

## NEERABUP NATIONAL PARK, LAKE NOWERGUP NATURE RESERVE AND ADJACENT BUSHLAND, NEERABUP

**Boundary Definition:** protected area/bushland (part taken to cadastre) boundary

### SECTION 1: LOCATION INFORMATION

**Bush Forever Site no.** 383

**Area (ha):** bushland 1736.1 (Site also includes open water.)

**Map no.** 19, 20, 27, 28

**Map sheet series ref. no.** 2034-I SW, 2034-IV NE, 2034-IV SE

**Other Names:** not known

**Local Authorities (Suburb):** Shire of Wanneroo (Neerabup, Carabooda, Nowergup, Clarkson, Tamala Park), City of Joondalup (Kinross, Neerabup)

**Includes CALM Managed Land:** Reserve 27575 (National Park), Reserve 24581 (Conservation of Flora and Fauna)

**System 6 (1983):** M6 area of bushland goes beyond System area boundaries, all bushland described

### SECTION 2: REGIONAL INFORMATION

#### LANDFORM AND SOIL

##### Spearwood Dunes

Sands derived from Tamala Limestone (Qts: S7)

Tamala Limestone (Qtl: LS1, LS2)

##### Wetlands (within the Spearwood Dunes)

Holocene Swamp Deposits (Qhw: Cps)

#### VEGETATION AND FLORA

##### Vegetation Complexes

###### Spearwood Dunes

Karrakatta Complex — Central and South

Cottesloe Complex — Central and South

###### Wetlands

Herdsmen Complex

**Floristic Community Types:** \*not sampled, types inferred

##### Supergroup 2: Seasonal Wetlands

\*S7 Northern woodlands to forests over tall sedgelands alongside permanent wetlands

##### Supergroup 4: Uplands centred on Spearwood and Quindalup Dunes

24 Northern Spearwood shrublands and woodlands

28 Spearwood *Banksia attenuata* or *B. attenuata* — *Eucalyptus* woodlands

\*26a *Melaleuca huegelii* — *M. acerosa* shrublands on limestone ridges

\*27 Species-poor mallees and shrublands on limestone

#### WETLANDS

**Wetland Types:** lake, sumpland

##### Natural Wetland Groups

###### Spearwood Dunes

Yanchep (S.1)

**Wetland Management Objectives:** Conservation (66.7ha)

**Swan Coastal Plain Lakes EPP:** <53.1ha + 1.8ha + 0.8ha + <10.9ha = 57.5ha (total)

#### THREATENED ECOLOGICAL COMMUNITIES

Not assessed, Not determined, Endangered (floristic community type 26a)

### SECTION 3: SPECIFIC SITE DETAIL

**Landscape Features:** limestone ridge, open water, vegetated wetland, vegetated uplands

**Vegetation and Flora:** limited survey (part Site — DEP 1999, EPA and WAWA 1990 (Lake Nowergup NR), Gibson *et al.* 1994 (Neer 11) (Lake Nowergup NR), Gibson *et al.* 1994 (Neer 1–10, 20–23) (Neerabup NP), Semeniuk, V&C Research Group 1991a (Neerabup NP)); detailed survey (part Site — Keighery, BJ, *et al.* 1997b (Neerabup NP))

**Structural Units:** mapping (EPA and WAWA 1990, Keighery, BJ, *et al.* 1997b, Semeniuk, V&C Research Group 1991a)

Uplands — Sands derived from Tamala Limestone: *Eucalyptus gomphocephala* Woodland to Open Forest;

*Eucalyptus marginata* Woodland to Forest generally over *Banksia* woodland; Woodlands dominated by *Banksia*

*attenuata*, *B. menziesii*, *Allocasuarina fraseriana* and *Nuytsia floribunda* and combinations of these; *Jacksonia sternbergiana* Low Forest

Uplands — Tamala Limestone: Shrublands to Open Low Heath dominated by *Xanthorrhoea preissii*, *Hakea trifurcata*, *Calothamnus quadrifidus*, *Melaleuca systena*, *Dryandra sessilis* var. *cygnorum*, *Melaleuca huegelii* and *Acacia lasiocarpa* and combinations of these

Wetlands: *Eucalyptus rudis* Open Forest; *Eucalyptus rudis* and *Banksia littoralis* Forest; *Melaleuca raphiophylla* Low Closed Forest to Low Woodland; *Acacia saligna* Low Open Forest; *Typha* Closed Sedgeland; *Baumea articulata* Closed Sedgeland; mixed Closed Sedgeland to Sedgeland

**Scattered Native Plants:** not assessed

**Vegetation Condition:** >85% Very Good to Excellent, <15% Good to Degraded, with areas of severe localised disturbance

**Total Flora:** 315 native taxa, 66 weed taxa (Keighery, BJ, *et al.* 1997b plus four records from EPA and WAWA 1990) (estimated >85% expected flora)

**Significant Flora:** *Lepidium pseudohyssopifolium* (1), *Jacksonia sericea* (3), *Stylidium maritimum* (3), *Hibbertia spicata* subsp. *leptothea* (3, endemic to Tamala Limestone); *Conostylis candicans* subsp. *calcicola*, *Ricinocarpus glaucus*, *Hemiandra pungens* (dune form), *Alyogyne huegelii* var. *glabrata*, *Baeckea robusta* subsp. nov. (perhaps a local variant of a widespread species), *Nemcia reticulatum* (coastal form), *Grevillea crithmifolia*, *Hakea lissocarpa*, *Persoonia comata* (at southern end of range), *Petrophile serruriae* subsp. nov., *Leptomeria empetriformis*, *Glischrocaryon aureum*, *Lechenaultia linarioides*; typical Tamala Limestone Taxa: Keighery, BJ, *et al.* 1997 — *Grevillea preissii*, *Diplopeltis huegelii* var. *huegelii*, *Eucalyptus foecunda*, *Pimelea calcicola*, *Trymalium ledifolium* var. *ledifolium*, *Stylidium junceum* (limestone variant), *Astroloma microcalyx*, *Caladenia longicauda* subsp. *calcigena* ms, *Schoenus lanatus*, *Petrophile serruriae* subsp. nov. (GJK 11421), *Leptomeria empetriformis*

**Fauna:** multiple surveys for birds (56 species) (RAOU 1996 D, 9 visits; Dell *et al.* 1998), native mammals (4 species) (CALM 1993), reptiles (19 species) and amphibians (2 species) (B. Maryan and D. Robinson pers. comm.). Significant populations of insectivorous passerine birds including Splendid Fairy-wren, Broad-tailed, Western and Yellow-rumped Thornbills, Weebill, White-browed Scrubwren, Scarlet Robin, Golden Whistler and Grey Shrike-thrush. Lake Nowergup has large numbers of waterfowl (D. Lamont pers. comm. IN: EPA 1990). Significant bird species: category 1 (1), category 3 (12) and category 4 (7). Significant mammal species: Honey Possum and Western Brush Wallaby. Significant reptile species: Carpet Python (*Morelia spilota*)

**Linkage:** adjacent bushland to the north, south (Site 299, across road), east and west (Site 323, through bushland to Site 397); part of Greenways 35, 2, 5 (Tingay, Alan & Associates 1998a); part of a regionally significant contiguous bushland/wetland linkage (Part A, Map 7)

**Other Special Attributes:** contains five regional floristic groups; recommended for protection in the study of City of Wanneroo bushland (Trudgen 1996); includes core of areas recommended for conservation by Semeniuk, V&C Research Group (1991a); part of a regionally significant contiguous bushland/wetland linkage (Part A, Map 7)

#### **SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE**

Entered in the Register of the National Estate (Neerabup National Park and Nowergup Lake Fauna Reserve); subject to protection under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

#### **SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS**

**Criteria:** Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation

**Recommendation:** Part A: Site with Some Existing Protection; the existing purpose, care, control and management of Reserves 27575 and 24581 is endorsed. Part B: Proposed Parks and Recreation Reservation. Part C: Other Government Lands Mechanism (see Table 3, Volume 1).

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**Boundary Definition:** protected area/bushland (part taken to cadastre) boundary

**SECTION 1: CADASTRAL INFORMATION**

(Lots, locations and derived information to be updated in the public submission period)

Bushplan Site no. 383    Map no. 18, 25, 26, 31, 32    Map sheet series ref. no. 2034-I SW, 2034-IV NE, 2034-IV SE, 2034-V SE

System 6 (1983): M6 area of bushland goes beyond System area boundaries, all bushland described

**Other Names:** not known

**Area (ha):** total 1858.3 (includes open water); bushland 1717.2

**Local Authorities (Suburb)**

Shire of Wanneroo (Neerabup, Carabooda, Nowergup, Clarkson, Tamala Park), City of Joondalup (Kinross, Neerabup)

**Zoning**

MRS: Parks and Recreation, Rural, Urban, Other Major Highways, Important Regional Road, Public Purposes-Water Authority of WA

TPS: Rural, Landscape, Parks and Recreation.

**Ownership Categories**

State Government, Private (including commercial organisation), Local Government

**Lot/Location/Reserve numbers (Purpose),**

**Street name**

1, 2, 3, 12, 14, 3323, 6270, 6764, 6765, 9245, 10313, 11533, 11607 Wanneroo Rd; 10313 Lukin Dr; 52, 3323, 9538, 9630 Burns Beach Rd; 19, 3323 Connolly Dr; 3, 4 Gibbs Rd; 11 Joondalup Dr; Crown; 12, 52, 70, 13712, 12520 street not identified

Crown Reserve

Reserve 27575 (National Park), Reserve 24581 (Conservation of Flora and Fauna)

CALM Managed Land

**SECTION 2: REGIONAL INFORMATION**

**LANDFORM AND SOIL**

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Tamala Limestone (Qtl: LS1, LS2)

**Wetlands (within the Spearwood Dunes)**

Holocene Swamp Deposits (Qhw: Cps)

**VEGETATION AND FLORA**

**Vegetation Complexes**

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**Wetlands**

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Not assessed, Not determined



### SECTION 3: SPECIFIC SITE DETAIL

**Landscape Features:** limestone ridge, open water, vegetated wetland, vegetated uplands

**Vegetation and Flora:** detailed survey (part Bushplan Site, Neerabup NP — Keighery, BJ, *et al.* 1997b); limited survey (part Bushplan Site, Lake Nowergup NR — EPA and WAWA 1990, Gibson *et al.* 1994 (Neer 1–11, 20–23); part Bushplan Site, Neerabup NP — Semeniuk, V&C Research Group 1991a)

**Structural Units:** mapping (EPA and WAWA 1990, Keighery, BJ, *et al.* 1997b, Semeniuk, V&C Research Group 1991a)

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**Linkage:** adjacent bushland to the north, south (BS299, across road), east and west (BS323, through bushland to BS397); part of proposed Greenways 36, 2, 5, 42 (Tingay, Alan & Associates 1997a); part of a regionally significant contiguous bushland/wetland linkage (Volume 2A, Map 8)

**Other Special Attributes:** contains six regional floristic groups; recommended for protection in the study of City of Wanneroo bushland (Trudgen 1996); includes core of areas recommended for conservation by Semeniuk, V&C Research Group (1991a); part of a regionally significant contiguous bushland/wetland linkage (Volume 2A, Map 8)

### SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Listed on the Register of the National Estate

### SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

**Criteria:** Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation

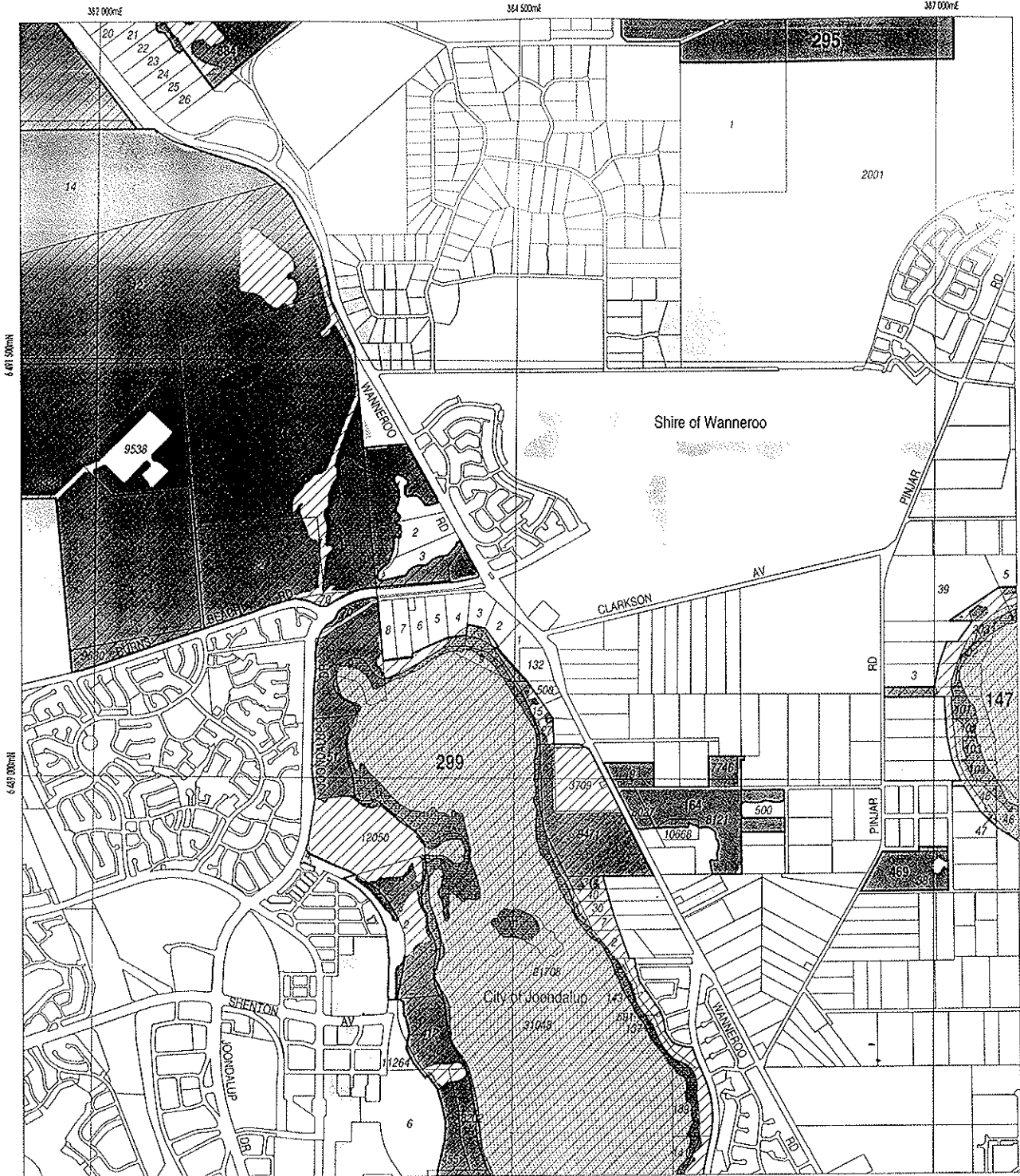
#### Opportunities and/or Constraints

**Opportunities:** Bushplan Site/part Bushplan Site subject to Swan Coastal Plain Lakes EPP; location of Scheduled Fauna, conservation category wetlands; under MRS Parks and Recreation Reservation and TPS Landscape Zoning and Parks and Recreation Zoning, Crown Reserve

**Constraints:** private land; under MRS Urban Zoning, MRD regional road requirements, Priority and General Mineral Resource Area (limestone), mining tenement M70/717 (General Building Co. Pty Ltd) for limestone roadbase

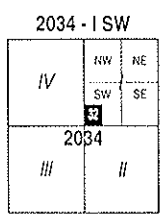
**Recommendation:** The existing purpose, care, control and management of Reserves 27575, 24581 is endorsed. The most appropriate mechanism for the protection of the remainder of this Bushplan Site be considered through the public comment period in consultation with the land owner(s). This may include parts for which: The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme, purchased and added to Neerabup National Park.





