

# 7 Existing environment—terrestrial vegetation and flora

This chapter reviews the existing terrestrial vegetation and flora of the region, as well as the conservation significance of vegetation associations and species in the Project Area. The chapter also describes and summarises past surveys and comparative studies of the Project Area and regional vegetation. Other chapters of relevance are Chapter 8, which describes the terrestrial fauna; Chapter 9, which describes the aquatic flora and fauna; and Chapter 10, which describes the proposed conservation strategy for the Project.

## 7.1 OVERVIEW

### 7.1.1 The Victoria–Bonaparte Biogeographic Region

The Project Area lies within the Victoria–Bonaparte Biogeographic Region of the Interim Biogeographical Regionalisation for Australia, as developed by the Australian Conservation Agency (Thackway and Cresswell 1995). The region adjoins the lower part of the Joseph Bonaparte Gulf and is about 73,000 km<sup>2</sup> in extent. It exhibits a diversity of landforms and vegetation types, including red earth and black-soil (‘cracking-clay’) plains, plateaux, ranges of sandstone, open savanna and tall grassland.

The Kimberley region has generally proved problematic for land and industrial development because of its isolation, vast rugged landscape and climate. As a consequence, formal biological studies to date have been limited.

Scientific knowledge of the vegetation and fauna of cracking-clay environments in the Victoria–Bonaparte Biogeographic Region is limited, and there is no one single or comprehensive account of the biota of these habitats and their biogeography. The majority of research to date on cracking-clay environments has concentrated on the northern floodplains and, in particular, the Alligator River region of the Northern Territory. In 1999, the Parks and Wildlife Commission of the Northern Territory (PWCNT) received a grant to undertake biological surveys of the cracking-clay systems throughout the Northern Territory. The current PWCNT research will extend the biological knowledge of the region.

### 7.1.2 Biological surveys in and adjacent to the Project Area

Published biological surveys of varying relevance to the Project Area are summarised in Table 7.1. Many of the studies do not include work within the Project Area, and are either specific to small areas or broad-scale (regional) in nature (e.g. Beard 1979; Stewart et al. 1970; Wilson et al. 1990).

**Table 7.1 Published biological information\* for the region**

| Reference   | Description  |
|---|--|
| Gardner (1923) and Perry (1956)                       | Preliminary descriptions of the vegetation of the Kimberley region.  |
| Stewart et al. (1970)                                 | Vegetation survey of the Northern Territory.   |
| Miles and Burbidge (1975)                             | Biological surveys in the Prince Regent River Nature Reserve.  |
| Kabay and Burbidge (1977)                             | Biological surveys in the Drysdale River National Park.  |
| Aldrick and Moody (1977); Dixon (1996)                | Soils of the Weaber and Keep River plains, including some details of vegetation within the Project Area.             |
| Beard (1979)  | An account of previous botanical exploration in the Kimberley region and an outline of broad-scale vegetation types. |
| Henshall and Mitchell (1979)                          | Vegetation survey of the Keep River area.  |
| Gowland and Sonnemann (1980)                          | Reptile and amphibian survey for the north-east Kimberley region.  |
| Gowland and Brennan (1980); Gowland (1980)            | Bird and mammal survey for the ORIA.   |
| Western Australian Museum (1981)                      | Biological survey of Mitchell Plateau and Admiralty Gulf.  |
| Dames & Moore (1982)                                  | Biological survey for the Argyle Diamond Project.  |
| McKean (1986)   | Avifauna of the Keep River National Park.  |
| Forbes and Kenneally (1986)                           | Plant life in the Purnululu National Park and Osmond Range.  |
| Tidemann et al. (1987)                                | Unpublished ecological survey of Spirit Hills Station, which focused on the upland sandstone area.                   |
| Wilson et al. (1990)                                  | Vegetation mapping of all the Northern Territory.  |
| Petheram and Kok (1991); Wheeler et al. (1992)        | Monographs of the flora of the Kimberley region.   |
| McKenzie et al. (1991)                                | A wide-scale survey of Kimberley rainforest areas.   |
| Department of Conservation and Land Management (1992) | Biological surveys in the Purnululu National Park.   |
| Connors, Oliver and Woinarski (1996)                  | Biological data for the Victoria–Bonaparte Biogeographic Region in the Northern Territory portion.                   |
| Ecologia (1997a)                                      | Terrestrial Biological Assessment of the Project Area.   |
| Ecologia (1997b)                                      | ORIA Stage Two Riverside Development Area Terrestrial Biological Assessment.   |
| Connell Wagner Pty Ltd (1997)                         | EIS and EMP for the Bradshaw Field Training Area, Northern Territory.  |
| Brocklehurst et al. (1998)                            | Botanical survey of Auvergne Station and sections of Spirit Hill Station.  |
| Department of Conservation and Land Management (1998) | Draft management plan for the lower Ord River Ramsar site.   |
| Larson (1999)   | Survey of aquatic fauna in the Keep River, Border Creek, Knox Creek and lagoons.                                     |
| Kinhill Pty Ltd (1999) (Appendix J)                   | Additional survey of the flora and fauna of the Project Area.  |

\* Includes fauna surveys that contain some information on vegetation and flora.

Detailed terrestrial vegetation and flora surveys within the Project Area have recently been conducted for the Project by Ecologia (1997a) and by Kinhill in 1999 (see Appendix J). Prior to these comprehensive surveys, no detailed flora surveys had been conducted on the black-soil plains within the Project Area.

The Ecologia surveys were commissioned by the Department of Resources Development to provide baseline data on the terrestrial biology of the Project Area for use in an unpublished

Public Environmental Review. These surveys were undertaken in the 1996 dry season and 1996–97 wet season by a team of thirteen botanists and zoologists. A total of eighty-six sites was surveyed in the dry season and forty-five sites in the wet season. Nineteen of the wet-season sites were new sites and twenty-six were dry-season sites that were re-sampled, making a total of 105 different sites that were sampled during the surveys.

Brocklehurst et al. (1998) undertook a survey of Auvergne Station and a section of the Spirit Hills Station in the Northern Territory. This area is approximately 100 km east of the Project Area and, like the Project Area, includes extensive cracking clays typical of the Ivanhoe land system. The survey was commissioned by the Northern Territory Government to compare the vegetation in these areas with the vegetation recorded in the Ecologia surveys of the Project Area (see Section 7.2.2).

The Kinhill surveys were commissioned by Wesfarmers–Marubeni and the Water Corporation to supplement the data from the Ecologia (1997a) surveys and enable the preparation of a vegetation map of the Project Area (Section 7.2.1). Two surveys were undertaken, in May and June 1999. The rock outcrops, watercourses and lagoons were not resurveyed by Kinhill. The data obtained by Ecologia were used to prepare the vegetation map in these portions of the Project Area.

AGWEST has undertaken surveys in the East Kimberley as part of the Western Australian Rangeland Monitoring System (WARMS). These unpublished surveys form part of a long-term monitoring strategy, which monitored sites established on pastoral leases that include all ten of the land systems identified in the Ord–Victoria area by Stewart et al. (1970). The WARMS data are compared with those for the Project Area in Section 7.2.3.

During 1999, the Parks and Wildlife Commission of the Northern Territory commenced a biological survey of the cracking-clay systems across the Victoria River Downs and the Barkly District (G. Leach, Biodiversity Unit, Parks and Wildlife Commission of the Northern Territory, pers. comm., February 1999). The sites selected include thirty-five from Spirit Hills/Legune/Keep River area, and seventy-nine on Bradshaw and Auvergne stations (A. Fischer, Parks and Wildlife Commission of the Northern Territory, pers. comm., December 1999). The data available from this research was not available at the time of publication of this ERMP/draft EIS.

The cracking-clay soils earmarked for the proposed development have been well surveyed, although the surrounding rocky areas and the riverine vegetation have not been investigated in the same detail.

