:

- perennial or intermittent rivers (mostly freshwater);
- estuaries subject to large seasonal changes in salinity brought about by the balance between seasonal intrusion of marine water, evaporation, rainfall and river discharge;
- ephemeral wetlands on rock outcrops;
- seasonal lakes and associated swamps. (These are common as there are very few permanent lakes.)

In addition, there are also artificial wetlands such as those formed in association with dams, irrigation water and water storage structures.

The Ramsar Classification (1990) groups wetlands into three major categories: marine and coastal, inland, and man-made/intensively farmed or grazed wetlands. Within the Victoria–Bonaparte Biogeographical Region there are two listed Ramsar sites—Lake Argyle and Lake Kununurra (jointly) and the Ord River Floodplain.

The Australian Nature Conservation Agency (ANCA) developed a system based on the original Ramsar Classification as modified for Australian conditions known as the ‘Directory of Important Wetlands in Australia’ (ANCA 1995). The directory details nominated wetlands and their present conservation status. The five wetlands listed for the Victoria–Bonaparte Biogeographical Region are the Ord Estuary, Parry Floodplain, Lake Argyle and Lake Kununurra and the Legune Wetlands. All these wetlands are outside the Project Area.

Benson (1997) modified the ANCA classification system when studying wetlands within the Project Area. Table 9.1 summarises the wetland classification and the number of wetlands identified by Benson (1997) within the Project Area (Figure 9.1).

Table 9.1 Wetland classification of the plains in the Project Area

ANCA classification	ANCA description	Weaber Plain	Knox Creek Plain	Keep River Plain
A	Marine and coastal zone wetlands			
A6	Estuarine wetlands, and permanent waters of estuaries and estuarine systems of deltas.	–	–	KEP3, KEP5, KEP9
B	Inland wetlands			
B2	Seasonal and irregular rivers and streams	WP1, WP2, WP3, WP4, WP5, WP6, WP8	KXP2, KXP3, KXP4, KXP5, KXP6, KXP9, XKP10	KEP2, KEP4
B4	Riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna.	–	KXP8	–
B9	Permanent freshwater ponds (< 8 ha) and marshes and swamps on inorganic soils, with emergent vegetation waterlogged for at least most of the growing season.	–	KXP1	KEP1, KEP6, KEP7, KEP8
B10	Seasonal/intermittent freshwater ponds and marshes on inorganic soils, including sloughs, potholes, seasonally flooded meadows and sedge marshes.	WP9	KXP7	KEP10
C	Man-made wetlands			
C2	Ponds, including farm ponds, stock ponds and small tanks (generally < 8 ha).	WP10	–	–
C10	Drains	WP7		

Source: Benson (1997).

9.2 RIPARIAN VEGETATION

Throughout the Project Area the vegetation fringing the creeks, rivers and other watercourses is dominated by freshwater mangrove (*Barringtonia acutangula*), paperbark (*Melaleuca argentea*), screw palm (*Pandanus spiralis*), *Cathormium umbellatum*, wattle (*Acacia colei*) and rivergum *Eucalyptus* spp., including (*Eu. camaldulensis*) and guttapercha tree (*Excoecaria parvifolia*). These species are mainly associated with fresh or slightly brackish water. Scattered mangroves occur along the northern reaches of the Keep River within the Project Area, but extensive mangrove woodlands are located further downstream and outside the Project Area.