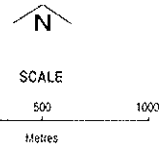
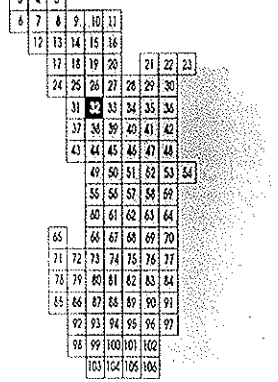
**LEGEND**

- 472** Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 695** Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary



1:25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown








**PERTH'S BUSHPLAN MAP INDEX**



Produced by Project Mapping Section  
 Land Information Branch, Ministry for  
 Planning, Perth W.A. November 1998  
 ntw-map11/environ/bushplan/bushw2\_32.dgn  
 Cadastral Data supplied by Department  
 of Land Administration, W.A.  
 Wetlands Data supplied by  
 Water and Rivers Commission  
 Native Vegetation Extent for Study Area  
 supplied by Agriculture Western Australia



**LEGEND**

-  Bushplan Sites With Regionally Significant Bushland
-  Other Native Vegetation
-  Conservation Category Wetlands
-  Bushplan Sites With Some Existing Protection
-  Lot Number, Location Number
-  Channel Wetlands
-  Local Government Boundary

**2034 - IV NE**

NW	NE
IV	SE

**2034**

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1:25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

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Produced by Project Mapping Section  
Land Information Branch, Ministry for  
Planning, Perth W.A. November 1998  
nw-map77/environ/bushplan/bushv2\_16.dgn  
Cadastral Data supplied by Department  
of Land Administration, W.A.  
Wetlands Data supplied by  
Water and Rivers Commission  
Native Vegetation Extent for Study Area  
supplied by Agriculture Western Australia

Bushplan Site Map



**LEGEND**

**472** Bushplan Sites With Regionally Significant Bushland

Other Native Vegetation

Conservation Category Wetlands

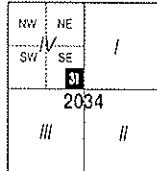
Bushplan Sites With Some Existing Protection

696 Lot Number, Location Number

Channel Wetlands

Local Government Boundary

2034 - IV SE



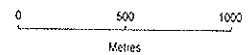
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**PERTH'S BUSHPLAN MAP INDEX**

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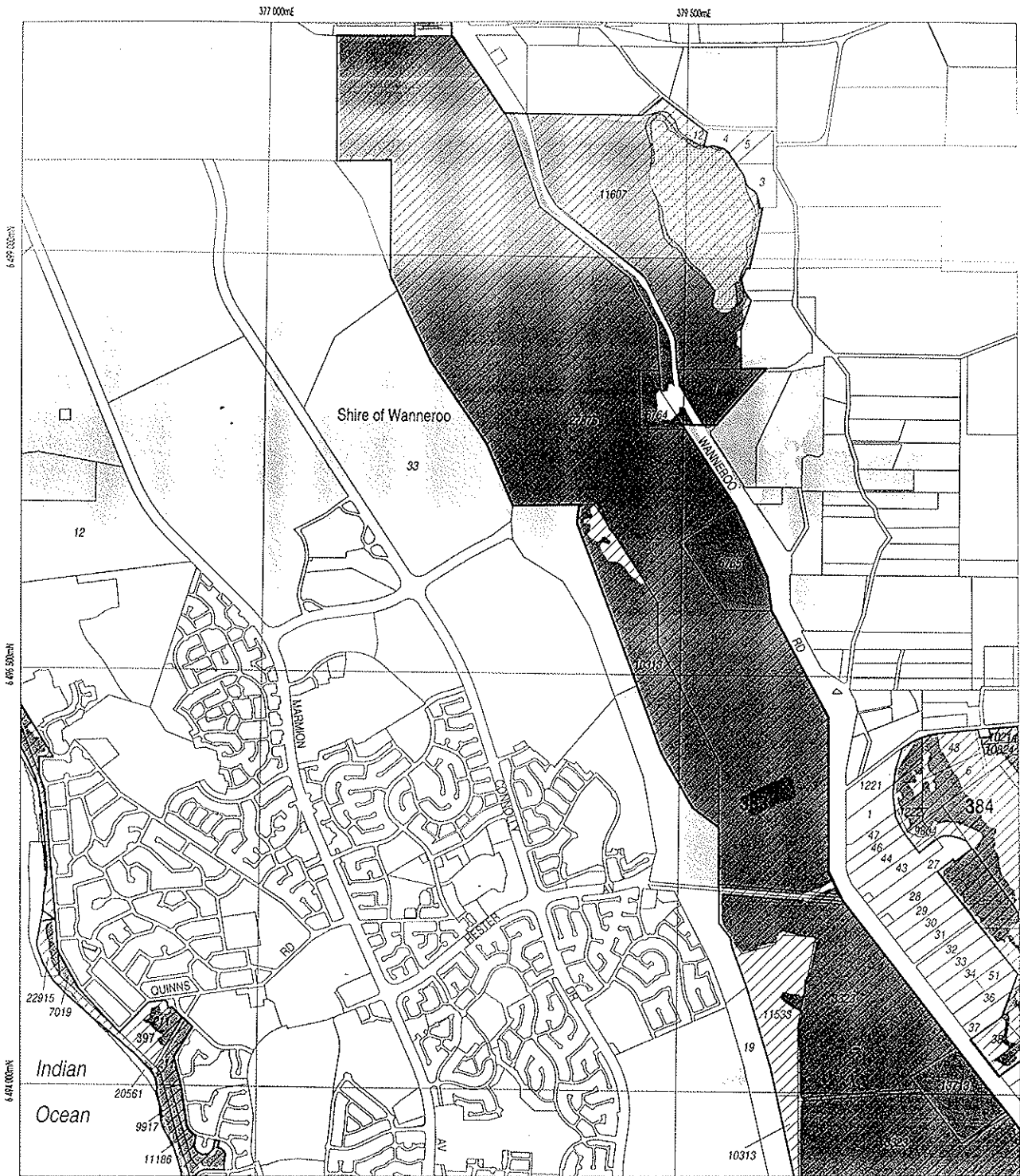


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Planning, Perth W.A. November 1998  
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



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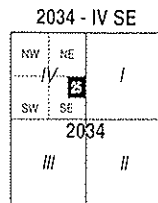
Wetlands Data supplied by  
Water and Rivers Commission

Native Vegetation Extent for Study Area  
supplied by Agriculture Western Australia



LEGEND

-  Bushplan Sites With Regionally Significant Bushland
-  Other Native Vegetation
-  Conservation Category Wetlands
-  Bushplan Sites With Some Existing Protection
-  Lot Number, Location Number
-  Channel Wetlands
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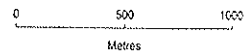
1 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

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SCALE

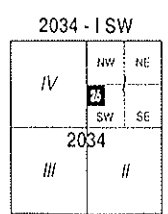


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ntw-map11\environ\bushplan\bushv2\_25.dgn  
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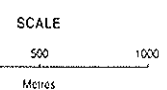
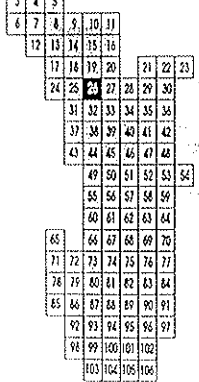
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-  Conservation Category Wetlands
-  Bushplan Sites With Some Existing Protection
-  Lot Number, Location Number
-  Channel Wetlands
-  Local Government Boundary



1: 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown.

**PERTH'S BUSHPLAN MAP INDEX**



Produced by Project Mapping Section  
 Land Information Branch, Ministry for  
 Planning, Perth W.A. November 1998  
 nlw-map11\enviro\busplan\busv2\_26.dgn  
 Cadastral Data supplied by Department  
 of Land Administration, W.A.  
 Wetlands Data supplied by  
 Water and Rivers Commission  
 Native Vegetation Extent for Study Area  
 supplied by Agriculture Western Australia

411

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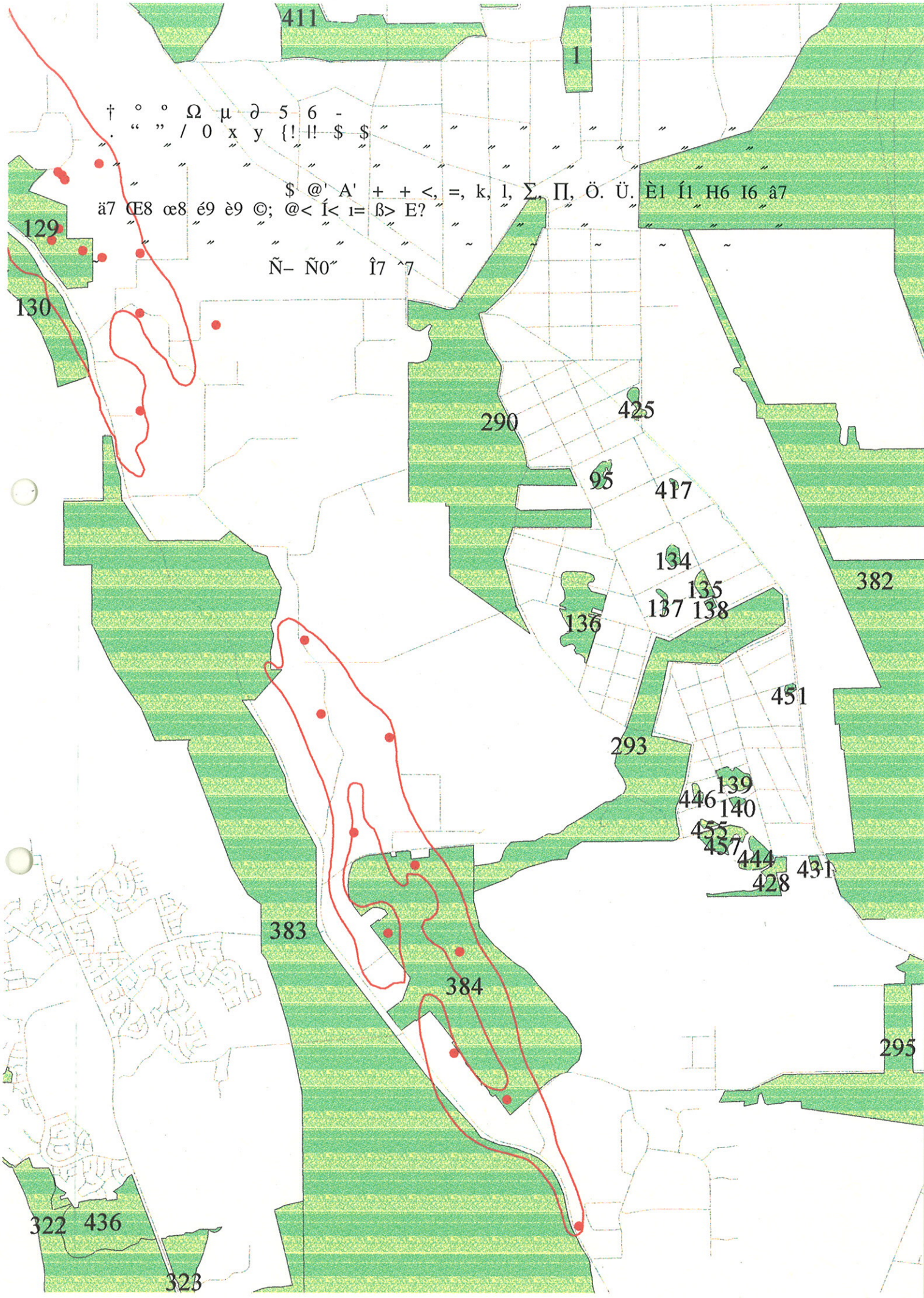
383

384

295

322 436

323





**AREA INFORMATION**

System 6 Area (C or M) or Update Area (Update)

<b>Conservation Area</b>	
Nature Reserve	
Reserve No	
National Park	M6 Neerabup National Park.
Reserve No	
Local Government	
Reserve No	
Other	
<b>Proposed Conservation Areas</b>	
Local Government	
Reserve No	
Other	

<b>Conservation Area</b>	
Nature Reserve	
Reserve No	
National Park	
Reserve No	
Local Government	
Reserve No	
Other	

**AREA**

Total Area	hectares
Completely Degraded	hectares
comments:	

**AREA MAPPED FLORISTIC UNITS**

Boundaries: System6 CALM

Units	Site (Condition)	Code	Bound	Area (ha)	Area(ha)

Boundaries determined by use of *metro Regional Area*

aerial photograph	R6 5060, R7 5057, R8 5144	11/12/92
orthophoto	2034 ISW, 2034 IV SE, 2034 IUNE	
vegetation map		
soil map		

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for M<sub>6</sub> (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

**Department of Environmental Protection System 6 Update: Site Based Flora List M<sub>6</sub> Neerabup National Park**

(extracted from the CALM Swan Coastal Plain database, Neer sites 1-11, 20-23, 2/95)

Amaranthaceae

- Ptilotus drummondii
- Ptilotus manglesii

Anthericaceae

- Caesia micrantha
- Chamaescilla corymbosa
- Corynotheca micrantha
- Dichopogon capillipes
- Sowerbaea laxiflora
- Thysanotus manglesianus
- Thysanotus multiflorus
- Thysanotus patersonii
- Thysanotus sp. manglesianus/patersonii scps
- Thysanotus sparteus
- Tricoryne elatior

Apiaceae

- Daucus glochidiatus
- Eryngium pinnatifidum subsp. pinnatifidum scps
- Homalosciadium homalocarpum
- Hydrocotyle callicarpa
- Hydrocotyle diantha
- Hydrocotyle hispidula
- Hydrocotyle sp. scps
- Trachymene pilosa
- Xanthosia huegelii

Asparagaceae

- \* Myrsiphyllum asparagoides

Asteraceae

- Asteridea pulverulenta
- \* Carduus pycnocephalus
- \* Cirsium vulgare
- \* Conyza albida
- \* Hypochaeris glabra
- Lagenifera huegelii
- Millotia tenuifolia
- Podolepis gracilis
- Quinetia urvillei
- Siloxerus humifusus
- \* Sonchus asper
- Sonchus hydrophilus
- \* Sonchus oleraceus
- \* Urospermum picroides
- \* Ursinia anthemoides
- Waitzia suaveolens

Brassicaceae

- \* Brassica tournefortii
- \* Heliophila pusilla
- Stenopetalum robustum

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for ML (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