## 7.2 VEGETATION IN AND ADJACENT TO THE PROJECT AREA

The Western Australian portion of the Project Area lies within the eastern section of the Gardner Botanical District and was described by Beard (1979) as ‘grassland with sparse bauhinia (*Bauhinia cunninghamii*) and coolibah (*Eucalyptus microtheca*) on cracking clay soil’. In 1990 Beard further expanded the description of the black-soil plains of the Ivanhoe Land System, describing it as treeless, or with low trees 3–6 m high, including coolibah (*Eucalyptus microtheca*), bauhinia (*Bauhinia cunninghamii*), corky bark wattle (*Acacia ditricha*), *Terminalia* spp. and guttapercha tree (*Excoecaria parvifolia*). Shrubs include mimosa bush (*Acacia farnesiana*) and sparse conkerberry (*Carissa lanceolata*). The typical ground layer is a community of tall, perennial grasses reaching 2 m and more in height. Common grass species include blue grass (*Dichanthium tenuiculium*, *Dichanthium*

*fecundum*), plume sorghum (*Sorghum plumosum*), *Sorghum timorense*, silky browntop (*Eulalia fulva*), canegrass (*Ophiuros exaltatus*) and bull mitchell grass (*Astrebla squarrosa*).

The portion of the Project Area within the Northern Territory was mapped by Wilson et al. (1990) and described as golden beard grass (*Chrysopogon fallax*) and blue grass (*Dichanthium fecundum*) grassland.

### 7.2.1 Vegetation mapping of the Project Area

A vegetation map of the Project Area was considered essential to assist in the planning and selection of conservation areas.

The data from the Kinhill and Ecologia surveys, and an interpretation of aerial photography, were used to produce the vegetation map of the Project Area shown in Figures 7.1, 7.2 and 7.3. The vegetation map is complex; however, the vegetation variation depicted is distinctive and consistent in the field.

Based on the information from Ecologia (1997a) and Kinhill Pty Ltd (1999), a total of seventy-two vegetation communities within seventeen major groups is recognised (Appendix J). Examples of some vegetation communities in the Project Area are shown in Figure 7.4.

Connors et al. (1996) listed twenty-eight fine scale vegetation units for the Victoria–Bonaparte Biogeographic Region. Nine of these coincide with twenty-three of the seventy-two vegetation communities described for the Project Area as shown in Table 7.2.

**Table 7.2 Fine Scale Vegetation Units represented in the Project Area (Connors et al. 1996)**

| Description of Fine Scale Vegetation Units  | Vegetation Unit Number* | Project Area vegetation communities †  |
|---|-------------------------|--|
| <i>Eucalyptus miniata</i> , <i>Eu. tetradonta</i> open forest with <i>Sorghum</i> grassland understorey   | 4                       | Min2                                   |
| <i>Eu. microtheca</i> , <i>Excoecaria parvifolia</i> low woodland with <i>Chrysopogon fallax</i> , <i>Dichanthium</i> grassland understorey     | 24                      | Em1, Em2, Em3, Em4, Em5, Em6, Em7, Em8 |
| <i>Bauhinia cunninghamii</i> mixed species low open woodland with <i>Sehima nervosum</i> , <i>Chrysopogon fallax</i> open grassland understorey | 46                      | Bc1, Bc2, Bc3                          |
| <i>Melaleuca minutifolia</i> low woodland with <i>Sorghum</i> grassland understorey   | 50                      | Me4                                    |
| <i>Melaleuca viridiflora</i> , <i>Eucalyptus</i> low open woodland with <i>Chrysopogon fallax</i> grassland understorey                         | 51                      | Cb6, Me2                               |
| Mixed closed-grassland/sedgeland (Seasonal floodplain)  | 54                      | G6, G7                                 |
| <i>Astrebla</i> , mixed species grassland with scattered trees and shrubs   | 97                      | Em6                                    |
| <i>Chrysopogon fallax</i> , <i>Dichanthium fecundum</i> grassland   | 98                      | G1, G2, G3, G4                         |
| <i>Xerochloa</i> grassland  | 104                     | G5                                     |

\* Source: Connors et al. (1996).

† Source: Kinhill Pty Ltd (see Appendix J).