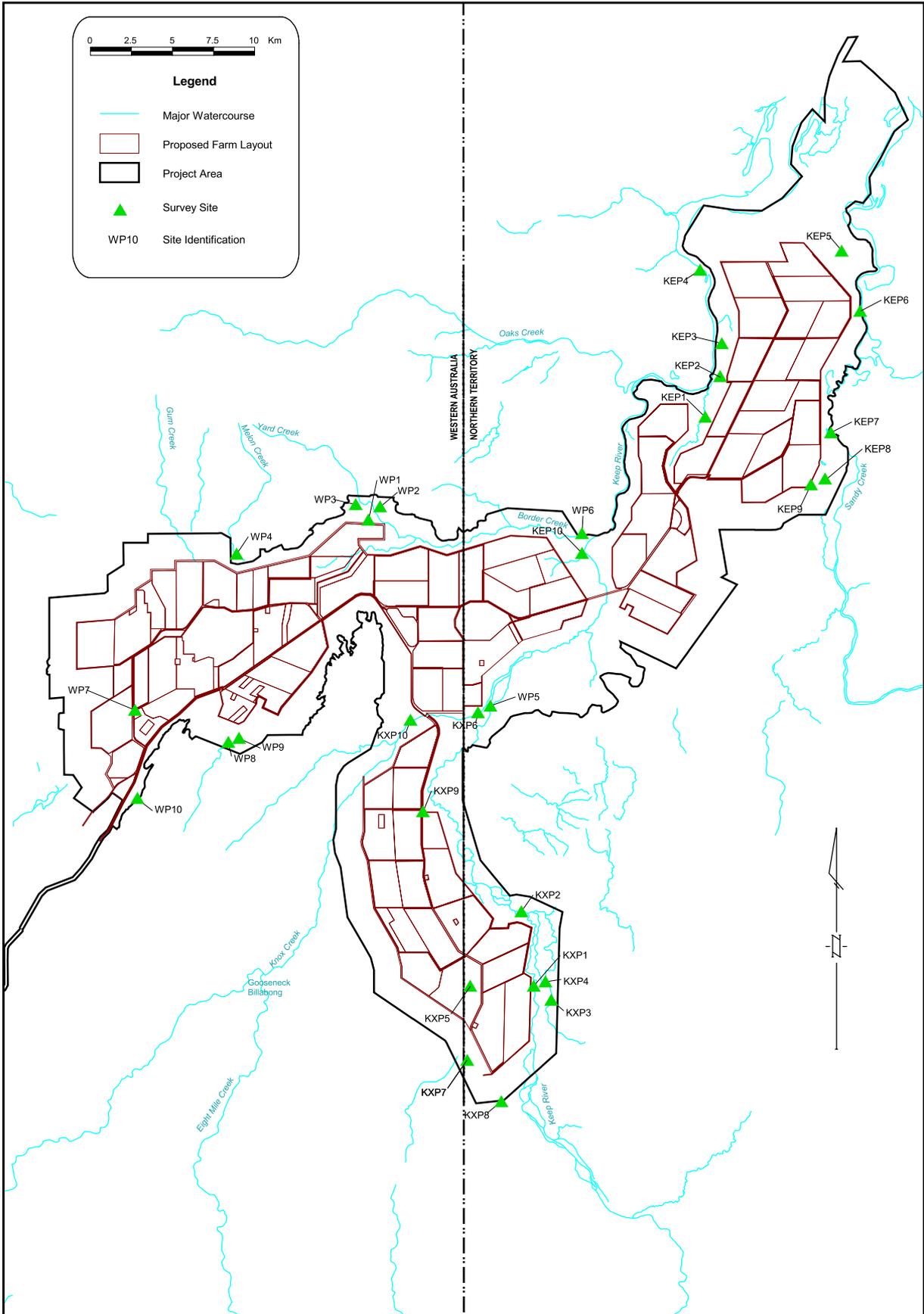


Figure 9.1 Wetlands surveyed by Benson within the Project Area

The riparian vegetation in or near to the Project Area recorded by Benson (1997) is summarised in Table 9.2.

9.3 AQUATIC VEGETATION AND FLORA

The records of the Western Australian Herbarium were used to determine which aquatic species were likely to occur in the Project Area. In addition, during the fauna study of the Keep River by Larson (1999), opportunistic recordings of aquatic plants were also made. Benson (1997) recorded only the riparian vegetation.