## Campanulaceae

Wahlenbergia preissii

## Caryophyllaceae

- \* Cerastium glomeratum
- \* Minuartia hybrida
- \* Petrorrhagia velutina

## Casuarinaceae

Allocasuarina fraseriana  
Allocasuarina humilis

## Centrolepidaceae

Centrolepis drummondiana

## Chenopodiaceae

Rhagodia baccata subsp. baccata

## Colchicaceae

Burchardia umbellata

## Crassulaceae

Crassula colorata  
Crassula pedicellosa

## Cyperaceae

- Carex preissii  
Isolepis cernua  
\* Isolepis marginata  
Lepidosperma "coastal terete" scps (BJK&NG 231)  
Lepidosperma angustatum  
Mesomelaena pseudostygia  
Schoenus clandestinus  
Schoenus curvifolius  
Schoenus discifer  
Schoenus lanatus  
Tetraria octandra

## Dasypogonaceae

Acanthocarpus preissii  
Calectasia cyanea  
Lomandra caespitosa  
Lomandra hermaphrodita  
Lomandra maritima  
Lomandra preissii  
Lomandra sericea  
Lomandra suaveolens

## Dilleniaceae

Hibbertia aurea  
Hibbertia hypericoides  
Hibbertia spicata subsp. leptotheca

## Droseraceae

Drosera erythrorhiza  
Drosera macrantha

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for M<sub>1</sub> (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

*Drosera menziesii*  
*Drosera menziesii* subsp. *penicillaris*

#### Epacridaceae

*Astroloma ciliatum*  
*Astroloma pallidum*  
*Conostephium pendulum*  
*Conostephium* sp. scps  
*Leucopogon parviflorus*  
*Leucopogon polymorphus*  
*Leucopogon propinquus*  
*Lysinema ciliatum*

#### Euphorbiaceae

*Phyllanthus calycinus*  
*Poranthera microphylla*

#### Geraniaceae

\* *Geranium molle*  
\* *Pelargonium capitatum*  
*Pelargonium littorale*

#### Goodeniaceae

*Lechenaultia linarioides*  
*Scaevola canescens*  
*Scaevola repens* var. *repens*

#### Haemodoraceae

*Anigozanthos humilis*  
*Conostylis aculeata*  
*Conostylis candicans*  
*Conostylis setigera*  
*Haemodorum laxum*  
*Haemodorum* sp. scps  
*Phlebocarya ciliata*

#### Haloragaceae

*Glischrocaryon aureum*

#### Iridaceae

\* *Gladiolus caryophyllaceus*  
\* *Homeria flaccida*  
*Orthrosanthus laxus*  
\* *Romulea rosea*

#### Juncaginaceae

*Triglochin calcitrapum*  
*Triglochin centrocarpum*  
*Triglochin* sp. scps

#### Lauraceae

*Cassytha glabella*  
*Cassytha racemosa*

#### Loranthaceae

*Nuytsia floribunda*

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for M<sub>1b</sub> (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

#### Mimosaceae

Acacia cyclops  
Acacia lasiocarpa  
Acacia pulchella  
Acacia rostellifera  
Acacia saligna  
Acacia truncata  
Acacia willdenowiana

#### Myrtaceae

Calothamnus quadrifidus  
Calothamnus sanguineus  
Calytrix flavescens  
Eucalyptus calophylla  
Eucalyptus gomphocephala  
Eucalyptus marginata  
Melaleuca acerosa  
Melaleuca huegelii

#### Orchidaceae

Caladenia "georgei" scps  
Caladenia flava  
Caladenia latifolia  
Caladenia sp. scps  
Cyrstostylis sp. scps  
Diuris longifolia  
Elythranthera brunonis  
Eriochilus dilatatus  
Leporella fimbriata  
Lyperanthus nigricans  
Prasophyllum fimbria  
Prasophyllum sp. scps  
Pterostylis "seratera" var robusta scps  
Pterostylis aff. nana scps  
Pterostylis brevisepala ms sthest  
Pterostylis sanguinea  
Pterostylis sp. scps  
Pterostylis vittata  
Thelymitra sp. scps

#### Orobanchaceae

\* Orobanche minor

#### Papilionaceae

Bossiaea eriocarpa  
Daviesia divaricata  
Daviesia nudiflora  
Daviesia triflora  
Gompholobium tomentosum  
Hardenbergia comptoniana  
Hovea trisperma var. trisperma  
Isotropis cuneifolia  
Jacksonia sternbergiana  
Nemcia capitata  
Templetonia retusa  
\* Trifolium campestre  
\* Trifolium dubium

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for M<sub>1</sub> (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

- \* *Trifolium glomeratum*
- \* *Trifolium sp. scps*
- \* *Vicia sativa*

#### Phormiaceae

*Dianella revoluta*

#### Poaceae

- \* *Aira caryophyllea*
- \* *Aira sp. scps*
- \* *Avena barbata*
- \* *Briza maxima*
- \* *Briza minor*
- \* *Bromus diandrus*
- \* *Bromus sp. scps*
- Danthonia occidentalis*
- Dichelachne crinita*
- \* *Ehrharta calycina*
- \* *Ehrharta longiflora*
- \* *Holcus setiger*
- \* *Lagurus ovatus*
- Microlaena stipoides*
- \* *Pentaschistis airoides*
- Poa drummondiana*
- Poa porphyroclados*
- Stipa compressa*
- Stipa flavescens*
- \* *Vulpia myuros*
- \* *Vulpia sp. scps*

#### Polygalaceae

*Comesperma calymega*

#### Portulacaceae

*Calandrinia corrigioloides*  
*Calandrinia liniflora*

#### Primulaceae

- \* *Anagallis arvensis*

#### Proteaceae

*Banksia attenuata*  
*Banksia menziesii*  
*Dryandra nivea*  
*Dryandra sessilis*  
*Grevillea thelemanniana* subsp. *preissii*  
*Grevillea vestita*  
*Hakea costata*  
*Hakea lissocarpha*  
*Hakea ruscifolia*  
*Hakea trifurcata*  
*Persoonia comata*  
*Petrophile linearis*  
*Petrophile macrostachya*  
*Petrophile serruriae*  
*Stirlingia latifolia*

CONTACT DR N. GIBSON CALM WOODVALE for further information.

Flora list for M<sub>6</sub> (extracted from Swan Coastal Plain database, Neer sites 1 -11, 20-23, 2/1995).

Restionaceae

*Loxocarya flexuosa*

Rhamnaceae

*Cryptandra mutila*

*Spyridium tridentatum*

Rubiaceae

\* *Galium murale*

*Opercularia vaginata*

Rutaceae

*Eriostemon spicatus*

Scrophulariaceae

\* *Bellardia trixago*

Stackhousiaceae

*Tripterococcus brunonis*

Stylidiaceae

*Levenhookia stipitata*

*Stylidium brunonianum*

*Stylidium calcaratum*

Thymelaeaceae

*Pimelea calcicola*

Violaceae

*Hybanthus calycinus*

Xanthorrhoeaceae

*Xanthorrhoea preissii*

Zamiaceae

*Macrozamia riedlei*

## R. A. O. U. TRACKING DATABASE

23/06/96

PARK SIGHTINGS REPORT

Page No. 1

Neerabup N.P. (M6)

ORDER:	REF:	BIRD NAME	NO.	SIGHTINGS
0025	0207	Australian Shelduck	1	
0175	0221	Brown Goshawk	4	3
0180	0224	Wedge-tailed Eagle	1	
0181	0225	Little Eagle	4	1
0182	0239	Brown Falcon	2	
0184	0957	Rock Dove	1	
0326	0988	Laughing Turtle-Dove	4	
0330	0034	Common Bronzewing	3	2
0339	0031	Diamond Dove	1	
0356	0794	Short-billed Black-Cockatoo	1	1
0356A	1266	White-tailed Black-Cockatoo	1	4
0359	0273	Galah	5	
0386	0294	Australian Ringneck	9	
0387	0290	Red-capped Parrot	9	
0397	0307	Elegant Parrot	3	
0405	0337	Pallid Cuckoo	1	
0408	0338	Fan-tailed Cuckoo	2	
0410	0342	Horsfield's Bronze-Cuckoo	2	
0411	0344	Shining Bronze-Cuckoo	2	
0446	0322	Laughing Kookaburra	7	
0451	0326	Sacred Kingfisher	1	
0453	0329	Rainbow Bee-eater	3	
0471	0532	Splendid Fairy-wren	3	7
0489	0565	Spotted Pardalote	1	
0492	0976	Striated Pardalote	4	
0500	0488	White-browed Scrubwren	3	1
0512	0465	Weebill	3	2
0517	0463	Western Gerygone	6	
0524	0476	Inland Thornbill	3	5
0528	0472	Western Thornbill	3	3
0531	0486	Yellow-rumped Thornbill	3	7
0537	0638	Red Wattlebird	7	
0539	0637	Little Wattlebird	4	7
0561	0608	Singing Honeyeater	6	
0583	0597	Brown Honeyeater	7	
0587	0631	New Holland Honeyeater	4	7
0588	0632	White-cheeked Honeyeater	4	2
0597	0592	Western Spinebill	8	
0613	0380	Scarlet Robin	3	4
0644	0549	Varied Sittella	3	1
0650	0398	Golden Whistler	3	4
0653	0401	Rufous Whistler	6	
0658	0408	Grey Shrike-thrush	3	6

① 1  
② 1  
③ 1  
④ 1

SUMMARY REPORT

TOTAL BIRDS SIGHTED	:	36
TOTAL NUMBER OF CARDS	:	7

\*\*\* END OF SUMMARY \*\*\*



**M6 Neerabup National Park**

Bulletins 230 (Mindarie Tip), 485 (Housing Burns Beach, Stage 2)

Other Names: Mindarie (extension to the coast)

**Specific Study/studies**

**Miscellaneous studies**

Flora

Vegetation Map 1

Flora list

Rare Taxa

2

3

1

2

3

done / suitable / doubtful

Fauna

part area

**Mammals**

**Birds**

**Reptiles and Amphibia**

Invertebrates

1

1

1

1

2

2

2

2

RAOU

Vegetation Condition

Map

Sites

Comment

Disturbance Factors

Comment

Management

**Swan Coastal Plain Floristic Survey**

AHC. National Estate- Listed / Interim / Notified

National Trust: Heritage Classification

A REPORT ON THE VEGETATION OF PART OF NEERABUP NATIONAL PARK AND ADJOINING PRIVATELY OWNED LAND, WITH ANALYSIS OF THE CONSERVATION ISSUES INVOLVED.... / Trudgen, M.E.

(Unpublished Report for Maunsell and Partners.)

M6

- 1. DARLING. 2. NEERABUP. 3. STATUS. 4. SWAN. 5. VEGETATION.
- 6. NATIONAL PARKS. 7. CONSERVATION.
- PEP TOPIC: 1. VEGETATION TYPES.

Location(s) : CALM



Area M & Name		<u>Neerabup National Park</u>	
Source		<u>Gary Hartnett / Paul Brown / Gordon Miller</u>	
Purpose (why was the study done?)			
Government			
Corporate			
Community Group			
Management Plan			
Publication Planned	Yes	No	Date
Planned Location			
Soils			
Units	described	referenced	
Landscape			
Features	described	referenced	
Flora			
Vegetation Map			
Units Mapped	Site based		
Veg Units	Comparable	Heddle <i>et al</i>	Compared Here
			<u>it not mapped by Heddle <i>et al</i>.</u>
Flora list			
Timing	% completion		
	Trees	Shrubs	Herbs Sedges
			W
Fauna			
Timing	% completion		
	Mammals	Birds	
	Reptiles	Invertebrates	
Vegetation Condition			
Site based	Mapped	Units	
Disturbance Factors			
Phytophthora	observed	<u>Survey done</u>	
	tested		
Notes			
<u>Other sources</u>			
<u>- David W</u>			
<u>- WAWA</u>			

Author: Keighery G.J.  
 Date: 1991  
 Title: Flora and vegetation of the Mindarie Cusp area  
 Source: C.A.I.M. Unpublished Report

Significant Taxa  
 JRF CALM Priority Other

Significant Taxa  
 Sched1 Sched2 Other

response to specific need  
 ital  
 sed

**M5 Neerabup National Park**

Bulletins 230 (Mindarie Tip), 485 (Housing Burns Beach, Stage 2)

M5.1 Regional park recommendations be applied to this area.	Unresolved Issues	CALM's 1992 draft Forests Strategy recommends conservation park. Management as a conservation park could satisfy the regional park recommendation.
M5.2 Purpose of Reserves C13713, C25252 and C25253 be amended to Parkland and Water.	Unresolved Issues	Local authority agreement to the change of purpose has not been obtained.
M5.3 DPUD consider reserving areas not already reserved for Parks and Recreation under the Metropolitan Region Scheme.	Implementation Progressing	Being considered through DPUD's north-west corridor structure plan.  Quinns Rock Environmental Research Group has an interest in this area.

SHEET 1: System 6 - REPORT Information Search

Date 4/5/94 LM  
AHB

Please circle the appropriate response or respond in the space provided.

Not at EPA  
3-10-96

Area M 6 Name Neerabup  
(extension)

Title Flora and Fauna Studies in the Water Supply Reserve (A34537) adjacent to Neerabup National Park - 2 reports

Published/Unpublished  Date CALM 1993

Author/s

Location of Publication WANA, ?CALM (Woodvale)

Purpose (why was the report prepared?) use of reserve for water supply

Government WANA

Corporate

Community Group

Management Plan

Soils

Units mapped described referenced

Landscape

Features described referenced

Flora Mattiske and Associates

Vegetation Map

Units Site based (no)

Mapped

Veg Units Comparable Heddle *et al* Compared Heddle *et al* Unit not mapped by Heddle *et al*.

Flora list

Timing %completion Significant Taxa

Trees Shrubs Herbs Sedges Weeds DRF CALM Priority Other

Fauna CALM 2 sites Reserve WANA, 1 site Neerabup

Timing %completion Significant Taxa

1 week  Mammals  Birds  Sched1 Sched2 Other

Reptiles  Invertebrates

Vegetation Condition

Site based Mapped Units

Disturbance Factors

Phytophthora observed Other incidental

tested itemised

Notes Fauna brief study, over 1 week significantly under sampled (weather poor also)

SHEET 1: System 6 - REPORT Information Search

Date 4/5/94 LM

Please circle the appropriate response or respond in the space provided.

not at EPA  
2-10-96

*EPA*

Area M <u>6</u> Name <u>Neerabup (part)</u>
Title <u>Botanical Studies in Neerabup</u>
<u>Pipeline proposal note line</u>
Published/Unpublished _____ Date <u>1990</u>
Author/s _____
Location of Publication _____
Purpose (why was the report prepared?) _____
Government <u>WANA (general rep book background)</u>
Corporate <u>FOR CER 1994</u>
Community Group _____
Management Plan _____

Soils
Units mapped described referenced

Landscape
Features described referenced

Flora <u>MATTISKE - Background Doc</u>
Vegetation Map
Units _____ Site based (no)
Mapped
Veg Units <u>Comparable Heddle et al</u> <u>Compared Heddle et al.</u> <u>Unit not mapped by Heddle et al.</u>
Flora list
Timing %completion _____ Significant Taxa
Trees Shrubs Herbs Sedges Weeds DRF CALM Priority Other

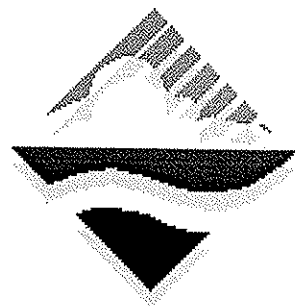
Fauna <u>MINOX - Background Doc</u>
Timing %completion _____ Significant Taxa
Mammals _____ Birds _____ Sched1 Sched2 Other
Reptiles _____ Invertebrates _____

Vegetation Condition
Site based _____ Mapped _____ Units _____
Disturbance Factors
Phytophthora <u>observed</u> _____ Other <u>incidental</u>
_____ tested _____ itemised

Notes



# Facsimile Message



**ATTENTION:** Carolyn MacPherson  
**ORGANISATION:** ecologia  
**FROM:** Bronwen Keighery  
**DATE:** 14/9/99  
**TELEPHONE:** (08) 9222 7028 Fax. (08) 9485 1187  
**PAGES:** 3 including this sheet  
**SUBJECT:** **Neerabup Rail Yards**

---

**MESSAGE:**

Carolyn

Please find attached a rough map of vegetation in the proposed alternative area. The map generally only maps areas in good and better condition (on my determination). The area at your site 17 needs to be added.