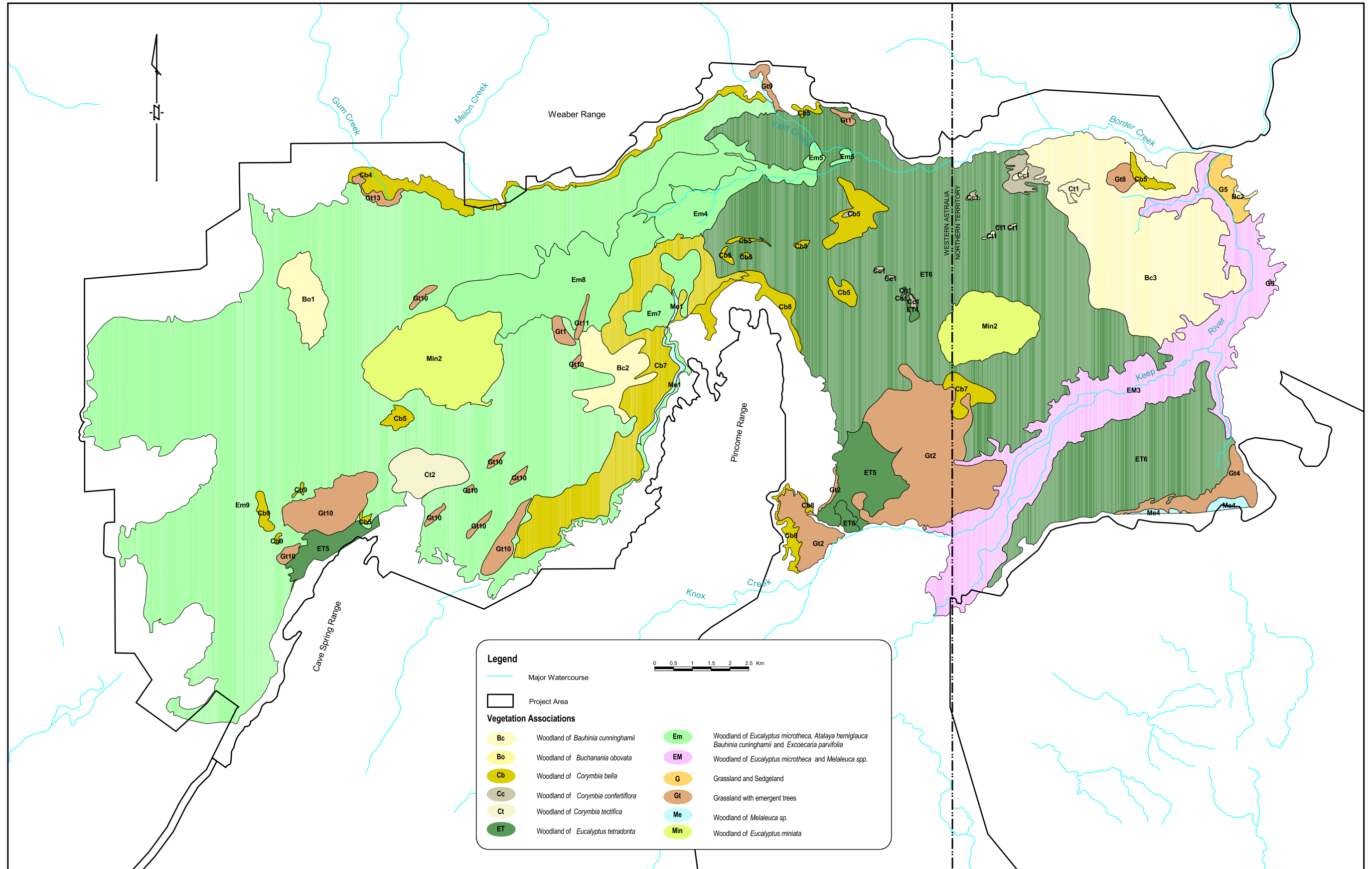


Figure 7.1 Vegetation associations of the Weaber Plain

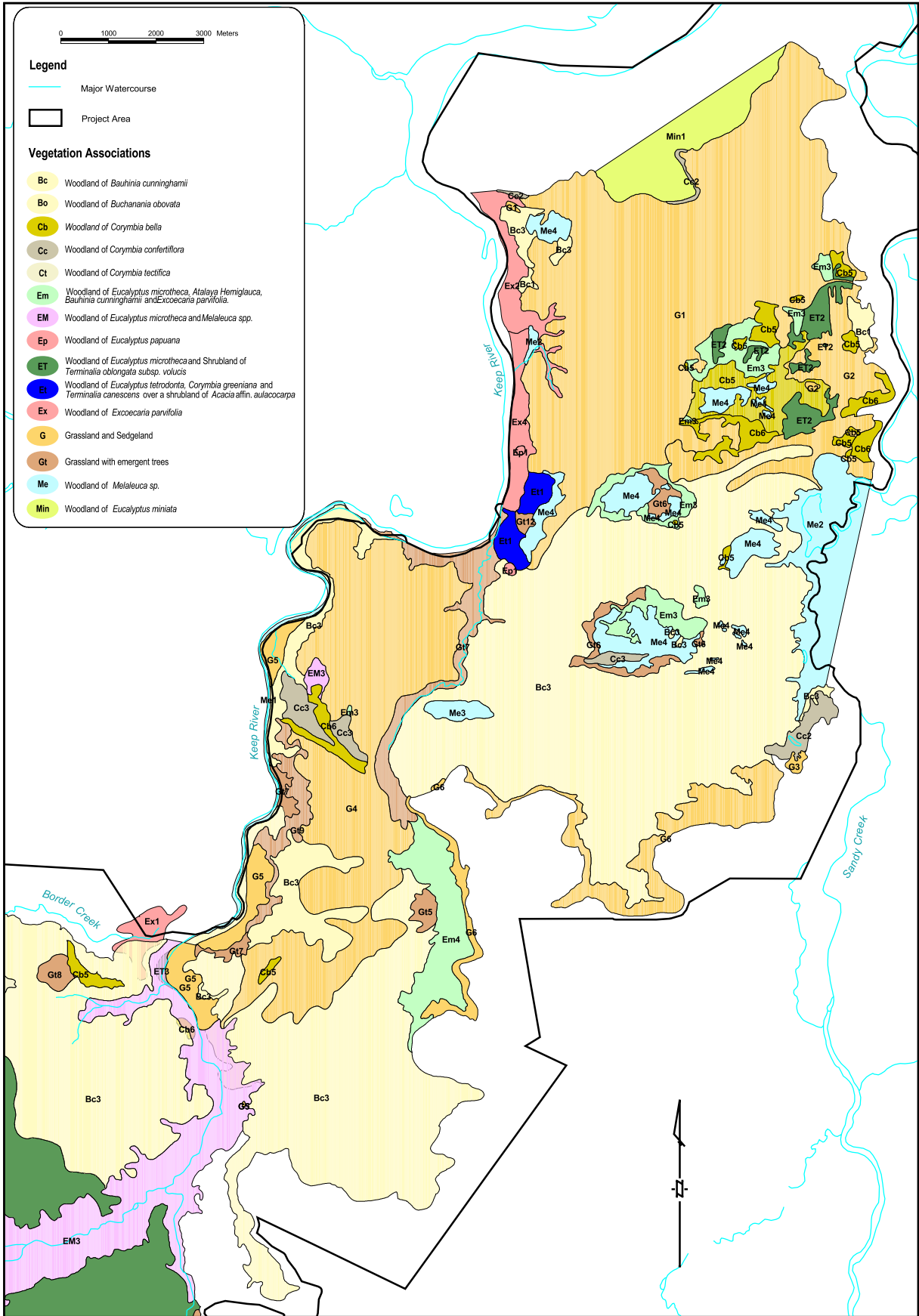


Figure 7.2 Vegetation associations of the Keep River Plain

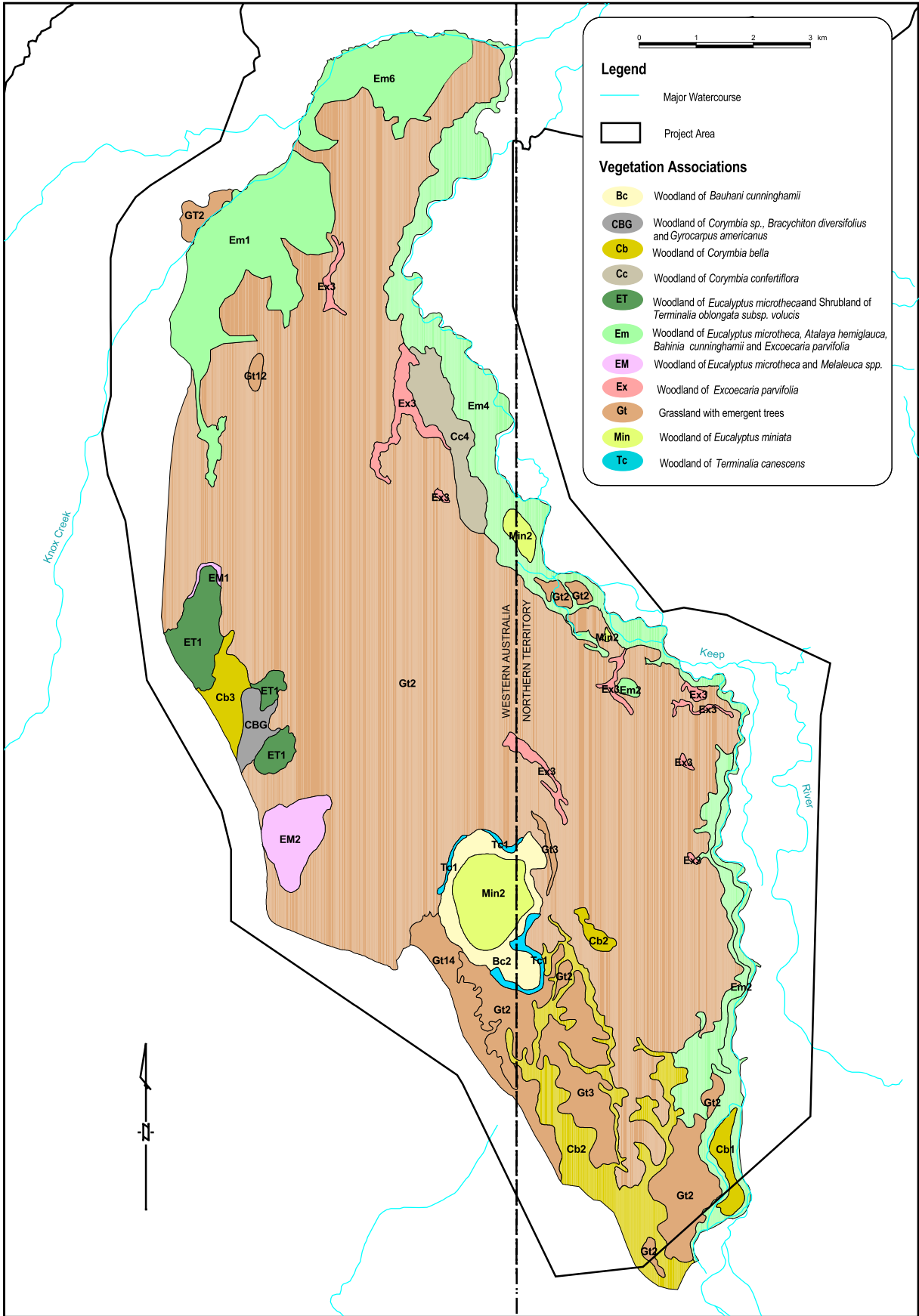


Figure 7.3 Vegetation associations of the Knox Creek Plain

**Figure 7.4 Selected vegetation communities of the Project Area**



Ex3 Woodland of *Excoecaria parvifolia* with scattered *Eucalyptus microtheca* over a low grassland dominated by *Sehima nervosum* and *Cyperus viscidulus*. Occurs on the Knox Creek Plain. Soil Unit 1e.