Table 9.2 Riparian vegetation of wetlands in or near to the Project Area

Watercourse or wetland	Dominant vegetation
Weaber Plain	
Border Creek (WP2, WP6)	<i>Melaleuca argentea</i> , <i>Melaleuca leucadendra</i> , <i>Barringtonia acutangula</i> , <i>Lophostemon grandiflora</i> , <i>Eucalyptus parvifolia</i> , <i>Acacia colei</i> and <i>Terminalia</i> sp.
Yard Creek (WP3)	<i>Barringtonia acutangula</i> , <i>Ficus opposita</i> , <i>Petalostigma pubescens</i> , <i>Terminalia oblongata</i> subsp. <i>volucris</i> and <i>Pandanus spiralis</i> .
Melon Creek (WP4)	<i>Barringtonia acutangula</i> , <i>Melaleuca argentea</i> , <i>Pandanus spiralis</i> , <i>Petalostigma pubescens</i> , <i>Terminalia oblongata</i> subsp. <i>volucris</i> , <i>Pandanus spiralis</i> and <i>Passiflora foetida</i> .
Knox Creek (WP5), WP6	<i>Eucalyptus</i> spp., <i>Excoecaria parvifolia</i> and <i>Cathormium umbellatum</i> .
Seasonal wetland—Cave Spring and Pincombe Ranges (WP9)	<i>Lophostemon</i> sp., <i>Acacia</i> spp. and <i>Eucalyptus</i> spp.
WP1, WP8, WP9	No riparian vegetation
Knox Creek Plain	
Milligan Lagoon (KXP1)	<i>Barringtonia acutangula</i> , <i>Excoecaria parvifolia</i> , <i>Corymbia bella</i> , <i>Eucalyptus</i> sp. and <i>Cathormium umbellatum</i> .
Overflow stream Keep River (KXP8)	<i>Cathormium umbellatum</i> , <i>Excoecaria parvifolia</i> , <i>Barringtonia acutangula</i> , <i>Eucalyptus camaldulensis</i> and <i>Corymbia bella</i> .
Seasonal wetland (KXP7)	<i>Excoecaria parvifolia</i> , <i>Eucalyptus</i> sp., <i>Adansonia gregorii</i> and <i>Bauhinia cunninghamii</i> .
Knox Creek (KXP10)	<i>Excoecaria parvifolia</i> , <i>Cathormium umbellatum</i> and <i>Eucalyptus</i> sp.
Unnamed tributaries (KXP3, KXP4,)	<i>Barringtonia acutangula</i> , <i>Terminalia</i> sp., <i>Melaleuca argentea</i> , <i>Eucalyptus camaldulensis</i> , <i>Corymbia bella</i> , <i>Cathormium umbellatum</i> , <i>Excoecaria parvifolia</i> , <i>Acacia colei</i> , <i>Lophostemon</i> sp. and <i>Bauhinia cunninghamii</i> .
Unnamed seasonal creek (KXP9)	<i>Cathormium umbellatum</i> , <i>Excoecaria parvifolia</i> , <i>Terminalia</i> sp., <i>Petalostigma pubescens</i> and <i>Hakea arborescens</i> .
Keep River (KXP2, KXP5, KXP6)	<i>Barringtonia acutangula</i> , <i>Pandanus spiralis</i> , <i>Eucalyptus camaldulensis</i> , <i>Eu. papuana</i> , <i>Terminalia grandiflora</i> , <i>Melaleuca argentea</i> , <i>Excoecaria parvifolia</i> , <i>Cathormium umbellatum</i> and <i>Acacia holosericea</i>
Keep River Plain	
Interconnected pools (KEP3)	<i>Barringtonia acutangula</i> , <i>Melaleuca argentea</i> , <i>Cathormium umbellatum</i> , <i>Excoecaria parvifolia</i> , <i>Lophostemon</i> sp. and <i>Passiflora foetida</i> .
Seasonal wetland (KEP5)	<i>Melaleuca argentea</i> , <i>Excoecaria parvifolia</i> , <i>Eucalyptus</i> sp. and <i>Parkinsonia</i> sp.
Permanent wetland (KEP9)	<i>Melaleuca viridiflora</i> , <i>Barringtonia acutangula</i> and <i>Eucalyptus camaldulensis</i> .
Sandy Creek (KEP6)	<i>Melaleuca argentea</i> , <i>Eucalyptus camaldulensis</i> , <i>Pandanus spiralis</i> , <i>Barringtonia acutangula</i> , <i>Acacia colei</i> , <i>Melaleuca acacioides</i> , <i>Excoecaria parvifolia</i> , <i>Cathormium umbellatum</i> and <i>Grevillea striata</i> .
Tributary Keep River (KEP1, KEP7)	<i>Melaleuca acacioides</i> and <i>Excoecaria parvifolia</i> .
Seasonal creek (KEP8)	<i>Cathormium umbellatum</i> , <i>Excoecaria parvifolia</i> , <i>Melaleuca leucadendra</i> and <i>Eucalyptus</i> sp.
Keep River (KEP2, KEP4, KEP10)	<i>Melaleuca argentea</i> , <i>Aegicera cornulatum</i> , <i>Pandanus spiralis</i> , <i>Barringtonia acutangula</i> , <i>Melaleuca argentea</i> and <i>Nauclea orientalis</i> .

Source: Benson (1997).

9.3.1 Freshwater vascular flora

Table 9.3 provides a listing of freshwater vascular plants that have been recorded in the vicinity of Kununurra.