As discussed by telephone the condition scales need to be adjusted to be consistent.

Regards Bronwen

**Department of Environmental Protection**  
Westralia Square, 141, St Georges Terrace, Perth, Western Australia, 6000.  
Facsimile: (08) 9322 1598 Telephone: (08) 9222 7000



SYSTEM 6 BUSHLAND SUBMISSION FORM  
FOR CONSIDERATION IN THE UPDATE PROGRAMME

BUSHLAND NEAR CORNER WANNEROO ROAD AND  
BURNS BEACH ROAD

*LOCATION, OWNERSHIP AND ZONING OF THE AREA*

**1. Location**

- a) Bordering Roads: Burns Beach Rd and Wanneroo Rd
- b) Nearest Corner: as above
- c) Lot Number: Lots 1 and 2 Wanneroo Rd, Neerabup
- d) Suburb/Location: Neerabup
- e) Local Council: City of Wanneroo
- f) Site Name: east of proposed additions to Neerabup National Park
- g) Approximate size of area (ha): estimated area size 50 ha
- h) Location on map: please see attached copy of aerial photo
- i) Map: Streetsmart Street Directory, 1996
- j) Map no.: 15
- k) Grid Ref.: Map 15: E9 (top)  
E10(bottom)
- l) Other information to find location: please see attached copy of aerial photo.
- m) Aware of any development proposals that are likely to affect the area?  
No

**2. Who owns the area?** Privately owned

**3. If you own the land?** not applicable

**4. What is the area zoned?** Rural

*PHYSICAL CHARACTERISTICS*

**5. Why do you consider this area important?** The area adjoins land proposed for addition to Neerabup National Park (System 6 area M6). It includes Banksia woodland and would provide a transect of remnant vegetation from Wanneroo Road to the wetland within the System Six area and protect the catchment of the wetland from inappropriate, degrading uses.

**6. What are the soil type/s and colours?** Yellow/brown sands of Cottesloe and Karrakatta soil types, also black sand of the Herdsman soil type.

**7. Any special features such as unusual landforms/landscapes?** n/a

**8. Is the area a wetland or does it include a wetland?** swamp/dampland to west of which most is included in the System Six area M6.

**9. What percentage of the wetland is open water in summer?** not known

#### *VEGETATION/FAUNA*

**10. What percentage of the area is indigenous vegetation?** 50-60%

**11. If the area includes regions of cleared native bushland please indicate reasons for the inclusion.** To consolidate Neerabup National Park and protect wetland catchment. The submitted area will increase the size of Neerabup National Park and prevent inappropriate development which may affect the national park.

**12. Has any previous flora or fauna work been done on the area?** not aware

**13. The condition of the native bushland?** Very good

**14. Disturbances affecting the area?**

a) Partial clearing; agriculture

m) Grazing; horses

**15. Plant species of interest in the area?** not aware

**16. Do you know of any animals that use the area?** not aware

**17. Is the area used by any native animals of special interest?** not aware

*SURROUNDING AREA*

**18. Are there any bushland areas (including wetlands) near this area?** Yes, proposed additions to Neerabup National Park including paperbark swamp adjacent to the west of the submitted area. Yellagonga Regional Park is just to the south of this area

**19. Does the submitted area link other bushland areas?** Yes, as above.



Bushland corner Wanneroo Rd / Burns Beach Rd.



5312 WA3490 (C) METRO REGIONAL AREA RUN 7 (5244-5328) 1:20000 06.01.95 940900

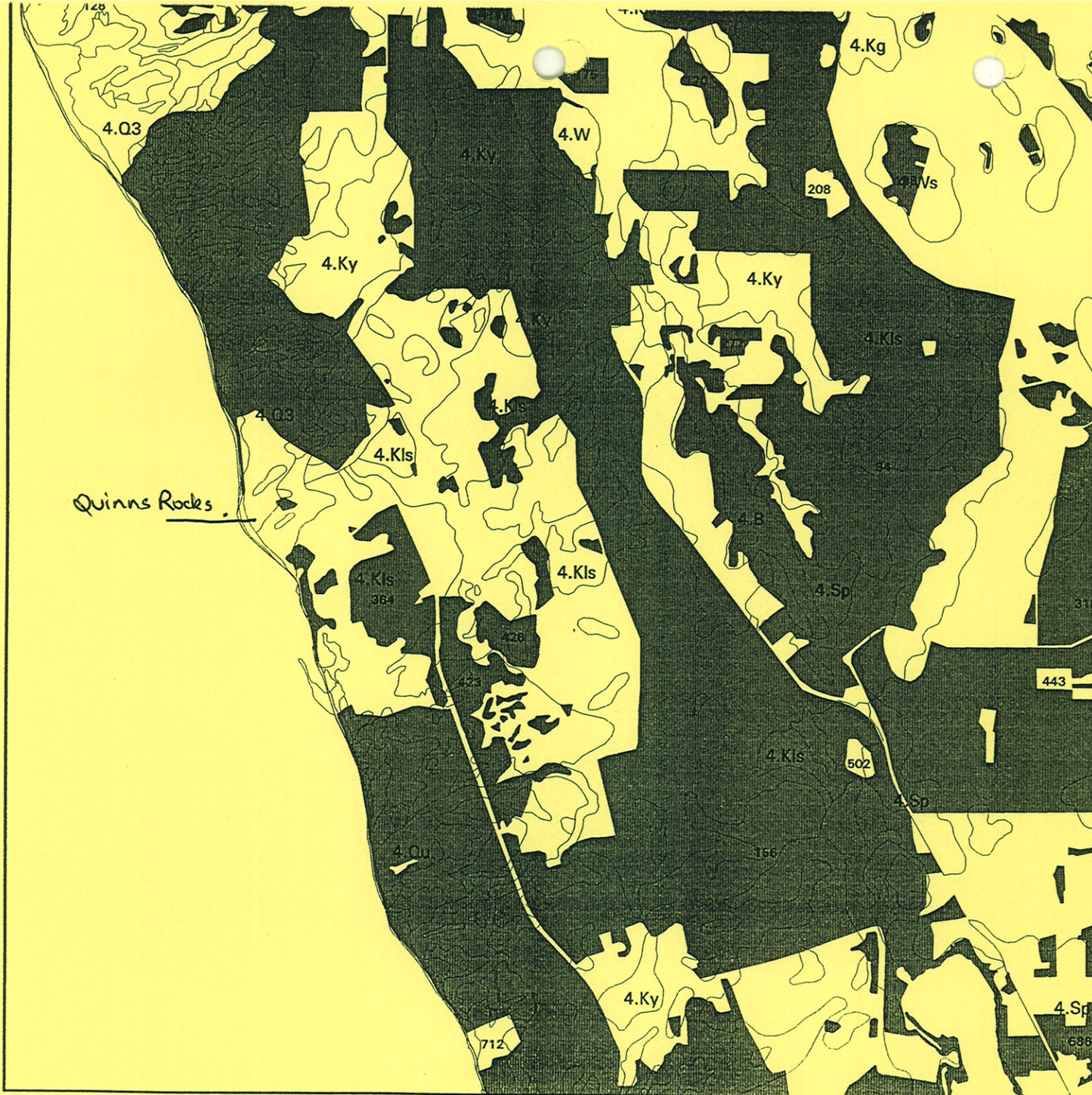
# Quinns Rocks Env. Gp

DPUD INTERNAL USE ONLY

-  Remnant Vegetation
-  soils 50 boundaries

Remnant vegetation left  
in the Quinns Rocks area.

Prepared By: Jim Dixon  
Prepared For:  
Date: 29 Sep 94  
Scale: 1:45669  
Map Ident: plot940929 2



# **WESTERN AUSTRALIAN PLANNING COMMISSION**

## **METROPOLITAN REGION SCHEME AMENDMENT 992/33 CLARKSON-BUTLER**

### **PROPOSAL 5:**

**The Reservation of the proposed Mitchell Freeway  
Transportation Corridor for Primary Regional Roads to enable  
future proposed extensions to the Mitchell Freeway and the  
Northern Suburbs Railway; the reservation of land for Railways  
for the proposed Clarkson Railway Station near Neerabup Road  
and a possible station near Hester Avenue; and land surplus to  
Freeway requirements being transferred from Rural and Parks  
and Recreation to the Urban zone**

### **ENVIRONMENTAL REVIEW**

**PREPARED FOR THE DEPARTMENT OF TRANSPORT  
BY *ecologia* ENVIRONMENTAL CONSULTANTS & MINISTRY FOR PLANNING**

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## EXECUTIVE SUMMARY

The proposed reservation of the proposed Mitchell Freeway Transportation Corridor for Primary Regional Roads to enable future proposed extensions to the Mitchell Freeway and the Northern Suburbs Railway; the reservation of land for Railways for the proposed Clarkson Railway Station near Neerabup Road and a possible station near Hester Avenue; and land surplus to Freeway requirements being transferred from the Rural zone and Parks and Recreation reservation to the Urban zone forms part of Metropolitan Region Scheme (MRS) Amendment 992/33 for the Clarkson-Butler area. The Western Australian Planning Commission (WAPC) proposes to amend the MRS to incorporate changes to zones and reservations within the area so as to enable planning and development proposed under various structure plans to proceed. Other proposals in the amendment include the rezoning of part of Lot 2 Burns Beach, part of Lot 17 Tamala Park, the reservation of two east-west distributor roads and the reservation of land for Parks and Recreation and Public Purposes.

The Environmental Protection Authority decided that some proposals within the Amendment could have a significant environmental impact and under Section 48A of the *Environmental Protection Act, 1996*, required the preparation of an Environmental Review for 6 proposals. In particular, this Environmental Review examines Proposal 5 of MRS Amendment 992/33, which proposes to reserve the alignment for the extension of the Mitchell Freeway and the Northern Suburbs Rail System, and the transfer of land surplus to freeway requirements from Rural/Parks and Recreation to the Urban zone.

The purpose of this Environmental Review is to provide information related to the proposed amendment that will enable the community to comment on the proposal and the EPA to evaluate the potential impacts on the environment. The EPA issued instructions that identify the key factors that should be addressed to assist preparation of this document. The instructions outline the environmental issues or key factors that the EPA has identified as relevant to the proposed amendment to the MRS (Appendix A). These factors are vegetation communities, System 6, Declared Rare and Priority Flora, terrestrial fauna, subterranean fauna, Specially Protected (Threatened) Fauna, underground wetlands, landforms, Aboriginal and European heritage, dust/particles, groundwater quality, noise, vibration, light, public health and safety, recreation and visual amenity. This report provides information regarding these key environmental issues so that the potential impact of the proposed rezoning can be assessed.

This Environmental Review discusses the existing environment in detail, identifies potential impacts that may result from the proposal and proposes management measures to minimise these environmental impacts.

The proposed alignment for the Mitchell Freeway Transportation Corridor traverses across and along the border of the Neerabup National Park. To the west of the proposed alignment are residential areas and land proposed for future urban development.

The reservation of the areas of the National Park and the resultant loss of remnant bushland

and fauna habitat is the principal biophysical constraint to the construction of the proposed freeway and railway; however, it is considered that the vegetation associations that will be cleared are well represented in secure conservation reserves.

Severance of both the north and south linkage between the remnant vegetation in coastal regions and that present within Neerabup National Park is unavoidable; however, the width of the reservation will be minimised at these points as far as possible. The northern linkage is earmarked for future development and therefore impacts to this corridor resulting from the freeway and railway are not considered to be significant.

Vegetation clearance for construction of the proposed freeway and railway and the impact of habitat fragmentation and barriers to fauna movement may result in the loss fauna. This impact is not anticipated to be significant; however, as large areas of the Neerabup National Park will remain intact. In addition, revegetation and rehabilitation of areas in the vicinity of the alignment may provide additional resources or habitat for fauna. Techniques such as fauna underpasses and the erection of exclusion fencing will be incorporated into the road design to facilitate fauna movement between the large habitat areas and to minimise the incidence of road deaths of fauna.

The other environmental factors identified by the EPA are not considered to be significantly affected by the proposed development. The EPA objectives, existing environment, potential impacts and proposed management for each factor are summarised in Table 1.1.

Approved management strategies will be implemented through incorporation of environmental conditions into the MRS. The environmental conditions will be set by the Minister for the Environment on agreement with the Minister for Planning, on advice from the EPA.

Table 1.1 Summary of Environmental Factors

Environmental Factor	Present State of the Environment	Potential Impacts	Proposed Management/Predicted Outcome
<b>Biophysical Factors</b>			
Vegetation Communities	<p>Native vegetation within the Mitchell Freeway Transportation Corridor can be broadly categorised as the Cottesloe Central and South Complex. At higher resolution, two of the community types described by Gibson <i>et al</i> are represented, with a small area present which most closely resembles an additional community type. These community types are:</p> <p>Type 24: Northern Spearwood shrublands and woodlands.</p> <p>Type 28: Spearwood <i>Banksia attenuata</i> or <i>B. attenuata-Eucalyptus</i> woodlands</p> <p>Affinities to Type 26a: <i>Melaleuca heugellii/M. acerosa</i> (now <i>M. syntina</i>) shrublands of limestone ridges</p> <p>The condition of the vegetation ranges from excellent to degraded, with the majority of the vegetation evaluated as excellent occurring within Neerabup National Park</p>	<p>Impacts include:</p> <ul style="list-style-type: none"> <li>• Loss of regionally significant vegetation;</li> <li>• Vegetation fragmentation;</li> <li>• Increased susceptibility of Neerabup National Park to fire;</li> <li>• Increased susceptibility of Neerabup National Park to weed invasion; and</li> <li>• Increased susceptibility of Neerabup National Park to dieback.</li> </ul>	<p>Vegetation communities lost as a result of clearing for the freeway and railway are considered to be adequately represented in the adjacent Neerabup National Park.</p> <p>Clearing of vegetation will be minimised by demarcation of a limit-of-works prior to commencement of site. Areas damaged or cleared during construction will be rehabilitated using suitable vegetative material and topsoil.</p> <p>Severance of both the north and south linkage between the remnant vegetation in coastal regions and that present within Neerabup National Park is unavoidable; however, the width of the reservation will be minimised at these points as far as possible. The northern linkage is earmarked for future development and therefore impacts to this corridor resulting from the freeway and railway are not considered to be significant. The southern linkage will be retained to some extent through the reservation of Tamala Park proposed by this Amendment.</p> <p>Native vegetation present along the eastern border of the alignment will be protected from potential impacts of construction and other edge effects, through the creation of appropriate fencing and implementation of the management measures proposed. Construction of the freeway will minimise edge effects currently occurring, by restricting the uncontrolled access to the Park on the western edge.</p> <p>Potential sources of fire from the proposed freeway and railway, both during and after construction, will be identified by the proponent and appropriate control measures implemented to the satisfaction of the City of Wanneroo.</p> <p>A weed control program will be developed and implemented by the proponent in areas infected by noxious or exotic weeds to the satisfaction of CALM.</p> <p>A Dichack Management Program will be prepared and implemented prior to commencement of construction to the satisfaction of CALM.</p> <p>Best practice drainage design will be used to minimise the impacts of drainage from the roads on the adjacent vegetation</p> <p>Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities" can be met.</p>
System 6	<p>The proposed Mitchell Freeway Transportation Corridor alignment is to traverse 122 hectares of the Neerabup National Park. This includes 31 hectares proposed for the railcar stowage and servicing depot. Neerabup National Park is a Class A reserve that is classified as a Bushplan site</p>	<p>The overall Amendment proposes the excision of 140 hectares from the Neerabup National Park, 122 hectares of which is for the Mitchell Freeway Transportation Corridor.</p>	<p>Loss of regionally significant vegetation will be minimised as far as possible.</p> <p>The loss of portions of the Neerabup National Park will be offset by the reservation of approximately 190ha of private land and existing reserves generally situated between the Freeway and Wanneroo Road proposed by this Amendment. If the overall 140ha proposed to be excised is deducted from the proposed additions, the net increase in Parks and Recreation reservation adjacent to the Park would be 432ha.</p> <p>Regionally and locally significant vegetation will be lost as a result of this proposal, however the vegetation associations that will be cleared are well represented in secure conservation reserves.</p> <p>Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "ensure that regionally significant flora and vegetation communities identified in System 6 and draft Perth's Bushplan are adequately protected" can be met.</p>