Ex 2 Woodland of *Excoecaria parvifolia* over an open to dense grassland dominated by *Ophiuros exaltatus*, *Iseilema fragile* or *Heteropogon contortus*. Occurs on the Keep River Plain in Soil Unit 1.



Cb5 Open Woodland of *Terminalia platyphylla*, and *Corymbia bella* over an open woodland of *Bauhinia cunninghamii* and *Terminalia oblongata* subsp. *volucris* and scattered *Acacia ditricha* over a dense annual and tussock grassland of *Themeda triandra*, *Heteropogon contortus*, *Aristida latifolia*, *Ophiuros exaltatus* and *Sorghum timorense*. Occurs on the Weaber and Lower Keep River Plain. Soil Units 4a, 4b, 4c.



G1 Dense Grassland mosaic dominated by *Heteropogon contortus*, *Iseilema fragile*, *Themeda triandra*, *Chrysopogon fallax* or *Sorghum timorense*. Occurs on the northern Keep River Plain. Soil Unit 1.



Cc1 Open Woodland of *Corymbia confertiflora*, *Planchonia careya* and *Terminalia latipes* var. *latipes* over moderately dense *Bauhinia cunninghamii* and a very open tussock grassland of *Heteropogon contortus*, *Themeda triandra* and *Sorghum plumosum*. Occurs on the Weaber Plain. Soil Unit 2b.



EM7 Open Woodland of *Eucalyptus microtheca* and *Acacia ditricha* over a tall grassland dominated by *Oryza australiensis* and *Sorghum timorense* over *Panicum decompositum*. Occurs on the Weaber Plain. Soil Unit 1.



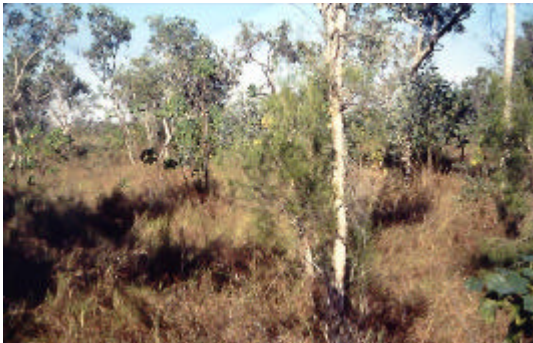
**Figure 7.4 Selected vegetation communities of the Project Area (continued)**



ET6 Open Low Woodland of *Excoecaria parvifolia*, *Bauhinia cunninghamii* and *Eucalyptus microtheca* over a Shrubland of *Terminalia oblongata* subsp. *volucris* and a grassland of *Panicum decompositum*, *Iseilema vaginiflorum* and *Sorghum timorense*. Occurs on the Weaber Plain. Soil Unit 1.



G7 Open Sedgeland dominated by *Eleocharis dulcis* and *Schoenoplectus praelongatus* with emergent *Excoecaria parvifolia* and *Barringtonia acutangula* on the edge of Milligans Lagoon. Occurs on the Knox Creek Plain. Soil Unit 1.



Me 4 Woodland of *Melaleuca minutifolia*, *Melaleuca viridiflora*, *Excoecaria parvifolia* and *Cochlospermum fraseri* over a grassland of *Themeda triandra*. Occurs on the Keep River Plain. Soil Units 2a, 2a/3a, 3a/4a.



Em3. Dense vegetation surrounding the lagoon on the Keep River at Legune Crossing. Soil Unit 7.



GT2 Dense grassland of *Iseilema vaginiflorum*, *Aristida latifolia*, *Sorghum timorense*, *Themeda triandra* with emergent *Eucalyptus microtheca*, *Excoecaria parvifolia*, *Atalaya hemiglauc*a and *Bauhinia cunninghamii*. Occurs on the Knox Creek Plain. Soil Unit 1.



Bc1 Low Woodland of *Bauhinia cunninghamii* over tussock and annual grassland of *Iseilema* sp., *Panicum decompositum*, *Sehima nervosum*, *Aristida latifolia*, *Cyperus bifax*, *Sehima nervosum*, *Chrysopogon fallax* and *Sorghum timorense*. Occurs on the Weaber and Keep River Plains. Soil Unit 1.

The Keep River Plain has extensive areas of grassland with no, or only a few, scattered trees, which include coolibah (*Eu. microtheca*), *Corymbia bella*, guttapercha tree (*Excoecaria parvifolia*), corky bark wattle (*Acacia ditricha*) and bauhinia (*Bauhinia cunninghamii*). The vegetation of the Knox Creek Plain is predominantly grassland with emergent to dense low trees dominated by coolibah (*Eu. microtheca*), guttapercha tree (*Excoecaria parvifolia*), *Atalaya hemiglauca* and bauhinia (*Bauhinia cunninghamii*). The Weaber Plain is similar to the Knox Creek Plain, namely, a grassland with emergent trees dominated by coolibah (*Eu. microtheca*), guttapercha tree (*Excoecaria parvifolia*) and *Terminalia obovata* subsp. *volucris*. However, sections of the Weaber Plain retain water for longer periods and have grassland species associated with wetter areas (e.g. wild rice [*Oryza australiensis*] and canegrass [*Ophiuros exaltatus*]).

Ecologia (1999) provides an analysis of the floristic data from the Project Area that separates the sites into two broad groups. The first group is the black-soil plains of the Cununurra clay (normal phase) soils, associated cracking clays in depressions and Aquitaine soils. The second group includes sites on a miscellaneous array of soils and substrate types including red soil, sandy or stony substrates or upland areas such as the Cockatoo Land System, and riverbanks.

The Weaber Plain is well represented by Cununurra clay (normal phase) soils and Aquitaine soils; the Keep River Plain by Cununurra clay (normal phase) soils, and the periphery of the plain by Aquitaine soils; and the Knox Creek Plain by Cununurra leached phase soils. These differences in soil types result in a differing degree of representation of vegetation community types and floristics on each of the three plains.

The differentiation of the vegetation communities in relation to soil units is shown in Table 7.3. The seventeen major vegetation groups are listed in the legend on the maps (e.g. Me, ET, Gt), and the description for each vegetation community (e.g. Me4, ET5, Gt10) is given in Appendix J. Only the vegetation groups occurring on the individual maps are listed in the relevant legend.

Thirty-eight different soil units were sampled by Ecologia (1997a) and Kinhill Pty Ltd (1999) (Appendix J refers). Soil Unit 1 (a cracking clay) recorded the greatest diversity of vegetation communities, with four communities recorded for the Keep River Plain, six for the Knox Creek Plain and eight for the Weaber Plain. Some of the variations in these vegetation communities are subtle, while others are more obvious, such as the change from a tree layer dominated by *Eucalyptus microtheca* with grey bark to *Corymbia bella* with a white bark.

Some vegetation communities occur in several soil units but these units are usually adjoining and often small in size. When the structure of the soils varies considerably (e.g. adjacent areas of cracking clay and sand), the change in vegetation is marked. However, in adjacent areas of different clay soils the vegetation generally does not exhibit a significant change.