Table 9.3 Freshwater vascular plant species recorded in the vicinity of Kununurra

Vascular plant species	Plant type	Habitat	Occurrence
<i>Brachyachne tenella</i>	Rooted	Shallow water, herbaceous swamp	Ord River floodplain
<i>Ceratopteris thalictroides</i>	Floating or rooted	Pools	15 km south of old Ord River Station
<i>Chionachne cyathopoda</i>	Rooted	Base of riverbank	Ord River
<i>Echinochloa macrandra</i>	Rooted	Swamps	Ord River
<i>Eleocharis aff. brassii</i>	Rooted	Shallow water, swamps, billabongs and lagoons	Kununurra and Lake Argyle
<i>Eleocharis sphacelata</i>	Rooted	Lagoons	Lower Ord River
<i>Eleocharis spiralis</i>	Rooted	Tidal pools	Lower Ord River
<i>Fimbristylis blakei</i>	Rooted	Springs	Lower Ord River
<i>Hydrilla verticillata</i>	Rooted	Stagnant or slow-flowing fresh water	Lower Ord River
<i>Ipomoea aquatica</i>	Floating or rooted	Floats on water or grows in mud along edges of creeks and drainage channels	Kununurra and Ord River
<i>Lygodium microphyllum</i>	Rooted	Swamps	Near Kununurra
<i>Marsilea mutica</i>	Floating or rooted	Pools and in water or on edge of watercourses	Plain of Ord River and Parry Lagoon
<i>Myriophyllum trachycarpum</i>	Rooted	Shallow water at edge of lakes	Lake Argyle
<i>Myriophyllum verrucosum</i>	Floating or rooted	Shallow water at edge of lakes	Lake Argyle and Lake Kununurra
<i>Najas graminea</i>	Rooted	Fresh water and swamps	Ord River and Kununurra
<i>Najas melesiana</i>	Rooted	Fresh water	Near Kununurra
<i>Najas tenuifolia</i>	Rooted	Fresh or rarely brackish, still or flowing water	Ord River, Lake Argyle and ORIA Stage One
<i>Nymphaea hastifolia</i>	Rooted	Ephemeral in creeks and billabongs	Ord River Basin
<i>Nymphaea violacea</i>	Rooted	Ephemeral or permanent water	Widespread in region
<i>Nymphoides indica</i>	Rooted	Still to flowing, permanent to near permanent water to a 1.3 m depth	Kununurra and Ord River
<i>Pandanus aquaticus</i>	Rooted	In and along watercourses	Ord River
<i>Pandanus spiralis</i>	Rooted	In and along watercourses	Ord River
<i>Potamogeton tricarinatus</i>	Rooted	Still or slowly flowing fresh water and drainage channels	Lake Kununurra, Ord River and Lake Argyle
<i>Salvinia molesta</i> *	Floating	Still or flowing fresh water	Kununurra (eradicated), but potential weed
<i>Tacca leontopetaloides</i>	Rooted	Pools	Point Spring
<i>Typha domingensis</i>	Rooted	Freshwater pools and streams	Ord River (widespread)
<i>Utricularia gibba</i>	Floating	Still pools or ephemeral swamps	Parry Lagoon
<i>Utricularia muelleri</i>	Floating	Ephemeral swamps	Kununurra
<i>Utricularia stellaris</i>	Floating	Still pools or ephemeral swamps	Parry Lagoon
<i>Vallisneria annua</i> (previously <i>Vallisneria spiralis</i>)	Rooted	Pools with water > 1 m deep, watercourses and drainage channels	Kununurra, Ord River and Packsaddle Swamp
<i>Vallisneria nana</i>	Rooted	Irrigation channels	Kununurra
<i>Wolffia angusta</i>	Floating	Pools	Parry Lagoon and Lake Kununurra

* Introduced species.

Source: *Western Australian Herbarium florabase*; Flora of the Kimberley Region (Wheeler 1992).

The list in Table 9.3 indicates the potential for aquatic plant species to occur in the pools, billabongs, creeks and rivers of the Project Area. Larson (1999) recorded the algae *Chara* spp. and *Enteromorpha* spp. Filamentous algae would also be expected to occur in waterbodies within the Project Area.

Gowland (1982) listed the common species of the littoral zone and those growing in the water of wetlands adjoining Lake Kununurra. He commented upon the rapid spread of cumbungi (*Typha domingensis*), which is replacing the native *Eleocharis* spp. The water around submerged vegetation also periodically supports blooms of an alga, *Eucaryota* spp.

Larson (1999) recorded the aquatic vegetation in the pools along the Keep River near the southern boundary of the Project Area as comprising:

- mixed grasses and nardoo (*Marsilea* sp.) in the water;
- spikerush (*Eleocharis* spp.) and taro (*Colocasia esculenta*) in the soil at the water's edge.