Environmental Factor	Present State of the Environment	Potential Impacts	Proposed Management/Predicted Outcome
Declared Rare Flora	No declared rare flora were found during vegetation surveys of the proposed Mitchell Freeway Transportation Corridor. <i>Acacia benthamii</i> , a Priority 2 species was recorded during the survey.	The potential loss of one population of a Priority 2 taxon, <i>Acacia benthamii</i>	The extent of the population of <i>Acacia benthamii</i> within Neerabup National Park beyond the area of the alignment will be determined by the proponent to establish the proportion of the population that will be impacted by the development. If the population is found to be significant on advice from CALM, appropriate management measures will be undertaken to the satisfaction of CALM. Given consideration of the above factors and proposed management measures, it is believed that the EPA's objective to "protect Declared Rare and Priority Flora, consistent with the provisions of the <i>Wildlife Conservation Act, 1950</i> " can be met.
Terrestrial Fauna	Native vegetation within the area of the proposed Mitchell Freeway Transportation Corridor alignment could support up to 160 vertebrate fauna species, with the majority of these being native birds, but with significant numbers of reptiles and mammals.	Potential impacts are: <ul style="list-style-type: none"> <li>• loss and degradation of fauna habitat through native vegetation clearance</li> <li>• habitat fragmentation and disruption of fauna populations</li> <li>• barrier to fauna movement, particularly within the east-west wildlife corridor</li> <li>• road fauna deaths</li> <li>• competition and predation by introduced fauna</li> </ul>	As large areas of the Neerabup National Park will remain intact, the loss of habitat resulting from this proposal is not considered to be significant. However, impacts will be minimised through the provision of exclusion fencing to prevent access to roadways to minimise road fauna deaths; rehabilitation and revegetation of areas in the vicinity of the alignment; construction of fauna underpasses to aid fauna movement and access to habitats and resources; and monitoring the use of these underpasses. It is acknowledged that the freeway and railway will sever both fauna corridors between Neerabup National Park and the Burns Beach Bushland and fauna habitat in Jindalce and Butler. This impact is not considered to be significant; however, due to the proposed future development of the northern corridor and the minimisation of the width of the alignment in the vicinity of the southern corridor and the installation of fauna underpasses to maintain the southern corridor. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the abundance, species diversity and geographical distribution of terrestrial fauna" can be met.
Subterranean Fauna	The area has the potential to support subterranean fauna. Troglodytic fauna depend on there being a cave deep enough, and with a permanently dark chamber, to have a limited connection with the surface. No surface expression of the presence of caves was recorded. Stygofauna may be present if there is a conduit of the Ginangara Mound underlying the area. They can have an extremely localised distribution. Sampling of two bores within the area and two to the west did not reveal any stygofauna.	Any changes to groundwater quantity or quality has the potential to deprive subterranean fauna of water, food sources and habitat (eg preferred root mat habitat). In areas of cut where Tamala limestone occurs there is the potential to open hidden karst or cave landforms to the surface. Impact to these environments would be severely detrimental on a local scale to troglodytic fauna.	As no evidence of caves was discovered in the proposal area and the proposal is unlikely to impact the groundwater, it is unlikely that this proposal will impact subterranean fauna. However, if any hidden karst or cave formations are discovered in the development area during construction activities, CALM will be notified and the appropriate actions undertaken to the satisfaction of CALM and the DEP. In addition, best practice drainage design will be utilised by the proponent to control potential impacts to the groundwater through as detailed in the Construction Management Plan. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to "maintain the abundance, species diversity and geographical distribution of subterranean fauna including stygofauna and protect stygofauna, consistent with the provisions of the <i>Wildlife Conservation Act, 1950</i> " can be met.
Specially Protected Fauna	Species protected by the Wildlife Conservation Act, 1950, that may occur within the project area include the Chuditch, Carnaby's Cockatoo, Peregrine Falcon and the Carpet Python. Threatened fauna, designated a Priority listing by CALM, which may occur within the area include the Southern Brown Bandicoot and the Western Brush Wallaby. The Fork-tailed Swift may also be present and this species is protected under international migratory bird agreements.	Impacts include: <ul style="list-style-type: none"> <li>• loss and degradation of habitat that supports threatened fauna</li> <li>• habitat fragmentation and disruption of threatened fauna populations</li> <li>• loss of local populations of threatened fauna</li> </ul>	The loss and degradation of fauna habitats that support rare fauna species will be kept to a minimum, although it is recognised that these habitats are adequately represented within the Neerabup National Park. Areas to be cleared shall be clearly demarcated by the proponent prior to commencement of site works following MRWA Specification No. 204 Environmental Management Requirements and the 300 Series regarding Earthworks. A targeted fauna survey for scheduled and priority fauna species shall be undertaken by the proponent along the proposed alignment prior to commencement of any site works to the satisfaction of CALM. Individuals will be relocated if their ranges lie within or overlap the area of the proposed alignment. Given consideration of the above factors and the management measures proposed, the EPA's objective to "protect Specially Protected (Threatened) Fauna, consistent with the provisions of the <i>Wildlife Conservation Act 1950</i> " can be met.

Environmental Factor	Present State of the Environment	Potential Impacts	Proposed Management/Predicted Outcome
Underground Wetlands	A karstic assessment of the proposal area determined that karst landform, and hence underground wetlands, within the Proposal 5 area are unlikely. In addition the absence of surface expression of water over the proposal area further lessens the probability of underground wetlands.	The absence of karst landform and surface water expression along the Freeway and rail line alignment indicates that there is not, as far as can be determined, any issues relating to the maintenance of values relevant to underground wetlands	As there is an apparent absence of underground wetlands there are no management issues to be addressed in relation to this environmental factor. However, the management measures proposed for the protection of subterranean fauna and maintenance of groundwater quality will also provide for the protection of underground wetlands should they occur in the development area. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the integrity, functions and environmental values of underground wetlands" can be met.
Landforms	The area of Proposal 5 occurs to the west of the identified karstic zone. This zone contains the wetland chain that includes Loch McNess, Mindarie Lake, Carabooda Lake, Nowgup Lake and Necrabup Lake. The identified karstic zone is parallel to the Mitchell Freeway alignment, approximately 1.5 to 2km to the east. The geomorphology of the area consists of rolling relic dunal landscape with outcrop and subcrop on the highs and sand filled, broad valleys in topographic lows. Karst scenery was not observed during the field assessment. Based on the GSWA geological mapping of the area and the preliminary field study, it is evident that the presence of karst landforms within the alignments, such as caves, swallows and dolines, within the alignments is unlikely.	The construction of the proposed Mitchell Freeway Transportation Corridor may impact upon the natural form of the terrain by being inconsistent with the surrounding landforms and leading to a noticeable visual impact. If the freeway and rail line are constructed over areas of karst formation, subsidence or collapse could occur. As there is an apparent absence of karst landform along the alignments there are unlikely to be potential impacts with respect to karst landforms.	It is recognised that to construct the freeway and railway, cuts and fills to this natural landform will be required. However, the planned construction profile interrelates with the existing landform, as the design is based on conforming with the dimensions and form of the natural environment as far as practicable, whilst complying with safety and engineering standards. The proposed landuse (road and rail construction) is suited to the geomorphology of the area provided the development is managed with careful consideration to drainage in valleys and the relevant geotechnical considerations. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to "establish stable, sustainable landform consistent with surroundings and to maintain the environmental, scientific, cultural and recreational values of karst landforms" can be met.
<b>Social Surroundings</b>			
Aboriginal Culture and Heritage	From previous site surveys and discussions with relevant Aboriginal people no archaeological sites were found or were known to occur within the area of the proposed Mitchell Freeway Transportation Corridor.	Clearing of the proposed alignment could destroy any previously unidentified archeological sites.	No archaeological sites have been located or are known to occur within the proposed alignment area, therefore no management measures are proposed. If any sites are uncovered during clearing and excavation activities, material will be properly salvaged and managed in accordance with Section 16 of the <i>Aboriginal Heritage Act, 1972</i> . Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to "ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972 and that changes to the biological and physical environment resulting from the project will not adversely affect cultural associations with the area" can be met.
Non-Aboriginal Heritage	Necrabup National Park is listed as a Heritage Place within the WA Heritage Council's database. The Park contains two heritage walking trails; the 10 <sup>th</sup> Light Horse Heritage Trail and the Yaberoo Budjara Heritage Trail.	The construction of the proposed Mitchell Freeway Transportation Corridor would cut the Yaberoo Budjara Heritage Trail	The 10th Light Horse Heritage Trail will not be disturbed by the proposed alignment. The south-west corner of Necrabup National Park includes part of the Yaberoo Budjara Heritage Trail around an old rehabilitated limestone quarry. This part of the trail is proposed for rehabilitation and realignment by CALM, to ensure that the heritage values of the trail are maintained subsequent to construction of the freeway and railway. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "comply with statutory requirements in relation to areas of cultural or historical" can be met.

Environmental Factor	Present State of the Environment	Potential Impacts	Proposed Management/Predicted Outcome
<b>DEFERRED ENVIRONMENTAL FACTORS</b>			
<b>Pollution Management</b>			
Dust/Particulates	Existing residents adjacent to the proposed Mitchell Freeway Transportation Corridor may be susceptible to sporadic generation of dust arising from the clearing of surrounding land for future urban development.	Construction activities will generate dust. This may cause a nuisance to the neighbouring residents and may also have implications for human health in high volumes, particularly in reference to respiratory complaints and eye irritations. Dust may also impact the vegetation adjacent to works areas, where it settles on leaves and hinders biological function. The potential for dust generation from the site will continue until land rehabilitation is successfully implemented.	<ul style="list-style-type: none"> <li>Cleared soil will be stabilised as soon as possible using techniques outlined in EPA Guidance for the Assessment of Environmental Factors, No 18: Air Quality Impacts from Development Sites and activities; and</li> <li>Construction methods will comply with MRWA Specification No. 203 Occupational Safety &amp; Health Management Requirements.</li> </ul> <p>Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards" can be met.</p>
Groundwater Quality	The proposed Mitchell Freeway Transportation Corridor is situated over a Priority 3 groundwater pollution control area.	Road/trail run-off consists of hydrocarbons and heavy metals deposited on the road through traffic movement and then washed off following rain events. Run-off will be captured along the route via drainage sumps at various locations, however there is the potential for these retention basins to cause localised waterlogging.	<p>Best practice drainage design will be implemented to address measures to facilitate the removal of pollutants but to hinder water logging of the surrounding areas.</p> <p>Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993) and the NIIRMC/ARMCANZ Australian Drinking Water Guidelines - National Water Quality Management Strategy" can be met.</p>
Noise	Currently the suburbs adjacent to the proposed Mitchell Freeway Transportation Corridor abut either vacant land or Neerabup National Park and would therefore feature low environmental noise levels.	<ul style="list-style-type: none"> <li>Temporary impact of construction noise levels on adjacent residents (including blasting).</li> <li>Operational noise levels of Freeway and Railway on adjacent residents.</li> </ul>	<p>Utilisation of appropriate management techniques is expected to reduce noise from traffic on the proposed Mitchell Freeway extension and Northern Suburbs Rail Line to acceptable levels.</p> <p>Noise generated by traffic and trains will be managed through a Noise Management Plan prepared by the proponent prior to the finalisation of detailed design plans for the proposed freeway and/or railway, whichever occurs first. Construction activities will be managed as outlined in the Construction Management Plan.</p> <p>Given consideration of the above factors and the management measures proposed, the EPA's objective to "protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring that noise levels meet statutory requirements and acceptable standards" can be met.</p>
Vibration	Currently the suburbs adjacent to the proposed alignment area abut either vacant land or Neerabup National Park and are therefore not subject to significant vibration levels.	<ul style="list-style-type: none"> <li>Temporary impact of construction vibration levels on adjacent residents (including blasting).</li> <li>Operational vibration levels of Freeway and Railway on adjacent residents.</li> </ul>	<p>Construction activities will be managed in accordance with a Construction Management Plan prepared by the proponent prior to commencement of construction works, including compliance with MRWA Specification No. 203 Occupational Safety &amp; Health Management Requirements.</p> <p>Further investigation will be undertaken by the proponent to determine the potential level of vibration that may be expected in adjacent urban areas.</p> <p>Given consideration of the above factors and the management measures proposed, that the EPA's objective to "protect the amenity of nearby residents from vibration impacts resulting from activities associated with the proposal by ensuring that vibration levels meet statutory requirements and acceptable standards" can be met.</p>