## 7.2.2 Comparison of the Project Area with portions of Auvergne and Spirit Hills stations

Auvergne and Spirit Hills stations include the major extent of the Ivanhoe Land System in the Northern Territory (Figure 4.2). A study (Brocklehurst et al. 1998) was commissioned by the Northern Territory Government to compare the vegetation of these black-soil plain areas with that of the Project Area and, in particular, to 'consider whether the plant species diversity and the floristic communities present in the Project Area are well represented in the Auvergne region'.

**Table 7.3 Vegetation communities and associated soil units within the Project Area**

| Soil      |  | Vegetation community*                  |                                |                        |
|-----------|--|--|--------------------------------|------------------------|
| Soil Unit | Description                                  | Weaber Plain                           | Keep River Plain               | Knox Creek Plain       |
| 1         | Cracking clay                                | Gt2, Gt8, Em6, Em7, ET6, Cb7, Bc1, Ex1 | G1, Gt1, Ex2, Cb7 Bc1, Bc3, G3 | G7, GT3, Em1, EM1, Bc2 |
| 1c        | Brownish cracking clay                       | Em6                                    |                                |                        |
| 1e        | Grey and brown cracking clay                 |  |                                | Ex3                    |
| 1g        | Grey cracking clay                           |  |                                | Em2                    |
| 2a        | Red-brown earths                             | Ct1                                    | Cc3                            |                        |
| 2b        | Red-brown earths, sandy topsoils             | Cc1                                    | GT12                           |                        |
| 2c        | Red earths, sandy topsoils                   | Ct1                                    |                                |                        |
| 2a/3a     | Complex of 2a/3a                             |  | Me4                            |                        |
| 3a        | Red-brown earths                             |  | G2                             |                        |
| 3c        | Red-brown earths                             |  |                                | ET2                    |
| 3a/4a     | Complex of 3a/4a                             |  | Me4                            |                        |
| 4a        | Cracking clays in large depressions          | Cb5                                    | GT6, Cb5                       |                        |
| 4b        | Cracking clays in medium depressions         | Em3, Cb5                               | Em3, Cb5                       |                        |
| 4c        | Brownish cracking clays                      | Cb5                                    | Cb5                            |                        |
| 4d        | Cracking clays with hydromorphic attributes  | ET4                                    | Cc2                            |                        |
| 5c/4d     | Complex 4d with included stones or rocks     | G6                                     |                                |                        |
| 5a        | Cracking clays with hydromorphic attributes  | Gt4m, GT9, Em4, Em9                    | ET3                            | Em4                    |
| 5b        | Cracking clays with hydromorphic attributes  | Gt5, ET5, EM8                          |                                |                        |
| 5c        | Cracking clays with hydromorphic attributes  | GT13                                   | G4                             |                        |
| 5bt       | Cracking clays with hydromorphic attributes  | ET5                                    |                                |                        |
| 5e        | Grey cracking clays                          |  | ET1, Cb3                       | ET1                    |
| 6         | Small steep hills                            | Gt10                                   |                                |                        |
| 6e        |  |  |                                | CBG                    |
| 7         | Rivers/streams                               |  | Ep1, Ex4, Me3                  | Cb1                    |
| 7a        | Rivers and major creeks                      | EM3                                    | G5, GT7, Cb6, Me2              |                        |
| 7a/b      | Complex of 7a/7b                             |  |                                | Cb1                    |
| 7b        | Cracking clays, severe erosion               | Em5                                    |                                |                        |
| 7f        | Remnant levees of prior streams              |  |                                | Cb2                    |
| 8         | Undifferentiated complex of 8a/8b            | Cb8                                    |                                |                        |
| 8a        | Complex peripheral zone to sand and laterite |  |                                | Cc4, Me1               |
| 8b        | Complex between 8a and sand                  | Cb4                                    |                                |                        |
| 9c        | Brownish cracking clays                      | Gt11, Cb9                              |                                |                        |
| 11        | Colluvial outwash slopes                     |  |                                | Gt14, Em2              |
| Rock      | Cockatoo                                     |  | Min1, Et1                      | Min2                   |
| Rock      | Dolomite                                     | Bo1                                    |                                |                        |
| Rock      | Sandstone                                    |  |                                | Tc1                    |

\* Refer to Appendix J for description of communities.

A total of 226 20 × 20 m quadrats was assessed by the survey over seventeen days during March and April 1998. The survey was undertaken on areas of black soil only. The sandstone areas (the Cockatoo Land System) were not surveyed, but the basal area of canopy cover and the plant species present were recorded. A total of thirty-seven vegetation associations in seven main groupings was recorded, but no interpretive mapping was undertaken. As a consequence, the extent of each vegetation association is unknown.

The Auvergne region appears to have a greater variation of vegetation and soil regimes than the Project Area. At a descriptive level, there is a similarity between many of the vegetation associations of the Auvergne region and those of the Project Area; however, the degree of this similarity was unable to be reliably quantified because of the different survey methodology used by Ecologia (1997a) and Brocklehurst et al. (1998).

Ecologia (1999) (Appendix K) compared the vegetation groups in the Auvergne region using Project Area data and noted that six broad associations are present (Table 7.4). Seven of the seventeen vegetation associations identified by Ecologia in the Project Area are not represented in the Auvergne region. Of these, six are associated with non-clay soils that were not sampled by Brocklehurst et al. (1998).

Brocklehurst et al. (1998) considered that Group 1 and Group 5 (cracking clay soils) are most likely representative of the same floristic community and that it was mainly the season when sampled that distinguishes the two groups. Group 1 mainly consists of wet-season sites, and Group 5 predominantly of dry-season sites. Group 1 records herbs and sedges as the dominant understorey species and Group 5 records grasses. Group 3 includes saline sites that are poorly represented in both the Project Area and the Auvergne region. Group 6 includes wetland and riverine sites and their margins.

Compared with the Auvergne region, the Project Area has a predominance of *Sorghum timorense*, *Acacia ditricha* and *Themeda triandra*, and a scarcity of *Sorghum bulbosum*. The Project Area also has a greater diversity and possibly a higher biomass of plant species than the Auvergne region, but the same dominant species are present in each region.

**Table 7.4 Broad vegetation groups of the Project Area and the Auvergne region**

| Group        | Number of sites in Project Area | Number of sites in Auvergne region | Project Area                        |  |
|--------------|---------------------------------|------------------------------------|-------------------------------------|--|
|              |                                 |                                    | Landforms and soils                 | Vegetation   |
| 1            | 28                              | 9                                  | Cracking clays                      | Characterised by sedge and herb understorey.   |
| 2            | 25                              | 79                                 | Red-browns; hills, CcLS; peripheral | <i>Heteropogon contortus</i> , <i>Cayratia trifolia</i> , <i>Corymbia confertiflora</i> , <i>Grewia retusifolia</i> .  |
| 3            | 3                               | 2                                  | Rivers, creeks; inundated; saline   | <i>Xerochloa</i> sp., <i>Trianthema</i> sp., <i>Sesbania cannabina</i> , <i>Panicum decompositum</i> , <i>Avicennia</i> sp., <i>Halosarcia</i> sp. etc.      |
| 4            | 8                               | 11                                 | Red-browns; CcLS; peripheral        | <i>Acacia hemiglauca</i> , <i>Drosera ordensis</i> , <i>Senna artemisioides</i> .  |
| 5            | 56                              | 87                                 | Cracking clays                      | <i>Chrysopogon fallax</i> , <i>Bauhinia cunninghamii</i> , <i>Panicum decompositum</i> , <i>Aristida latifolia</i> , <i>Themeda</i> sp., <i>Ophiuros</i> sp. |
| 6            | 10                              | 19                                 | Creeks, wetland margins             | <i>Excoecaria parvifolia</i> , <i>Eucalyptus microtheca</i> .  |
| <b>Total</b> | <b>130</b>                      | <b>224</b>                         |                                     |  |

Source: Ecologia 1999.