At Alligator Hole and Milligan Lagoon, Larson (1999) recorded waterlilies (*Nymphaea macrosperma* and *Nymphaea violacea*), water nymph (*Nymphoides indica*, *Najas tenuifolia*), bladderwort (*Utricularia australis*), water thyme (*Hydrilla verticillata*) and *Chara* spp.

9.3.2 Seagrasses and macroalgae

Little information is available on the estuarine and marine flora present or likely to occur in the northern Kimberley region. The turbid water at the river deltas and the abundance of crocodiles make the survey of estuarine and marine plants difficult and hazardous. The only major survey undertaken within the eastern Kimberley was a survey of eleven different locations, approximately 80 km from the Project Area, within the Cambridge Gulf in the northern Kimberley, by Walker et al. (1996); a summary follows.

Seagrasses

Three seagrasses were collected, with *Enhalus acoroides* having extensive cover at Cape Londonderry. Subtidal populations of seagrasses are not known, but it appears that the northern Kimberley does not have the seagrass richness recorded for the southern Kimberley. A similar survey of the southern Kimberley recorded eight species of seagrasses (Walker et al. 1996).

Macroalgae

Ninety species (Table 9.4) of macroalgae were collected. All reefs have a large number of *Sargassum* spp. (brown algae), and the rhizobenthic green algae are common on reefs with sediment pockets. Red algae are less diverse.

The diversity and abundance of the algal flora recorded were poor. This was probably due to the extreme tidal exposure, highly turbid waters which reduce light penetration, and the smothering of plants with sediment. In addition the effects of freshwater inundation and sediment load in the wet season are expected to be a major ecological factor controlling the distribution of macroalgae. The delta of the Keep River is similar to the Cambridge Gulf, so the abundance of species of macroalgae would be expected to be comparable.

Table 9.4 Macroalgae collected from the Cambridge Gulf, northern Kimberley

Macroalgae	Number of species recorded				Total at 11 sample sites
	Vancouver Point*	Cape Domett†	Lacrosse Island‡	Reveley Island#	
Phaeophyta (brown algae)	2	0	1	3	18
Chlorophyta (green algae)	1	4	2	6	35
Rhodophyta (red algae)	5	3	3	11	37
Total	8	7	6	20	90

* From Myrmidon Ledge, a sandy bay fringed by mangroves with rocks down to and below water level.

† An intertidal sandy beach with occasional rock platforms.

‡ A sandy beach and rocky peninsula.

A low sandy island with extensive sandbars and upper intertidal rocky shoreline, and a lower intertidal platform cemented together with coralline algae.

Source: Walker et al. (1996).

9.4 AQUATIC FAUNA

A survey of aquatic fauna in and near to the Project Area was undertaken in October 1998 (Larson 1999—see Appendix L). Seventeen sites were sampled along the Keep River and Sandy Creek.

This 1998 survey recorded five mammal, ninety-three bird, thirteen reptile, eleven frog and thirty-five fish species. The mammals, birds, reptiles and frogs recorded by Larson (1999) are described in Chapter 8. Larson (1999) states that the aquatic invertebrates comprise assemblages typical of Northern Territory rivers, creeks and billabongs. Insects and molluscs are common in most waterbodies and some insects are locally common.

9.4.1 Sponges

Larson (1999) recorded a bright green sponge, possibly a *Radiospongilla* spp., growing on the limestone rocks in the Keep River and on the aquatic vegetation and rocks at Alligator Hole and Milligan Lagoon.

9.4.2 Fish

Based on fish distributions and drainage patterns, Australia may be divided into nine regions (Allen 1982). The richest inland faunal region—in terms of the number of species—is the Leichardian region, which includes the Kimberley, the northern portion of the Northern Territory and the Gulf of Carpentaria drainage of Queensland. Approximately 18% of the species found there are also recorded from southern New Guinea, indicating that the fish fauna of northern Australia is closely allied to that of New Guinea (Allen 1982). The Kimberley region contains forty principal species, of which sixteen (37.5%) are endemic to the region (Table 9.5).

Table 9.5 Distribution of endemic species of freshwater inland fishes in Western Australia

Distribution of inland fish	Number of endemic species
Kimberley	16
Northern Australia – southern New Guinea	10
Widespread tropical Australia	8
Unique to the south-west	8
Western Australia and the Northern Territory	5
Unique between Murchison and De Grey rivers, Western Australia	4
North Australia and Indo-Malayan Archipelago	2
Widespread Southern Hemisphere	1
Common to Western Australia, South Australia, Victoria and Tasmania	1

Source: Allen 1982.