Environmental Factor	Present State of the Environment	Potential Impacts	Proposed Management/Predicted Outcome
Light	Land currently adjacent to the proposed Mitchell Freeway Transportation Corridor is either Neerabup National Park, cleared land, or residential properties. The existing properties would be affected by street lighting only.	The construction site may need to be lit if building is not restricted to daylight hours. When the project is operational, lighting of the Freeway and railway stations will provide a safe environment for users, which may interfere with the welfare or amenity of adjacent residents. Lighting along the Freeway may deter nocturnal and assisting in the reduction of road deaths. Lighting would also aid drivers in seeing animals on the road.	Lighting requirements will comply with Australian Standard 1158.1 Public Lighting Code – Performance and Installation Design Requirements to ensure the safety of road and rail users. Lightspill into neighbouring residential areas during construction will be managed by the proponent in accordance with Australian Standard 4282: Control of the Obtrusive Effects of Outdoor Lighting. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "manage potential impacts from light overspill and comply with acceptable standards" can be met.
<b>Social Surroundings</b>			
Public Health & Safety	Residential areas adjacent to the proposed Mitchell Freeway Transportation Corridor would currently face the risks and general hazards of light to medium street traffic.	Construction of the proposed Mitchell Freeway Transportation Corridor will increase the risk of vehicular accidents, and pedestrian, cyclist and railway user fatalities	The proponent will manage the operation of the freeway and railway with respect to the Department of Minerals and Energy's requirements for public safety. The proponent will provide a safety plan addressing, among other safety factors, the use of shotfirers and explosives during construction. The safety plan will form part of the Construction Management plan that will be prepared prior to commencement of site works. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to ensure that "risk is managed to meet the EPA's criteria for individual fatality risk off-site and the DME's requirements in respect of public safety, and that roads are maintained or improved and road traffic managed to meet an adequate standard of level of service and safety and MRWA requirements" can be met.
Recreation	The two heritage walking trails are maintained, the 10 <sup>th</sup> Light Horse Heritage Trail and the the Yaberoo Budjara Heritage. The Park is also subject to uncontrolled access. Other human activities affecting the Park include the collection of firewood and rubbish dumping.	Construction of the proposed Mitchell Freeway Transportation Corridor will cut the Yaberoo Budjara Heritage Trail and also limit access to the National Park's western boundary.	As a management plan for Neerabup National Park has not been formulated there are no documented controls over the types of recreation that occur within it's boundaries. The recreational values, including future pedestrian and bicycle access to Neerabup National Park and the walking trails and other amenities will be maintained through future development of the management plan for Neerabup National Park by CALM. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the quality of the area in relation to recreational activities" can be met.
Visual Amenity	The low undulating hills of Neerabup National Park have a low scenic quality. Yet the diversity of the vegetation gives the Park a high visual amenity.	Construction of the proposed Mitchell Freeway Transportation Corridor will cause physical changes that effect the visual amenity of the National Park such as the clearance of native vegetation and cuts and fills to the surrounding landforms. The degree of visibility of the Freeway/railway from within the National Park will also affect the visual amenity of the area. The significance of this impact is determined by the presence of vantage points from which the alignment may be viewed and access to them	The impact on the visual amenity of the Park resulting from the railway and freeway is considered to be minimal. The landform of Neerabup National Park is reported as having low scenic quality. However, as the vegetation within the Park has a high scenic quality, the reservation of Lot 14 and other land parcels and the eventual inclusion of this land into the Park should compensate for loss through clearing. Rehabilitation of roadsides using native plants of local provenance will also provide visual screening. The potential visual impact of built elements associated with the road and railway will be designed to be harmonious with the surrounding environment whilst taking into account road safety and engineering standards. Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "ensure that the visual amenity of the area adjacent to the project should not be unduly affected by the proposal" can be met.

### **3. ENVIRONMENTAL FACTORS RELEVANT TO PROPOSAL 5 OF THE AMENDMENT**

#### **3.1 Vegetation Communities**

##### *3.1.1 EPA Objective*

Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.

##### *3.1.2 Relevant Policies*

Draft Perth's Bushplan (Government of WA, 1998)

##### *3.1.3 Existing Environment*

The proposed Mitchell Freeway Transportation Corridor alignment is situated within the Northern Swan Coastal Plain. This is an area of considerable environmental significance, lying in the Darling Botanical District, but including species from both the botanical districts of Irwin to the north and Avon to the east. Additionally, the plain is the centre of distribution for many species and contains numerous endemics, resulting in high species richness. In terms of landform, the proposed alignment area lies within the major landform element of the Spearwood Dune system which lies to the east of the Quindalup Dunes (which abut the coastline) and to the west of the Bassendean Dunes. These three geomorphological units occur as bands of variable widths running in a north-south direction along the Swan Coastal Plain and each possess distinctive soils and to a lesser extent topography, which in turn influence the type of vegetation present. This has significance when considering the transitions in vegetation that occurs from the coast moving inland.

The transportation corridor alignment traverses rural cleared land, remnant native vegetation and reserved native vegetation. For the first 800 metres, the freeway and railway alignment traverses rural and urban zones. It then crosses Neerabup National Park for 2.9 kilometres, separating about 73 hectares of the south west corner from the rest of the Park. Within this corner is a 9ha area previously excised from the Park, allocated to the Water Corporation's Groundwater Treatment Plant, currently under construction. The severing of the south west corner of the Neerabup National Park was proposed in the *North West Corridor Structure Plan* (WAPC, 1992) for use as a public golf course and water treatment plant.

To the west of the National Park boundary lies Tamala Park, which is zoned rural and contains the Tamala Park Refuse Disposal Facility, owned by the Cities of Perth, Stirling and Wanneroo, and proposed to be rezoned under this Amendment. Continuing north, between Neerabup Rd and Lukin Drive, the alignment is bounded by urban zones to the west and rural zones to the east. North of Lukin Drive it again enters the Neerabup National Park, traversing the western margin for a further 3 kilometres (apart from a small rural zoned section near the

northern extremity) until it reaches Romeo Road (Figure 1.1).

This Amendment proposes to rezone 140 hectares of the south western corner and northern margin of the Neerabup National Park for purposes other than Parks and Recreation. Proposal 5 will rezone approximately 122 hectares of this land for the Mitchell Freeway Transportation Corridor, including 31 hectares for the proposed railcar stowage and servicing facility (Proposal 6) and about 5ha for urban development. This land will be excised from Neerabup National Park prior to commencement of site works.

To compensate for the loss to the Park, the Amendment proposes to reserve an additional 190 hectares of private land and existing reserves generally situated between the Freeway and Wanneroo Road for Parks and Recreation. Previous amendments have reserved some 382ha of private land. If the overall 140ha proposed to be excised is deducted from the proposed and existing additions, the net increase in Parks and Recreation reservation adjacent to the Park would be 432ha. This land is proposed to be vested in the NPNCA and eventually incorporated into the National Park.

Northern and southern parts along the western border of the proposed alignment provide linkages between the Neerabup National Park and other native vegetation along the coast. These linkages provide corridors which are essential for the continued viability of the populations present, as they provide avenues for vertebrate movement, pollination and gene flow (Primack, 1998). The southern linkage is provided through the Tamala Waste Disposal Site area to the coastal vegetation communities of Burns Beach bushland. The corridor between Burns Beach bushland and the National Park is of particular significance as it provides a narrow corridor between significant vegetation through the surrounding urban areas of Clarkson and Mindarie to the north and Kinross to the south; however, part of the land is proposed to be rezoned by this Amendment (Proposals 1 and 2).

The northern linkage is provided through Jindalee and Butler; however, areas of Butler and Jindalee have been earmarked for future development. The *North West Structure Plan* (WAPC, 1992) classifies the area as Category A1: Future Urban (areas assessed as having no constraints to urban development in the short term, generally within 5 to 10 years) and much of the land is currently zoned Urban and Urban Deferred in the MRS. Most of this land is expected to be developed within five years.

### **Vegetation survey data and mapping**

In contrast to other parts of Western Australia, the proximity of the region to the metropolitan area has resulted in large amounts of biogeographical research. Broadly speaking the geology, landforms, soil type, climate and proximity to the coast were found to be the major determinants of plant community types (Griffin, 1993; Griffin, 1994; and Cresswell & Bridgewater, 1985).

The Darling Botanical District has been mapped in broad vegetation complexes at a scale of 1:250,000 by Hedde *et al* (1980), which have since been widely used for descriptive

purposes. Twenty nine of these complexes are present on the Swan Coastal Plain, the distribution of which appears to be primarily determined by landform and soil, with climate exerting a controlling influence leading to a reduction in both height and foliage cover of the upper stratum as one trends northwards. The proposed alignment lies entirely within an area mapped as Cottesloe Complex – Central and South, with areas of Quindalup Complex to the west in Burns, Jindalee and Mindarie, and fragmented pockets of the Herdsman Complex to the east of Wanneroo Road.

Other vegetation surveys in the vicinity include quadrats investigated for the floristic survey of the southern Swan Coastal Plain conducted by Gibson *et al* (1994), a study of conservation values of remnant vegetation within the City of Wanneroo by Malcolm Trudgen in 1996, and a biological survey of proposed east to west roads which traverse Neerabup National Park between the proposed freeway alignment and Wanneroo Road by *ecologia* in 1996.

The *Floristic Survey of the Swan Coastal Plain* (Gibson *et al*, 1994) surveyed over five hundred sites on the Swan Coastal Plain. The floristic analysis defined 30 community types which were further subdivided, and a total of 43 types identified (Gibson *et al*, 1994). These floristic community types are commonly used to describe vegetation on the Swan Coastal Plain. Vegetation associations, complexes and types described in the above surveys found in the proposed alignment area or adjacent to the alignment are listed in Table 3.1.

An additional survey of the proposal area was undertaken by *ecologia* Environmental Consultants in 1999.

### Vegetation Survey Results

A five day floristic survey of the study area, incorporating twenty-eight 10 by 10 metre quadrats and numerous opportunistic transects was conducted between 6 and 13 June 1999. A total of 163 taxa were collected including one Priority taxon, *Acacia benthamii* (Appendix C). The vegetation was mapped into seven vegetation units (Figure 3.1), which can be correlated to three of the community types described by Gibson *et al* (1994).

Broadly speaking, the Eucalypt forests vegetation units are finer scale mapping units which fall within Gibson's *et al*'s Community type 28: Spearwood *Banksia attenuata* or *Banksia attenuata* – *Eucalyptus* woodlands. The *Dryandra sessilis* heath and Tuart forest units correspond to Community Type 24: Northern Spearwood shrublands and woodlands and the mixed low heath most closely resembles Type 26a (Woodlands and mallees on limestone). The correlation between the vegetation associations mapped in Figure 3.1 and Gibson's community types is summarised in Table 3.2.

Table 3.1 Expected Vegetation Communities/Complexes

Report & Author	Location relative to alignment	Vegetation Complex/	Community Type
<i>A Floristic Survey of the Southern Swan Coastal Plain.</i> Gibson <i>et al.</i> , 1994	Neerabup National Park and Lake Nowergup Nature Reserve, subset of fifteen quadrats east of alignment	<u>Cottesloe Complex Central &amp; South</u> <ul style="list-style-type: none"> <li><i>Eucalyptus gomphocephala</i> woodland</li> <li><i>Eucalyptus gomphocephala/ E. marginata/ E. calophylla</i> open forest</li> <li>Closed heath on limestone outcrops</li> </ul> <u>Karrakatta Complex Central &amp; South</u> <ul style="list-style-type: none"> <li><i>Eucalyptus gomphocephala/ E. marginata/ E. calophylla</i> open forest</li> <li><i>Eucalyptus marginata/ Banksia sp.</i> woodland</li> </ul>	Type 24 (Northern Spearwood shrublands and woodlands)  Type 28 (Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands)
<i>Report on the Proposed Route of the Mitchell Freeway Extension, Burns Beach to Romeo Road Section.</i> Anna Napier & Associates, 1989	Presumably on alignment (no map included)	<u>Banksia Woodland</u> <ul style="list-style-type: none"> <li><i>Banksia attenuata/ B. menziesii</i></li> <li>Shrublands dominated by either <i>Hakea trifurcata</i>, <i>Xanthorrhoea preissii</i>, <i>Macrozamia reidiei</i>, <i>Jacksonia sternbergiana</i>, <i>Dryandra sessilis</i> &amp; <i>Hibbertia hypercoides</i></li> </ul> <u>Limestone Heath</u> <ul style="list-style-type: none"> <li>Dominant species including <i>Dryandra sessilis</i>, <i>Jacksonia lehmannii</i>, <i>Grevillea thelmaniana</i></li> </ul>	
<i>Neerabup National Park Roads Study: ecologia</i> , Winter 1996 & Spring 1997	Three proposed roads extending from the alignment east to Wanneroo Road at Lukin Drive; Quinns Avenue; and Neerabup Road.	<u><i>Eucalyptus</i> dominated forests &amp; woodlands</u> <ul style="list-style-type: none"> <li><i>Eucalyptus gomphocephala</i> forest over <i>Xanthorrhoea preissii</i> dominated understorey</li> <li><i>Eucalyptus marginata/ Banksia attenuata/ A. menziesii</i> woodland over low <i>Hibbertia hypercoides</i> dominated understorey</li> <li><i>Eucalyptus marginata/ Allocasuarina fraseriana</i> over <i>Xanthorrhoea preissii</i> &amp; <i>Hibbertia hypercoides</i> dominated shrubland</li> <li><i>Eucalyptus calophylla</i> over <i>Acacia rostellifera</i></li> </ul> <u>Low <i>Banksia</i> woodlands</u> <ul style="list-style-type: none"> <li><i>Banksia attenuata/ B. menziesii</i> over mixed shrubs</li> <li><i>Eucalyptus decipiens</i> over dense <i>Allocasuarina humilis</i> &amp; <i>Melaleuca</i> shrubland</li> </ul> <u><i>Dryandra sessilis</i> dominated shrublands</u> <ul style="list-style-type: none"> <li><i>Dryandra sessilis/ Hakea trifurcata</i> shrublands</li> <li><i>Dryandra sessilis/ Hakea trifurcata/ Xanthorrhoea preissii</i> shrubland over <i>Hibbertia hypercoides</i> dominated understorey</li> </ul>	Community type 28 – Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands  Community Type 24 – Northern Spearwood shrublands and woodlands  affinities to Community Type 26a <i>Melaleuca heugelii</i> - <i>M. acerosa</i> shrublands of limestone ridges and Type 24 – Northern Spearwood shrublands and woodlands

Report & Author	Location relative to alignment	Vegetation Complex/	Community Type
Draft <i>Perth's Bushplan</i> . Western Australian Planning Commission, 1998 (refer to Figure 3.3)	Site 322 – Burns Beach Bushland, west of Site 323	<u>Cottesloe Complex Central &amp; South</u> <ul style="list-style-type: none"> <li>• <i>Eucalyptus gomphocephala</i> woodland</li> <li>• <i>Eucalyptus gomphocephala/ E. marginata/ E. calophylla</i> open forest</li> <li>• Closed heath on limestone outcrops</li> </ul> <u>Karrakatta Complex Central &amp; South</u> <ul style="list-style-type: none"> <li>• <i>Eucalyptus gomphocephala/ E. marginata/ E. calophylla</i> open forest</li> <li>• <i>Eucalyptus marginata/ Banksia sp.</i> woodland</li> </ul>	Community types: 24 (Northern Spearwood shrublands and woodlands) 28 (Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands) 29a (Coastal shrublands on shallow sands) 29b (Acacia shrublands on taller dunes)  Supplementary types: S11 (Northern Acacia <i>rostellifera</i> – <i>Melaleuca acerosa</i> shrublands) S13 (Northern <i>Olearia axillaris</i> – <i>Scaevola crassifolia</i> shrublands) S14 ( <i>Spinifex longifolius</i> grassland and low shrubland)
	Site 323 – Tamala Park Refuse Site and surrounding vegetation, immediately west of the alignment	Cottesloe Complex Central and South Quindalup Complex	Inferred <sup>1</sup> community types: 24 (Northern Spearwood shrublands and woodlands) 28 (Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands) 29b (Acacia shrublands on taller dunes)
	Site 383 – encompasses portions of the alignment but also includes Lake Nowergup Nature Reserve, Neerabup National Park and adjacent privately owned bushland	Cottesloe Complex Central & South Karrakatta Complex Central & South Herdsman Complex	Inferred <sup>1</sup> community types: 7 (Northern woodlands to forests over tall sedgeland alongside permanent wetlands) 24 (Northern Spearwood shrublands and woodlands) 26a ( <i>Melaleuca heugelii/M. acerosa</i> shrublands of limestone ridges) 27 (Species poor mallees and shrublands on limestone) 28 (Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands)
	Site 384 – Neerabup Lake and adjacent bushland, east of Wanneroo Road and Site 383	Cottesloe Complex – Central and South Herdsman Complex	Inferred <sup>1</sup> community types: 7 (Northern woodlands to forests over tall sedgeland alongside permanent wetlands) 24 (Northern Spearwood shrublands and woodlands) 28 (Spearwood <i>B. attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands)
	Site 397 - Coastal strip from Wilbinga to Mindarie. West of alignment with vegetation linkage present only in the northern portion of the alignment	Cottesloe Complex – Central and South Quindalup complex	Inferred <sup>1</sup> community types: 16 (Highly saline seasonal wetlands) 29a (Coastal shrublands on shallow sands) 29b (Acacia shrublands on taller dunes)  Supplementary types: S11 (Northern Acacia <i>rostellifera</i> – <i>Melaleuca acerosa</i> shrublands) S13 (Northern <i>Olearia axillaris</i> – <i>Scaevola crassifolia</i> shrublands) S14 ( <i>Spinifex longifolius</i> grassland and low shrubland)

Table 3.2 Comparison of Gibson et al community types with mapped vegetation associations.