Note: CcLS = Cockatoo Land System.

Due to the larger number of soil types represented, a greater number of vegetation associations were recorded at Auvergne and Spirit Hills stations than for the Project Area. Differences in sampling methodology (20 × 20 m quadrats by Brocklehurst et al. [1998] and 100 × 100 m quadrats by Ecologia [1997a]) and seasonal differences limit the validity of comparisons of data. Only the presence or absence of species is compared by Brocklehurst et al. (1998) although the differences in the two sampling areas (400 m<sup>2</sup> and 10,000 m<sup>2</sup>) reduces the probability of recording a species at one site compared with the other. The Auvergne survey sampled 226 sites making a total of 90,400 m<sup>2</sup> of sampling area and the Project Area had 133 sites sampled making a total of 1,330,000 m<sup>2</sup> of sampling area. On sampling area alone, it would be expected that the number of species recorded from the Project Area (550) would be greater than from Auvergne (458). Of the combined list of species from the two surveys, 38% were recorded only from the Project Area, 26% only from the Auvergne region and 36% were common to both surveys. Despite the limitations mentioned earlier, the analysis indicates a relatively high species richness in the Project Area.

### **7.2.3 Comparison of the Project Area with other areas**

#### **Ord Riverside Developments**

Ecologia (1997b) was also commissioned by the Department of Resources Development to undertake a survey of the Ord Riverside Developments. These areas have been identified as part of ORIA Stage Two (i.e. suitable for horticultural development) and include Mantinea Flats, the Carlton Plain and the Ord River West Bank area (Figure 1.1). A comparison of the results of the Ecologia surveys of the Project Area (Ecologia Environmental Consultants 1997a) and the Riverside Developments (Ecologia 1997b) is provided in Ecologia (1999). Data analysis clearly separated the Project Area sites from the Riverside Development sites. While there is a significant overlap between the floristic composition of sites from the two areas, there is little representation of Soil Unit 1 (cracking clays) and Soil Unit 5 (cracking clays) in the Riverside Developments; cracking-clay sites predominate in the Project Area.

#### **WARMS**

The monitoring method for the WARMS records the presence of perennial species within 100 quadrats (70 × 70 cm) at each site.

Data were provided for thirty-seven WARMS sites within ten land systems identified by Stewart et al. (1970):

- Antrim—five sites
- Inverway—fifteen sites
- Argyle—three sites
- Ivanhoe—one site
- Cowendyne—one site
- Pinkerton—one site
- Frayne—three sites

- Wave Hill—six sites
- Gordon—one site
- Willeroo—one site.

The soils of these land systems are predominantly grey and brown cracking clays of the Cununurra, Argyle and Barkly soil groups (Stewart et al. 1970). Statistical analysis of the data in Ecologia (1999) indicated that the floristic composition of the Ivanhoe Land System (one site only) is distinct from all other WARMS sites and that it can be grouped with sites from the Project Area. However, monitoring of more Ivanhoe Land System sites would be required to confirm whether these results are indicative of a general trend or are restricted to the one Ivanhoe site sampled.

#### 7.2.4 Conservation significance of the vegetation associations

The major vegetation associations of particular conservation significance within the Gardner Botanical District according to Beard (1990) are vine thickets and rainforest. An area along the middle reaches of the Keep River was recorded by Ecologia (1997a) as being a vine thicket, although it was considered degraded due to the long history of pastoral activity as cattle have a tendency to congregate in riverine areas for shelter and water. Several stretches of dense riverine vegetation, especially in the upper reaches of the Keep River within the Project Area, were located by Kinhill Pty Ltd (1999). These areas have the density of a vine thicket, are regarded as ‘vine thickets’ in this area, and are considered to be of conservation significance.

Ecologia (1997a) identified three other vegetation units that have conservation significance:

- Wild rice (*Oryza australiensis*) grasslands, usually with an open overstorey of guttapercha tree (*Excoecaria parvifolia*). The wild rice (*Oryza australiensis*) grasslands were described as rare, and confined to black-soil plains in northern Western Australia and the Northern Territory. The most extensive herb/grasslands of wild rice (*Oryza australiensis*) and *Diplachne parviflora* known in Western Australia dominate the wetland grassland at Parry Lagoon Nature Reserve (Department of Conservation and Land Management 1998). Wild rice has also been recorded as occurring in a number of scattered localities in the Kimberley region as well as in the Project Area. In the Northern Territory, wild rice is found from the Keep River through to eastern Arnhem Land. Three sites (WP1, WP9, WP19) of wild rice (*Oryza australiensis*) are located on the Weaber Plain (Ecologia Environmental Consultants 1997a);
- cork bark wattle (*Acacia ditricha*), bauhinia (*Bauhinia cunninghamii*) low open woodland over fantail grass (*Chrysopogon fallax*) tussock grassland and *Sorghum timorense* annual grassland. Fantail grass (*Chrysopogon fallax*) occurs in a similar habitat to that of wild rice (*Oryza australiensis*), particularly in areas subject to inundation for long periods. This vegetation is widespread throughout the eastern section of the Weaber Plain and dominates the southern section of the Keep River Plain;
- *Echinochloa kimberleyensis*. This was recorded during the wet season from seasonal wetlands on the Knox Creek Plain and Weaber Plain where *Echinochloa kimberleyensis* occurs with wild rice (*Oryza australiensis*) and fantail grass (*Chrysopogon fallax*) in small, scattered populations. The Western Australian Herbarium database records this

plant at Milligan Lagoon (on the Knox Creek Plain), in an area proposed for conservation (see Chapter 10), and in the Keep River National Park.

Connors et al. (1996) identified two fine scale vegetation communities that occur in the Project Area and that are currently unreserved or poorly reserved in the Northern Territory section of the Victoria–Bonaparte Biogeographic Region, namely:

- *Melaleuca minutifolia* low woodland with a *Sorghum* spp. grassland understorey
- *Xerochloa* spp. grassland.

*Xerochloa* spp. grassland was recorded in the northern section of the Keep River Plain within an area proposed for conservation (Chapter 10). This grassland is common on the mudflats outside the Project Area. *Melaleuca minutifolia* low woodland, typically associated with kangaroo grass (*Themeda triandra*), occurs in Soil Units 2a, 3a or 4a and while some of these areas are proposed for development, large areas would be specifically conserved in the Project Area (Chapter 10).

Mangrove communities are also recommended for preservation (Burbidge et al. 1991). Wightman (1989) indicates that a number of species of mangrove occur along the lower Keep River: white mangrove (*Avicennia marina*), ribbed-fruited orange mangrove (*Bruguiera exaristata*), yellow mangrove (*Ceriops tagal* var. *australis*), red mangrove (*Rhizophora stylosa*) and cedar mangrove (*Xylocarpus moluccensis*). However, only seedlings of white mangrove (*Avicennia marina*) were located by the Kinhill Pty Ltd (1999) surveys along the Keep River within the Project Area. The dense mangrove stands recorded by Wightman (1989) are downstream of the Project Area and near the river mouth. No mangrove plants were recorded along Sandy Creek within the Project Area (Ecologia 1997a).

### 7.3 FLORA OF THE PROJECT AREA

Based on data provided by the Western Australian Herbarium and the Parks and Wildlife Commission of the Northern Territory, 307 taxa of plants from eighty families were previously recorded within the Ord River area (Ecologia Environmental Consultants 1997a). The most numerous families are Poaceae (grasses—forty-nine taxa), Myrtaceae (eucalypts and paperbarks—twenty-nine taxa), Cyperaceae (sedges and rushes—twenty-three taxa), Mimosaceae (wattles—seventeen taxa), Asteraceae (daisies—thirteen taxa), Papilionaceae (peas—ten taxa) and Combretaceae (*Terminalia* spp.—ten taxa).