The fish fauna of the Keep River is diverse and numerous, primarily due to the low level of commercial and recreational fishing. A total of thirty-five freshwater and estuarine fish species was recorded by Larson (1999). No introduced fish species were recorded, although the mosquito fish (*Gambusia holbrooki*) is widespread in many river systems in Western Australia and is known from streams north of Broome (Arthington and Lloyd 1989).

Freshwater fish

Twenty-five species of freshwater fish were recorded from the Keep River and Sandy Creek areas (Larson 1999) and an additional fourteen species have been recorded as occurring in past surveys. Hutchins (1981) in a survey of the Mitchell Plateau and Admiralty Gulf recorded fourteen freshwater fish species, together with a further seven species that must return to estuarine waters to complete their life cycle. Gowland (1982) recorded sixteen fish species from the Lake Kununurra wetlands.

Allen (1982) recorded thirty-one freshwater fish from the Ord River, Lake Argyle and Lake Kununurra, and from the Kimberley area in general. Some of these species were not recorded in the Larson survey but are expected to occur there.

To the east of the Keep River there have been thirty-five species recorded from the Wickham River and forty-four from the Alligator River system. However, in a six-day survey of the Wickham River, twenty of the thirty-five species were recorded (Larson, in prep.), and in a nine-day survey, twenty-five of the forty-four species from the Alligator River system were recorded (Larson 1995). This demonstrates that additional fish species would be expected to occur in the Keep River.

Estuarine fish

Larson (1999) recorded ten species in her 1998 survey, although access for sampling was at times limited. By comparison, in a survey of estuarine and marine species in the Roper River, Larsen (1996) recorded 96 species. A total of 181 fish species are known from the estuaries and coasts within Kakadu National Park (Larson 1997), the Roper River estuary and nearby creeks (Larson 1996). With better access, the Keep River and Sandy Creek could be expected to resemble the Roper River and Alligator River estuaries and may have 100 or more estuarine species.

Threatened fish species

Two species of sawfish have been recorded in the Keep River—dwarf sawfish (*Pristis clavata*) and freshwater sawfish (*Pristis microdon*). Dwarf sawfish is coastal in distribution but can travel long distances up rivers into fresh water. Its conservation status is unknown but it may only occur in northern Australia. Freshwater sawfish is listed under the Commonwealth *Endangered Species Protection Act 1992* as ‘vulnerable’, as well as being listed as ‘Endangered’ in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (Larson 1999), and as ‘Potentially threatened’ in the 1998 Australian Society for Fish Biology’s Threatened Fish List (1998). It is usually located in fresh water and in the upper reaches of estuaries, and may be isolated in small billabongs for several years until floods release it back into the estuary. It has been recorded from several rivers in Western Australia, the Northern Territory and at Cape York in Queensland.

9.4.3 Crustaceans

Four crustacean species were recorded by Larson (1999) in the Keep River. Two species of freshwater prawns, *Macrobrachium rosenbergii* and *Macrobrachium bullatum*, are common. Wilson and Stoddart (1979) recorded freshwater crab (*Holtuisiana transversa*), freshwater prawns (*Macrobrachium rosenbergii*, *M. tolmerum* and *M. australiense cristatum*) and atyid shrimps (*Caridina* spp.) in their survey of the Keep River.

9.4.4 Molluscs

Wilson and Stoddart (1979) undertook a survey of the freshwater molluscs of the Ord River region to determine their potential as vectors of trematode parasites. A total of sixteen mollusc species was recorded from the five collecting trips (Table 9.6). Six different habitats were sampled and five of these were further separated into permanent or temporary water. The collections were centred on Kununurra, Lake Argyle and Keep River.

Larson (1999) recorded five species of molluscs from the Keep River and only one of these, *Austropeplea lessoni*, was not recorded by Wilson and Stoddart (1979). The freshwater mussel *Velesunio angasi*, which is abundant in the Kimberley region, was recorded from the Keep River in the Northern Territory. This is a new locality record for this species in the Northern Territory. None of these species are gazetted rare or priority species.

To determine if the distribution of species varied with the season, Wilson and Stoddart (1979) revisited many of the sampling sites. In permanent and temporary habitats there was little noticeable variation. Recently filled wetlands often had no live snails. The most commonly located snails were *Gyraulus essingtonensis* and *Amerianna carinata*, both occurring in ten out of the eleven sample sites.