Vegetation associations mapped in Figure 3.1	Community types by Gibson <i>et al</i> (1994)
<ul style="list-style-type: none"> <li>• Tuart forest</li> <li>• <i>Dryandra sessilis</i> heath</li> </ul>	Type 24: Northern Spearwood shrublands and woodlands
Mixed low heath	Affinities to Type 26a: <i>Melaleuca acerosa</i> / <i>M. heugellii</i> shrublands of limestone ridge
<ul style="list-style-type: none"> <li>• <i>Eucalyptus marginata</i>/<i>Banksia attenuata</i> woodland</li> <li>• <i>Banksia attenuata</i>/<i>B. menziesii</i> woodland</li> <li>• <i>Banksia attenuata</i> / <i>Allocasuarina fraseriana</i></li> <li>• Mosaic of <i>Banksia</i> woodland and <i>D. sessilis</i> heath</li> </ul>	Type 28: Spearwood <i>Banksia attenuata</i> or <i>Banksia attenuata</i> / <i>Eucalyptus</i> woodlands

A matrix detailing the species composition of each site is contained within Appendix D and Appendix E outlines the composition of each detailed quadrat. The structure and floristic composition of each of the vegetation units into which the area was mapped is described in Appendix F.

### Vegetation condition

Factors that adversely affect the condition of bushlands are commonly called disturbance factors. Such factors include: partial clearing; fragmentation; weed invasion; feral animal impact; changes in water regimes (eg, flooding and drainage); rubbish dumping; roads and tracks (fire breaks, walk trails and off road vehicle use); and service corridors (for electricity, water and roads).

Not all these factors have the same level of impact but generally they are interrelated and the presence of one type of disturbance frequently leads to further disturbance. An assessment of disturbance, in relation to the ability of the bushland to self-maintain, has been used as the basis for defining condition ratings for plant communities within draft Perth's Bushplan (Government of WA, 1998).

Using the criteria listed in Table 3.3, draft Perth's Bushplan (Government of WA, 1998) has rated the vegetation condition of the following areas:

- 85% of Neerabup National Park as being in a very good to excellent condition and <15% in good to degraded condition;
- the linkage native vegetation surrounding the area developed for Tamala Waste Disposal Site as <30% as good to very good;
- Burns Beach bushland as >70% excellent to pristine and <30% very good to good; and
- the coastal strip from Wilbinga to Mindarie from near pristine to degraded, with areas of severe localised disturbance near Jindalee.

In 1989, the brief biological survey of the proposed alignment (Anna Napier & Associates, 1989) found the native vegetation in the portions of the proposed alignment within Neerabup National Park to be in excellent condition, with no significant weed invasion and no evidence of dieback. Remnant vegetation in rural zoned areas was evaluated as good.

Table 3.3: Vegetation Condition Scales used in Perth's Bushplan (Government of WA, 1998)

Condition	Description
1. Pristine	Pristine or nearly so, no obvious signs of disturbance
2. Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are a non-aggressive species
3. Very good	Vegetation structure altered, obvious signs of disturbance.
4. Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
5. Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.

More recently, in the survey that assessed the conservation values of remnant vegetation within the City of Wanneroo, Trudgen (1996) evaluated the vegetation within the southern portion of the alignment which traverses Neerabup National Park as in very good condition, whilst the area immediately to the north extending to Hester Avenue is ranked as either cleared or very poor. Further north between Hester Avenue and Lukin Drive the vegetation was largely ranked as very poor or cleared, with a small area of very good vegetation approximately central between the roads.

The most recent survey undertaken by *ecologia* (1999) mapped the condition of the vegetation according to the Bushplan criteria (Figure 3.2). The vegetation distribution conforms very closely to that of Trudgen, although the condition rankings attached reflect the differences in coding. The areas within Neerabup National Park were evaluated as excellent, with sparsely scattered weeds. Very light grazing effects were observed in the southern portion close to where the alignment leaves the Park and enters rural land. The rural land through which the alignment traverses immediately north contains only scattered overstorey and remnant shrubs and most of the area was classified as degraded. To the immediate north of Hester Avenue a classification of good was applied – specimens of *Banksia* and *Xanthorrhoea preissii* and other dominants are relatively abundant but the diversity of the community is dramatically reduced and extensive weed invasion, particularly of *\*Lupinus* sp. and *\*Erharta calycina*.

### Vegetation linkages

As previously mentioned, the Amendment area contains remnant vegetation that links Neerabup National Park with the coast. Both the northern linkage through Jindalee and Butler, and the southern linkage through Tamala Park, contain the Cottlesloe Vegetation Complex - Central and South and the Quindalup Vegetation Complex. Whilst the majority of the Burns Beach bushland remains in excellent condition (Government of WA, 1998), the Tamala Waste Disposal Site contains large areas which have been heavily disturbed, with approximately 30% of the area at the margins described as good to very good.

The north western boundary of the Neerabup National Park abuts remnant vegetation on undeveloped land through Butler and Jindalee of the Quindalup complex. The condition of the majority of this linkage was evaluated by Trudgen (1996) as very good, including areas of

both Quindalup and Cottesloe - Central and South Complexes. A strip running north-south in Butler to the immediate west of the alignment was mapped as a mosaic of areas in poor to very poor condition, with some areas cleared.

### Weed Presence

A total of 21 introduced species were recorded from within the proposed alignment, however this figure probably slightly underestimates the total, as many annual species were in a very immature condition at the time of survey. Many species, such as *\*Ursinia anthemoides*, *\*Hypochaeris glabra*, *\*Erharta calycina* and *\*Gladiolus caryophyllaceus* were ubiquitous throughout the area, but present at much lower density in the areas ranked as in excellent condition.

A single species with scheduled status under the Agriculture and Related Resources Protection Act, 1976, *\*Homeria ?flaccida*, was recorded from several widely separated sites at low density. It is probably more widely spread than recorded given the immature state of specimens collected. It was also collected within Neerabup National Park during the biological assessment of the Neerabup National Park Roads (*ecologia*, 1996). This species has a coding of P1 throughout the state (i.e. plants which cannot be introduced or spread) which will have ramifications for earthworks should the proposed alignment proceed.

### Dieback

Within Western Australia a root rot fungi of the genus *Phytophthora* is responsible for killing or injuring native vegetation, with many species from the genera *Proteaceae*, *Epacridaceae*, *Myrtaceae*, *Dilleniaceae*, *Papilionaceae* and *Xanthorrhoeaceae* known to be particularly susceptible. There is no known or established method available to eradicate the fungi on a broad scale. New infection of the dieback fungi are mainly caused through human activities which move infected soil and roots, and by water. Consequently, roadworks are one of the main activities which can spread dieback (Main Roads, 1997). It has been shown that introduction and intensification of *Phytophthora cinnamomi* disease in four National Parks is directly attributable to disturbance of the area caused by road and firebreak construction and their subsequent use (*ecologia*, 1997).

Given the position of the proposed alignments at the western border of Neerabup National Park, the potential for introduction or exacerbation of infection is a significant conservation issue. Whilst the presence of *Phytophthora* species within Neerabup National Park has not been established by laboratory testing, the area is undoubtedly already vulnerable due to the high level of illegal use of tracks within the Park by four wheel drive vehicles and trail bikes. The vegetation of many areas is rich in species from genera known to be susceptible. A small patch of *Dryandra sessilis* to the immediate north and approximately midway between Hester Avenue and Lukin Drive was classified as excellent, as was a very small patch of *Eucalyptus marginata* (jarrah) dominated forest slightly further north, with the remainder of vegetation north to Lukin Drive classified as good. North of Lukin Drive all of the alignment was classified as excellent.

### 3.1.4 Potential Impacts

This Proposal proposes to reserve approximately 91 hectares of Neerabup National Park, for Primary Regional Roads to allow the future construction of the Mitchell Freeway and railway extensions. This land will be cleared in the future to facilitate construction.

Additional patches of remnant vegetation occur along the proposed Mitchell Freeway Transportation Corridor alignment outside the Park, as detailed in Figure 3.1, and will also be cleared where affected by the proposal.

This clearing of land will have several impacts:

- loss of regionally significant vegetation (refer to Section 3.2);
- vegetation fragmentation;
- increased susceptibility of Neerabup National Park to fire;
- increased susceptibility of Neerabup National Park to weed invasion; and
- increased susceptibility of Neerabup National Park to dieback.

#### Vegetation Fragmentation

The proposed alignment will sever corridors between the Neerabup National Park and the coastal vegetation communities in the vicinity of Jindalee in the north and Burns Beach in the south. This action may cause the vegetation communities within Neerabup National Park to become isolated from the adjacent remnant vegetation, fragmenting the ecosystems.

Issues of concern within fragmented ecosystems are:

- the requirement of animals, such as birds, mammals and many invertebrates, for large areas for their home ranges and hence their survival;
- animal movement, which is essential for maintenance of genetic diversity in plant communities by moving pollen and seed from one remnant vegetation area to another;
- isolation of plant and animal populations from other populations leaving them susceptible to local extinction; and
- the loss of genetic diversity through inbreeding.

(Government of WA, 1998)

Ramifications for Neerabup National Park in the short term are probably minimal as the reserve is large enough to support viable and isolated populations. However, in the long term, vegetation communities present in the park may become more susceptible to disturbances, such as fire, disease and weeds. The Park has long rectangular shape, causing it to have a large boundary to area ratio. The areas surrounding the Park have a defining impact on the long term "health" or viability of the species inhabiting it, by providing a buffering effect against edge effects. Edge effects can be defined as any factor, that by its introduction to an area, has a detrimental effect on the species present in that particular region (Primack, 1998).

↑ boundary to 1998/10/10.

Isolation of local populations may result with the gradual extinction of these populations. The decline of species richness and diversity that may occur within the Neerabup National Park may be directly attributed to a reduction in the gene flow from surrounding areas. The

injection of "new blood" into a community results in an increase in biodiversity and also an increased potential to survive disturbance, via natural selection or the selection of the "fittest" individual (Dobson, 1996). This would also increase the potential for species to survive edge effects.

Roads, by their very nature, can cause detrimental edge effects, by providing corridors for pest and weed species, diseases or fire caused by activities along the road (Main Roads, 1997). An increase in detrimental surrounding land use decreases the amount of land in the centre of the park that can be successfully buffered from edge effects. Therefore the Park's habitat size, quality, vegetation condition and species richness may be diminished.

In order to maintain a viable corridor in the long term and minimise the edge effects, it is generally accepted that a minimum width of several hundred metres is required in order for a remnant vegetation corridor to remain viable in the medium to long term. (EPA, 1998).

The proposed alignment on the north western edge of the Neerabup National Park will sever the link between the Park, through remnant vegetation within Butler and Jindalee, to the vegetation on the coast. The condition of the majority of this linkage area was evaluated by Trudgen (1996) as very good, including areas of both Quindalup and Cottesloe - Central and South Complexes; however, a strip running north-south in Butler to the immediate west of the alignment was mapped as a mosaic of areas in poor to very poor condition, with some areas cleared. This poor vegetation directly adjacent to the proposal area reduces the viability of the linkage to the coast. In addition, development planned for the Jindalee/Butler area is likely to clear the majority of the vegetation and it is unlikely that a corridor will remain in the future.

The southern corridor linking Burns Beach with Neerabup National Park is relatively narrow, bordered by urban development and containing the Tamala Waste Disposal site. This area has already suffered a loss of habitat due to these internal and external edge effects, and as a result, it exhibits a relatively low species richness and vegetation condition. The potential for further degradation is enhanced by the barrier imposed by the proposed freeway/railway reserve. The long term viability, condition and diversity of vegetation present within Tamala Park and Burns Beach may suffer as a result of the reduction in gene flow from the more species rich and diverse area of Neerabup National Park. As a result of this, the population may exhibit a decreasing ability to survive disturbances at a time when these disturbances may increase as a result of increasing edge effects.

It should also be noted that whilst this Environmental Review considers the potential impacts of the freeway/railway alignment, additional fragmentation is proposed by the reservation of land for two roads which traverse the Park east to west at Neerabup Road and Hester Avenue (Proposal 3) (Figure 1.1). Thus in the context of fragmentation this proposal should not be considered in isolation, as its development provides the impetus for further fragmentation by the construction of the extension of Neerabup Road and the development of the already existing Hester Avenue.

ultimately resulting in alterations to the composition of the surrounding vegetation. Sheet movement of water across the freeway and railway also has the potential to collect any spillage of hydrocarbons or other pollutants and distribute them more broadly into the adjacent native vegetation.

### ***3.1.5 Proposed Management***

#### **Vegetation Clearance**

Clearing of vegetation will be minimised by limiting clearing to that which is absolutely essential through the demarcation by the proponent of a limit-of-works prior to commencement of site works and by limiting access and track development through the erection of fencing. The amount of vegetation cleared will follow the detailed design and construction plans (yet to be developed). Areas with intact vegetation will not be disturbed if outside the limit-of-works. Large trees close to the limit of works will be identified by the proponent prior to clearing and fenced with temporary fencing to protect them from accidental damage.

Areas to be rehabilitated shall be seeded or planted with native species of local provenance. Suitable vegetative material and topsoil removed for construction will be used during the land rehabilitation process. Cleared vegetation will be re-applied to approximately the same area it was taken from. Where an excess of material occurs in a given area it will only be used in areas of the same vegetation association, as defined by vegetation mapping (Figure 3.1). Any vegetation not required for rehabilitation, or which has a high proportion of weeds, will be taken off-site to a pit area designated by the local authority.

The development of the freeway and railway will inevitably sever the linkage between the Quindalup Complex and transitional vegetation to the west, and the Cottesloe – Central and South Complex within Neerabup National Park. The degree of severance is mitigated to some degree, as this Amendment proposes to reserve the strip of native vegetation to the immediate north of the Tamala Waste Disposal Site for Parks and Recreation. In addition, the width of the alignment will be minimised in this area, through relocation of the rail car depot as proposed by Proposal 6 of this Amendment. Similarly at the northern extreme of the alignment, the reservation of some land in the urban zoned areas of Butler and Jindalee, for public open space, together with minimisation of the width of the alignment adjacent to this reserved land will reduce the degree of severance.