The Ecologia survey recorded 682 taxa from eighty-seven families, twenty-six of which were represented by a single taxon. Two hundred and seventy-six genera were recorded, with 138 of these represented by a single taxon. An additional 40 species were recorded by the Kinhill (1999) survey bringing the total number of recorded species to 316.

Western Australia and the Northern Territory have different requirements for the conservation of flora and, as the Project Area includes land in both Western Australia and the Northern Territory, the conservation requirements of each must be considered. Compliance with Western Australian and Northern Territory requirements would also allow for compliance with the *Endangered Species Protection Act 1992*.

Within Western Australia, rare flora is protected by the *Wildlife Conservation Act 1950*. The Act is administered by CALM and prohibits the taking of any Declared Rare Flora on any lands throughout Western Australia without the written consent of the Minister for the

Environment. CALM also maintains a supplementary listing of rare flora species referred to as 'Priority Flora'.

Rare flora in the Northern Territory is protected by the *Parks and Wildlife Act 1993*. This Act includes a schedule of protected plants (and animals) and a supplementary list of flora species.

Sixteen taxa known to occur within the Project Area have been listed by either the Western Australian or the Northern Territory Governments as being threatened, rare or poorly known (Table 7.5). An additional three taxa are listed by the Northern Territory as being restricted in Central Australia but common throughout the remainder of the Territory. Fourteen taxa considered to be rare within the Northern Territory were recorded within the Northern Territory portion of the Project Area, of which two are listed as Priority Flora in Western Australia. An additional two taxa of priority status were restricted to Western Australia.

The sixteen rare and priority species recorded by Ecologia (1997a) in the Project Area are listed in Table 7.6, together with the number of sampling sites, the vegetation associations and soils units in which these species were recorded.

Five of the seventeen vegetation associations identified by Ecologia (1997a) do not include any of the sixteen rare and priority plant species (vegetation associations 6, 12, 13, 16 and 17), and nineteen of the twenty-six soil types sampled do not include records of any of the sixteen rare and priority species.

Of the rare and priority species of conservation significance recorded by Ecologia (1997a) in the Project Area, fourteen species are not exclusive to the Kimberley region, and occur in other regions of Western Australia and the Northern Territory (Table 7.7).

Impacts on the flora of the Project Area from project development, and the management measures proposed to mitigate the impacts, are described in Chapter 10.

Connors et al. (1996) list species restricted to the Victoria–Bonaparte Biogeographic Region in the Northern Territory. These include *Acacia ditricha*, *Brachychiton tuberculatus*, *Goodenia malvina* and *Grevillea agrifolia* recorded from the Project Area. However, in Western Australia some of the species listed by Connors et al. are known to occur outside the Victoria–Bonaparte Biogeographic Region.

#### **7.4 INTRODUCED FLORA**

Eighteen introduced plants were recorded within the Project Area by Ecologia (1997a) and Kinhill (Appendix J). The most widely distributed introduced taxa recorded are *Passiflora foetida* var. *hispida* (wild passionfruit), *Echinochloa colona* (awnless barnyard grass), *Achyranthes aspera* (chaff flower) and *Stylosanthes hamata* (Caribbean stylo). Seven of the introduced plants have been declared noxious weeds under the *Agriculture and Related Resources Act 1976* in Western Australia, and the *Noxious Weeds Act 1978* in the Northern Territory; these are listed in Table 7.8. None of these are listed in the National Weeds Strategy (Agriculture and Resource Management Council of Australia and New Zealand et al. 1999).



**Table 7.5 Conservation codes and distribution of taxa recorded within the Project Area**

| Flora taxa  | Conservation code |     | Present in State or Territory |         |    | Recorded for cracking-clay soils |
|---|-------------------|-----|-------------------------------|---------|----|----------------------------------|
|   | WA                | NT  | WA                            | WA & NT | NT |                                  |
|   |                   |     |                               |         |    | ✓+                               |
| Largeleaf Kurrajong<br>( <i>Brachychiton tuberculatus</i> )       | P3                | 3r  |                               | ✓       |    |                                  |
| A lily ( <i>Caesia chlorantha</i> )                               | Nil               | 3r  |                               |         | ✓  | ✓+                               |
| Cleome ( <i>Cleome uncifera</i> )                                 | Nil               | 3r  |                               | ✓       |    |                                  |
| Grubweed ( <i>Corchorus fascicularis</i> )                        | Nil               | 3r  |                               | ✓       |    | ✓+                               |
| Barnyard grass ( <i>Echinochloa kimberleyensis</i> )              | P1                |     | ✓                             |         |    |                                  |
| A sedge ( <i>Fimbristylis laxiglumis</i> )                        | P2                | 3r  |                               | ✓       |    | ✓                                |
| Blady grass ( <i>Imperata cylindrica</i> )                        | Nil               | 3r  |                               | ✓#      |    | ✓+                               |
| Cow vine ( <i>Ipomoea</i> aff. <i>agrillicole</i> )               | Nil               | 3r  |                               |         | ✓  | ✓+                               |
| Lindernia ( <i>Lindernia tectanthera</i> )                        | Nil               | 3r  |                               | ✓       |    |                                  |
| Plumbago ( <i>Plumbago zeylanica</i> )                            | Nil               | 3r  |                               | ✓#      |    | ✓+                               |
| Sorghum ( <i>Sorghum grande</i> )                                 | Nil               | 3r  |                               | ✓       |    | ✓                                |
| Striga ( <i>Striga squamigera</i> )                               | Nil               | 3k  |                               | ✓       |    | ✓+                               |
| Tacca ( <i>Tacca maculata</i> )                                   | Nil               | 3r  |                               |         | ✓  |                                  |
| Camel bush ( <i>Trichodesma zeylanicum</i> )                      | Nil               | 3r  |                               | ✓#      |    |                                  |
| A grass ( <i>Triodia acutispicula</i> )                           | P3                | Nil | ✓                             |         |    |                                  |
| Typhonium ( <i>Typhonium liliifolium</i> )                        | Nil               | 3r  |                               | ✓       |    | ✓                                |
| A daisy ( <i>Vittadinia spechtii</i> var. <i>kimberleyensis</i> ) | Nil               | 3r  |                               | ✓       |    |                                  |

Notes:

Western Australia:

P1 = Priority One—Poorly Known Taxa. Taxa that are known from one or a few (generally < 5) populations that are under threat.

P2 = Priority Two—Poorly Known Taxa. Taxa that are known from one or a few (generally < 5) populations, at least some of which are not believed to be under immediate threat.

P3 = Priority Three—Poorly Known Taxa. Taxa that are known from several populations, at least some of which are not believed to be under immediate threat.

Nil = Not priority status.

Northern Territory:

2K = Insufficiently known nationally.

3r = Rare, but not currently endangered or vulnerable, occurring in small populations, restricted to specific and localised habitats.

3k = Poorly known.

# = Rare in Central Australia, common elsewhere (i.e. not significant flora in the 'Top End').

✓ = Species recorded from cracking-clay soils.

✓+ = Species recorded from cracking clay soils and additional soil units.

Source: CALM 1999, Darwin Herbarium and Herbarium Rare Checklist, Parks and Wildlife Commission of the Northern Territory 1997.