Table 9.6 Habitat types and occurrence of mollusc species in the Ord River region

Species name	Dams		Rivers		Pools		Irrigation		Creeks		Swamps (6)	Total (101)
	P (10)	T (4)	P (13)	T (8)	P (6)	T (9)	P (8)	T (3)	P (4)	T (30)		
Gastropods												
<i>Gyraulus essingtonensis</i>	6	3	3	3	1	4	2	2	1	13		38
<i>Amerianna carinata</i>	3	3	2	4	1	5	2	1		8	3	32
<i>Amerianna vinosa</i>			1	1		6	3	3	1	12	2	29
<i>Ferrissia petterdi</i>	1	1	2	3			1	1		7		16
<i>Thiara australis</i>	6		7				2					15
<i>Bayardella johni</i>				3						7		10
<i>Notopala essingtonensis</i>	2	1	3	2	1							9
<i>Notopala alisoni</i>						4				2	3	9
<i>Physastra badia</i>						3					5	8
<i>Bithynia australis</i>		2				4	1					7
<i>Isidorella sisurnia</i>										7		7
Bivalves												
<i>Velesunio angasi</i>	1		1							3		5
<i>Velesunio wilsoni</i>		1	1		3							5
<i>Corbicula</i> sp.	2			2								4
<i>Lortiella rugata</i>							1					1
<i>Lortiella froggattii</i>										1		1
Snails			4		2		2		2	1		11
Total	21	11	20	18	6	26	12	7	2	60	13	196

Note: P = permanent water; T = temporary water. The number of sample sites at each location is shown in brackets.

Source: Wilson and Stoddart (1979).

9.4.5 Insects

Larson (1999) recorded twenty-three insect species as detailed in Table 9.7. Most are common throughout northern Australia. However, other groups of the tabled species could be expected within the Project Area if additional surveys were undertaken. These include mayflies (Ephemeroptera), dragonflies (Odonata), caddisflies (Trichoptera), Hydrometridae (Hemiptera) and Gyrinidae (Coleoptera).

Halse et al. (1996) undertook a survey of water birds and invertebrates in the swamps of the Victoria–Bonaparte mudflats to the north of the Project Area. These mudflats form a band 10–20 km wide along the coast of the Joseph Bonaparte Gulf, between Cambridge Gulf in Western Australia and the north of the Victoria River in the Northern Territory. At least 131 species of invertebrates were collected during the survey. The number of species per site ranged from thirteen to sixty and a significant number of these were undescribed. The species-rich orders were Cladocera (twenty-seven species), Ploimida (twenty-four), Coleoptera (twenty), Copepoda (ten) and Ostracoda (ten).

Kay et al. (1999) sampled aquatic invertebrate fauna in the rivers of north-western Australia. The sites sampled closest to the Project Area were at Wilson Creek, Bamboo Creek and the Durack River, all more than 100 km from the Project Area.

Table 9.7 Insect species recorded in or near to the Project Area

Insect order and family	Number of species in Australia	Number of species in the Northern Territory	Number of species recorded
Hemiptera—bugs			
Belostomatidae (giant water-bugs)	4	2	1
Corixidae (water boatman)	31	2 genera	1
Galastoceridae (toad bugs)	23	3	1
Gerridae (water striders)	32	20	5
Nepidae (water scorpions)	8	7	3
Notonectidae (backswimmers)	40	3 genera	3
Coleoptera—beetles			
Dytiscidae (predaceous diving beetles)	185	54	6
Hydrophilidae (water scavenger beetles)	175	Many	1
Noteridae (burrowing water beetles)	5	Most	1
Orthoptera—grasshoppers and crickets			
Tridactylidae (pygmy mole crickets)	9	2	1

Source: Brown and Larson 1999.

9.4.6 Marine fauna

Table 9.8 lists the marine animals collected or observed from a survey of eleven different sites in the northern Kimberley (Walker et al. 1996).

Table 9.8 Marine fauna recorded in the northern Kimberley

Phylum	Number of species
Molluscs	194 gastropods; 62 bivalves; 2 chitons; 6 cephalopods; 1 scaphopod
Crustaceans	157 decapods; 1 conchostracan; 3 Thoracicans; 2 amphipods; 16 isopods; 2 stomatopods
Fish	194 marine and estuarine fish

Source: Walker et al. (1996).

The inshore Kimberley molluscan fauna is depauperate in comparison with other areas in the number of species, possibly due to the restricted number of habitats, lack of extensive coral reef fauna, and silty conditions. The crustacean fauna showed a higher diversity, and this diversity increased markedly at the estuarine sites and at well-developed mangrove communities (Walker et al. 1996).

A survey of the molluscan fauna of the Admiralty Gulf and nearby islands by Wells (1981) recorded 144 species, of which sixty-two were recorded from Point Warriadar. This site at the head of the Admiralty Gulf has a habitat similar to that described at the mouth of the Keep River, including rocky shores interspersed with deeply indented bays lined with mangrove swamps and extensive mudflats. There is no fresh water flowing through this area, except after heavy rains. The water is extremely turbid at low tide with a visibility of 15 cm or less, and as the tide rises, visibility increases to 1 m. Generally it was found that the molluscan fauna was site-specific. Fourteen gastropods and four bivalves were recorded from the mangrove swamps, of which only two bivalves live in the muddy substrate, the remainder living on the mud surface.

9.5 STYGOFAUNA

Stygofauna is the name given to fauna (usually invertebrate) that live exclusively in subterranean habitats. The stygofauna of Western Australia is largely unknown and predominantly undescribed.

The dispersion of stygofauna within an alluvial aquifer, as occurs in the Project Area, and as opposed to a karst of fissured aquifers, is likely to be widespread. However, individual species within alluvial aquifers are likely to have patchy distributions owing to local variations in groundwater characteristics.

The distribution of stygofauna is related, *inter alia*, to rock and sediment types, and the geological structure. Stygofauna habitat is best developed in karstic aquifers, but these are restricted in the Project Area to limestone formations beneath the western portion of the Knox Creek Plain. Stygofaunal habitat may also occur in unconsolidated sediments, if suitable water-filled voids are present. In unconsolidated sediments, the water-filled voids between grains of sediment, especially where these are sand-sized or larger, form an extensive groundwater habitat (porous aquifer). Thus stygofauna may be present in gravels and sands of the palaeochannels found under much of the Project Area (Chapter 6).

Thirty-four sampling locations were examined in the region from 1994 to 1998 by the Western Australian Museum of Natural Sciences (Appendix M). Of these, eleven sites contained stygofauna and another two sites contained fauna that was considered stygal. The sites ranged from the karstic limestone Devonian Reef system (Ningbing Range) outside of the Project Area, to the alluvial aquifers associated with the former course of the Ord River through the Ivanhoe Plain, Cave Spring Gap and the Weaber Plain. No sampling was undertaken in the Keep River Plain or the Knox Creek Plain although there could be Devonian/Carboniferous limestone underlying the western Knox Creek Plain of the Project Area.

The alluvial aquifers underlying the Ivanhoe Plain and ORIA Stage One contain undescribed species of stygofauna in two families of bathynellid syncarid Crustacea. The fauna from aquifers beneath the Cave Spring Gap and the Weaber Plain have similar characteristics, however it is unknown whether the fauna from this area is the same as that from the Ivanhoe Plain.

The groundwater salinity varies widely in different parts of the Project Area and this may have a major impact on the fauna it can support. While stygofauna is typically associated with freshwater (Gibert et. al. 1994), it is found in salinity of seawater strength in both near coastal aquifers (Humphreys in press b) and in the Yilgarn (W.F. Humphreys and H.J. Hahn, unpublished 1999).

Of marine origin, syncarids are one of the oldest groups of freshwater fauna. The Bathynellacea probably occupied surface freshwater in the Carboniferous and subsequently became restricted to living in the interstitial spaces in subterranean waters.

Syncarids are considered to be rare, but this may be due to the relatively low incidence of biological sampling of their subterranean habitat (Schminke 1986). Recent work in the Yilgarn has found both a high diversity and large populations of syncarids in calcrete aquifers (W.F. Humphreys and H.J. Hahn, unpublished 1999). The biology of syncarids is virtually unknown.

Of the two new species of syncarid Crustacea (H.K. Schminke pers comm.), belonging to two families (Bathynellidae and Parabathynellidae) taken in the groundwater of the ORIA, one is a species of *Atopobathynella* (Parabathynellidae). The recent findings of the genus in the arid (Barrow Island; Humphreys in press a) and monsoonal tropics of Western Australia (ORIA Stage One) suggests that syncarids of the genus *Atopobathynella* may be expected throughout Australia, at least in areas not inundated by the sea during the Cretaceous.

The fissured and karstic aquifers adjacent to the Knox Creek Plain are potential sources of stygofauna and, as they lie outside any immediate impact of the Project, could be potential buffer zones for subterranean fauna.