**Table 7.6 Flora of particular or listed conservation significance in the Project Area**

| Significant species                                   | Number of sites | Vegetation associations | Soil Unit                  |
|---|-----------------|-------------------------|----------------------------|
| <i>Brachychiton tuberculatus</i>                      | 1               | 2                       | 6a, 7a, 8a                 |
| <i>Caesia chlorantha</i>                              | 1               | 11                      | 1,5                        |
| <i>Cleome uncifera</i>                                | 2               | 1                       | 6, Cockatoo                |
| <i>Corchorus fascicularis</i>                         | 15              | 8, 9, 10, 11, 14, 15    | 1, 4, 5, 5a, 5e, 6e, 9, 9c |
| <i>Echinochloa kimberleyensis</i>                     | 1               | 3                       | 7a                         |
| <i>Fimbristylis laxiglumis</i>                        |                 | 15                      | 1, 5, 9a                   |
| <i>Ipomoea</i> aff. <i>agrillicole</i>                | 1               | 7                       | 2, 7                       |
| <i>Lindernia tectanthera</i>                          | 1               | 15                      | 8a                         |
| <i>Sorghum</i> ? <i>grande</i> *                      | 5               | 4, 10                   | 1, 2b, 3a, 4, 4a           |
| <i>Striga squamigera</i>                              | 1               | 8                       | 5e, 6e                     |
| <i>Tacca maculata</i>                                 | 1               | 1                       | 6, Cockatoo                |
| <i>Triodia acutispicula</i>                           | 4               | 1,2                     | 6, 6a, 7a, 8a, Cockatoo    |
| <i>Typhonium liliifolium</i>                          | 2               | 10, 11                  | 1, 4                       |
| <i>Vittadinia spechtii</i> var. <i>kimberleyensis</i> | 1               | 1                       | 6, Cockatoo                |

\* ? means insufficient material for positive identification, but believed to be that species.

Source: *Ecologia* (1997a).

**Table 7.7 Occurrence of significant flora of the Project Area in Western Australia and the Northern Territory**

| Significant species recorded in the Project Area      | Collection localities in Western Australia and Northern Territory   | Number of collections in WA Herbarium* | Number of collections in NT Herbarium |
|---|---|--|---------------------------------------|
| <i>Brachychiton tuberculatus</i>                      | Endemic to the Kimberley in the Ord River region.   | 11                                     | 8                                     |
| <i>Caesia chlorantha</i>                              | Limbunya, Petermann Reserve and Beetaloo Station.   | 0                                      | 4                                     |
| <i>Cleome uncifera</i>                                | Nita Downs Station, south to upper Gascoyne River, and east to the Great Sandy Desert.  | 56                                     | 4                                     |
| <i>Corchorus fascicularis</i>                         | Central Kimberley,  | 7                                      | 15                                    |
| <i>Echinochloa kimberleyensis</i>                     | Black-soil swamps along the Ord River.  | 3                                      | 0                                     |
| <i>Fimbristylis laxiglumis</i>                        | Black clay north of Kununurra.  | 1                                      | 4                                     |
| <i>Ipomoea</i> aff. <i>agrillicole</i>                | Connells Lagoon and Balbarini Station.  | 0                                      | 6                                     |
| <i>Lindernia tectanthera</i>                          | Possibly endemic to the Kimberley region. Recorded from Mitchell Plateau, Napier, Broome Bay, Kununurra, Prince Regent River Reserve, and between Broome and Derby. | 3                                      | 0                                     |
| <i>Triodia acutispicula</i>                           | Endemic to the Kimberley region, Drysdale River and Cape Leveque.   | 10                                     | 0                                     |
| <i>Sorghum grande</i>                                 | Katherine, Mittlebah Station, Willeroo and Manbulloo Station.   | 0                                      | 7                                     |
| <i>Striga squamigera</i>                              | Mt Nyulasy and Kununurra.   | 12                                     | 6                                     |
| <i>Typhonium liliifolium</i>                          | Mitchell Plateau and Kalumburu Mission.   | 5                                      | 4                                     |
| <i>Vittadinia spechtii</i> var. <i>kimberleyensis</i> | Possibly endemic to the Kimberley region, King Leopold Range and Prince Regent River Reserve.   | 1                                      | 0                                     |

\* Does not include field collections made by *Ecologia* (1997a).

**Table 7.8 Declared weeds recorded within the Project Area**

| Taxa  | Western Australia | Northern Territory |
|---|-------------------|--------------------|
| Parkinsonia ( <i>Parkinsonia aculeata</i> )               | P1, P2            | Class B            |
| Spinyhead sida ( <i>Sida acuta</i> )                      | P1                | Class B            |
| Flannel weed ( <i>Sida cordifolia</i> )                   | P1                | Class B            |
| Calotrope ( <i>Calotropis procera</i> )                   | P1, P2            | Class B            |
| Johnson grass ( <i>Sorghum halepense</i> )                |                   | Class C            |
| Hyptis ( <i>Hyptis suaveolens</i> )                       |                   | Class B            |
| Star burr, goat's head ( <i>Acanthospermum hispidum</i> ) |                   | Class B            |

Notes:

P1 = plants that cannot be introduced or spread.

P2 = plants that will be eradicated.

Class B = growth and spread of plants to be controlled.

Class C = plants not to be introduced into the Northern Territory—they are not known to exist but could pose a significant threat if introduced.

Source: *Ecologia* (1997a)

Black cracking-clay soil areas of the Project Area have not been significantly affected by weed invasion. However, an area in the south-west section of the Weaber Plain, currently utilised to drain excess water from ORIA Stage One and subject to permanent inundation, has been colonised by the native wetland plant cumbungi (*Typha domingensis*). This has resulted in the localised loss of some of the naturally occurring species adapted to seasonally wet sites.

The potential for weeds to invade neighbouring native vegetation after being brought into the Project Area (e.g. via agricultural or earthmoving machinery) has been assessed by examining the incidence of introduced species in and around ORIA Stage One. Herbicide use and mechanical weed control (tillage) have been effective in controlling weed infestations within farms in this area. However, some adjacent areas—including road verges, uncleared red and black-soil plains, river levees and channels—have been deleteriously affected by weed invasion originating from past agricultural activities.

There is the potential for weeds in ORIA Stage One to be transferred into the Project Area. This could include transfer by wind (e.g. calotrope [*Calotropis procera*]), or by the water movement from the Kununurra Diversion Dam to the Project Area (e.g. para grass [*Urochloa mutica*]).

The major weeds in the irrigation channels of ORIA Stage One are cumbungi (*Typha domingensis*) and lily or ribbon weed (*Vallisneria nana* [previously *Vallisneria spiralis*]). Weeds of the channel banks are caltrop (*Tribulus terrestris*), calotrope (*Calotropis procera*), johnson grass (*Sorghum halepense*) and para grass (*Urochloa mutica*). The invasion of the irrigation channels and balancing storage dams by *Vallisneria* and other waterweeds is inevitable. Two aggressive weeds that currently require control along and within the channels are ribbon weed (*Vallisneria nana*) and johnson grass (*Sorghum halepense*). Neither are listed Declared Weeds in Western Australia, but johnson grass is a Class C weed in the Northern Territory.

In addition to the analysis of weeds in ORIA Stage One, research has shown that there may be weeds from other areas which may potentially establish in the Project Area (S. Lloyd, pers. comm.). *Hymenachne amplexicaulis*, which establishes in water to 3 m deep and invades sugar fields, is a problem in Queensland. Two species, *Salvinia molesta* and the sensitive plant (*Mimosa pigra*), listed in the National Weed Strategy (1999) are of potential concern. *Salvinia molesta* (P1, P2 in Western Australia, noxious in the Northern Territory)

is an aggressive weed along watercourses in the Northern Territory and has been recorded and controlled in the Kimberley region. The sensitive plant (*Mimosa pigra*) (P1 in Western Australia, Class B in the Northern Territory), considered to be one of Australia's worst environmental weeds (Braithwaite et al. 1989), is a potential weed of floodplains. Sensitive plant (*Mimosa pigra*) is a problem in the Northern Territory (e.g. Kakadu) and is now in the Fitzmaurice River in the Northern Territory.

Chapter 10 provides a description of the management measures proposed to mitigate the introduction of weeds into the Project Area.