#### **Fire**

Potential sources of fire from the proposed freeway and railway, both during and after construction, will be identified by the proponent prior to commencement of site works, and appropriate control measures implemented to the satisfaction of the City of Wanneroo. This may include design of appropriate firebreaks, erection of fencing to prevent illegal vehicular access that may cause a fire and the provision of fire control equipment during construction.

## **Weed Control**

Prior to commencement of site works, a weed control program will be developed and implemented by the proponent in areas infected by noxious or exotic weeds to the satisfaction of the Department of Conservation and Land Management (CALM). A suitable herbicide will be applied where necessary, according to the manufacturer's specifications. The optimum timing for application is during the latter months of winter to early spring, August to September. Applications of herbicides during this period should prevent flowering and seeding of the majority of weeds occurring in the project area.

## **Dieback**

In order to determine the presence and location of dieback within native vegetation a dieback survey will be undertaken by the proponent prior to commencement of construction. Main Roads policy also requires the preparation and implementation of a Dieback Management Program. This program shall comply with the CALM Dieback Hygiene Manual (CALM, 1992). Issues such as the washdown of all earthmoving equipment and vehicles prior to entry and departure from the construction site, diversion of drainage patterns from uninfected vegetation, and the undertaking of roadworks in the dry months where possible, will be included within the Program to minimise the potential for introduction or spread of dieback.

The implementation of the above dieback control strategies prior to and during construction will minimise the potential transfer of dieback into Neerabup National Park as a result of earthmoving operations. The use of appropriate fencing and/or land barriers along each alignment will prevent illegal vehicular access into the Park, thereby minimising the introduction of dieback from this source.

## **Altered hydrology**

Run-off will be captured along the route via drainage sumps at various locations. These sumps can be designed as compensation basins, retaining the runoff and allowing settlement to occur. Best practice drainage design which considers the implications to existing vegetation from both sumps and altered surface hydrology will be used to minimise the impacts of drainage from the roads on the adjacent vegetation. Design of sumps will be undertaken in consultation with Water and Rivers Commission.

### **3.1.6 Proposed Outcome**

Severance of both the north and south linkage between the remnant vegetation in coastal regions and that present within Neerabup National Park is unavoidable; however, the width of the reservation will be minimised at these points as far as possible. The northern linkage is earmarked for future development and therefore impacts to this corridor resulting from the freeway and railway are not considered to be significant.

Vegetation communities lost as a result of clearing for the freeway and railway are considered to be adequately represented in the adjacent Neerabup National Park. The remainder of the

vegetation in Rural areas that will be cleared for construction is not considered to have significant conservation value.

Native vegetation present along the eastern border of the alignment will be protected from potential impacts from building the roads and other edge effects, through the erection of appropriate fencing and implementation of the management measures proposed above. It is considered that construction of the freeway will minimise edge effects currently occurring through restricting the uncontrolled access to the Park on the western edge.

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities" can be met.

## **3.2 System 6**

### **3.2.1 EPA Objective**

Ensure that regionally significant flora and vegetation communities identified in System 6 and draft Perth's Bushplan are adequately protected.

### **3.2.2 Relevant Policies**

The policies detailed in the draft Perth's Bushplan will supersede those of System 6 within the metropolitan area and are most relevant to the proposal.

### **3.2.3 Existing Environment**

#### **Regionally Significant Vegetation**

The first systematic study to identify areas of bushland, landscape and open space of regional significance in the area surrounding and including Perth (commonly referred to as the System 6 report) was completed by the Department of Conservation and Environment (DCE) in 1983. System 6 covered the most intensively used part of the State where land values are high and competition for differing land uses is often intense (EPA, 1994). The System 6 study attempted to define those parts of the region that should be kept mainly natural so as to reserve certain conservation, recreation and landscape values.

Draft Perth's Bushplan (Government of WA, 1998) updates and replaces the System 6 recommendations for the Swan Coastal Plain portion of the Perth Metropolitan Region.

Areas assigned regional significance by the draft Bushplan are those which protect important landscapes, serve a range of recreational pursuits and contribute to the conservation of valuable ecological functions and resources (Government of WA, 1998). The allocation of regional significance also endeavors to protect and retain at least 10% of each original vegetation complex of a region (Government of WA, 1998).

The alignment, including the south western and northern portions of Neerabup National Park through which the alignment passes, is broadly classified as the vegetation complex Cottesloe Complex – Central and South. In evaluating the conservation status of each vegetation complex, draft Perth's Bushplan compared the original area of each complex based on Heddlé *et al* (1980) to the area recorded by the Ministry for Planning as present in Agriculture WA's 1997 aerial photography. Based on this data, 36% of the Cottesloe Complex – Central and South was estimated to remain, with 15% of the original area currently protected (Table 3.4). (Land is classified as protected land if contained within CALM managed land designated for parks or recreation, or crown reserves with a conservation purpose). Moreover it should be noted that this figure of 36% has probably been slightly reduced by urban clearing since the aerial photography on which these estimates are based was conducted.

Table 3.4: Conservation of the Cottesloe Complex (Central & South) Under Bushplan (Government of WA, 1998)

Vegetation Complex	Original Extent (ha)	Extent Remaining		Currently Protected		Proposed protection of complex under Bushplan	
		(ha)	%	(ha)	%	(ha)	%
COTTESLOE - Central & South	34,439	12,362	36%	5,205	15%	6,442	19%

However, within the context of Bushplan's stated objective of a minimum area of 10% preservation, this complex can be regarded as moderately well conserved and certainly far better conserved than many other vegetation assemblages. A deficiency of this approach: however, is that given the broad scale of mapping, each complex contains many different sub units, many of which may not be included within preserved areas.

At a higher level of resolution Gibson *et al* (1994) have also attempted to evaluate both the reservation status (i.e. the amount contained within reserves) and the conservation status (i.e. the vulnerability of the community type to factors such as dieback, clearing etc) of each of the community types recorded within the Swan Coastal Plain Survey. The reservation status and conservation status of the three community types recorded within the alignment area is summarised in Table 3.5.

Table 3.5: Reservation and conservation status of proposal area vegetation

Community types by Gibson <i>et al</i> (1994)	% of alignment	Reservation status	Conservation status
Type 24: Northern Spearwood shrublands and woodlands	52	Well reserved	Susceptible
Affinities to Type 26a: <i>Melaleuca acerosa</i> / <i>M. heugellii</i> shrublands of limestone ridge	<1	Unreserved	Susceptible
Type 28: Spearwood <i>Banksia attenuata</i> or <i>Banksia attenuata</i> / <i>Eucalyptus</i> woodlands	47	Well reserved	Low risk

Due to the minimal occurrence of Mixed Heath within the alignment (which most closely resembles community type 26a, it is probably true to surmise that the vegetation community

types within the project area are ranked as "well reserved"; that is "known from two or more 'A' class National Parks or Nature Reserves". However, a large proportion of the vegetation is regarded as "susceptible", either "because there is evidence it can be modified or destroyed by human activities, or would be vulnerable to new threatening process" (Gibson *et al.*, 1994). This suggests that the loss of regionally significant vegetation necessary for construction of the freeway and railway should not be considered a significant environmental impact, however care should be taken to minimise the impact of construction and edge effects.

Neerabup National Park is classified as a Class A reserve. The classification of a reserve relates to the degree of security against its alienation, change of purpose or area. The purpose, vesting and area of Class A reserves can only be changed by an agreement of both houses of WA Parliament.

The Park is also identified as Bushplan Site No. 383, which will eventually replace System 6 area M6. The western boundary of the National Park provides links to other Bushplan sites. To the south, vegetation surrounding Tamala Waste Disposal Site is Site No. 323, which joins Burns Beach bushland, Site No. 322. To the north, the Park links remnant vegetation within the vicinity of Butler and Jindalee to a coastal strip from Wilbinga to Mindarie, which is classified as Bushplan Site No.397. To the east of the Park is Site No. 384 which encompasses Neerabup Lake (Figure 3.3).

Site No. 323 is recognised in the draft Perth's Bushplan as being part of a regionally significant contiguous bushland linkage between Burns Beach Bushland and Neerabup National Park (Government of WA, 1998).

This linkage, as well as the east-west corridor between Bushplan Site No.397 and the National Park, is identified as a potential 'Greenway' within the *Strategic Plan for Perth's Greenways* (Tingay, Alan & Associates, 1998). The development of the Strategic Plan was guided by a steering committee with representation from Environment Australia, State agencies such as CALM, DEP, Water and Rivers Commission and Main Roads WA, local governments and community groups; and had extensive public involvement and comment. 'Greenways' are defined as a linkage connecting and encompassing conservation areas and landscape features and having conservation, recreation, urban planning and/or aesthetic values (Tingay, Alan & Associates, 1998).

Released as a Final Report at the end of 1998, the *Strategic Plan for Perth's Greenways* builds on and connects areas of remnant vegetation, wetlands and walking trails within the Metropolitan Region. The Strategic Plan is intended to complement draft Perth's Bushplan as well as act as a catalyst for the identification of Greenways at a local level. Priority was given to identifying strategic Greenways that provide:

- east-west corridors which link the coast to freshwater or bushland habitats;
- linkages along foreshore areas;
- linkages between wetlands; and
- linkages between large areas of bushland.

Recommendations of the *Strategic Plan for Perth's Greenways* include protection of Greenways by the WAPC through appropriate zoning, such as Parks and Recreation, in the MRS. Other recommendations are for local governments to identify potential and existing corridors in their structure plans and town planning schemes, and protect them through zoning provisions.

### **Local Significance**

Areas not considered as Bushplan sites may either be cleared or have native vegetation where the structure and floristics have been altered to the extent that the vegetation cannot practically be restored to be representative of the structure and floristics of the natural vegetation (Government of WA, 1998). These areas still retain some conservation value as they provide habitat for some fauna but they are not generally considered prime conservation areas (Government of WA, 1998).

The proposed alignment traverses some areas of remnant vegetation outside the Neerabup National Park, including two small areas of land between Hector Avenue and Lukin Drive and the small areas immediately west of the Park boundary north of Lukin Drive. These areas are rated as excellent under Bushplan's criteria for condition assessment.

#### **3.2.4 Potential Impacts**

Approximately 122 hectares of Neerabup National Park, Bushplan Site No. 383 will be cleared for construction of the proposed extension to the Mitchell Freeway and the Northern Suburbs Rail Line, 31 hectares of which is proposed for the railcar stowage and servicing depot (Proposal 6). The proposed Mitchell Freeway Transportation Corridor will also sever a regionally significant contiguous bushland linkage between remnant vegetation at Burns Beach (Bushplan Site No. 322) and Neerabup National Park, Bushplan Site No. 323. The proposed alignment will also cut a corridor of remnant vegetation to the coastal Bushplan Site No. 397; however, this remnant vegetation is earmarked to be cleared for development in the future.

The construction of the freeway and railway will also potentially impact Neerabup National Park through increased potential for fire, weed invasion and dieback. These potential impacts have been discussed in section 3.1.4.

#### **3.2.5 Proposed Management**

The loss of regionally and locally significant vegetation will be minimised as far as possible. In order to offset the loss of portions of the Neerabup National Park, approximately 622ha of private land and existing Crown Reserves generally situated between the Freeway and Wanneroo Road (Figure 1.1, 2.1) have been reserved, or are proposed to be reserved for Parks and Recreation as part of this Amendment. This would result in a substantial overall increase in the amount of land set aside for conservation purposes, that is planned to be incorporated into the National Park.

### 3.2.6 *Proposed Outcome*

Although it is acknowledged that regionally and locally significant vegetation will be lost as a result of this proposal, it is not considered that this is a significant environmental impact. The vegetation associations that will be cleared are well represented in secure conservation reserves and will be appropriately managed to minimise the potential for modification from disturbance. Given the limited habitat diversity and the widespread occurrence of all the habitat types/vegetation associations, there do not appear to be any features of regional significance within the project area that are not adequately represented in secure conservation reserves.

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "ensure that regionally significant flora and vegetation communities identified in System 6 and draft Perth's Bushplan are adequately protected" can be met.

## 3.3 Declared Rare Flora

### 3.3.1 *EPA Objective*

Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act, 1950*.

### 3.3.2 *Relevant Policies*

*Wildlife Conservation Act, 1950*

### 3.3.3 *Existing Environment*

Declared Rare Flora (DRF) are extant taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction or otherwise in need of special protection.

Priority species are those species not designated DRF yet whose conservation status appears to warrant some special legal protection. The Priority species are maintained on a "Reserve List" and assigned to one of four priority categories.

<b>1: Priority One</b>	Poorly Known Taxa	Taxa which are known from one or a few (generally < 5) populations which are under threat.
<b>2: Priority Two</b>	Poorly Known Taxa.	Taxa which are known from one or a few (generally < 5) populations, at least some of which are not believed to be under immediate threat.
<b>3: Priority Three</b>	Poorly Known Taxa	Taxa which are known from several populations, at least some of which are not believed to be under threat.

**4: Priority Four** Rare Taxa

Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

(From Atkins, (1995).

A search of the CALM Threatened Flora and the Western Australian Herbarium Specimen databases was undertaken for any records of rare flora which may be expected in the region of the proposed Other Regional Roads alignments. Records of three species were retrieved, details of which are as follows:

***Eucalyptus argutifolia* - Declared Rare Flora**

*Eucalyptus argutifolia* is a small mallee. This taxon is known from only a few locations immediately north of Neerabup at Seabird, Wabbling Hill, Parrot Ridge and a single location approximately 8 to 10 km south west of Neerabup. It appears to occur on low hills with a limestone component, and as such Neerabup National Park would appear to contain some areas of favourable habitat.

***Hibbertia spicata* subsp. *leptotheca* - Priority 3**

*Hibbertia spicata* subsp. *leptotheca* is a domed green shrub 30 x 40 cm. The species is known from Yalgorup National Park to Yanchep, and also north to Lancelin. The nearest recording is from Burns Beach, approximately 10 km south-west of the study site. Its soil preference is recorded as grey to black sand over limestone and given the prevalence of *Hibbertia* species in the understorey in Neerabup National Park, its presence within the Park cannot be entirely discounted, particularly as, because of its smaller stature, it could easily be obscured by the very common *Hibbertia hypericoides*. However all previous collections have been recorded from more coastal locations in low coastal heath, a vegetation assemblage which does not occur within the proposed alignment.

***Jacksonia sericea* - Priority 3**

*Jacksonia sericea* is a low, spreading shrub to 0.6 m high. The small orange flowers occur terminally and the pods are ovoid and densely haired. The species is recorded widely within the Perth Metropolitan area and as far south as Mandurah and Pinjarra, on calcareous and sandy soils. It is probably more common than Herbarium and CALM records suggest (Dr. K. Atkins, pers. comm.). It is likely to occur within the Neerabup National Park.

***Acacia benthamii* - Priority 2**

During the survey an additional record of *Acacia benthamii* was recorded at a single location (Site 14) immediately north of Hester Avenue. *A. benthamii* is a shrub to 1 m high, flowering between August to September. New shoots have a woolly hair covering. Previously it has been recorded in Kings Park, Wanneroo and Yanchep. Whilst no additional locations were recorded along the alignment, it is probable that this species is more widespread within the boundaries of the Park. The local distribution of this species needs to be ascertained before the impact of the alignment can be reliably estimated.

### 3.3.4 Potential Impacts

Loss of one population of a Priority 2 taxon, *Acacia benthamii*.

### 3.3.5 Proposed Management

The extent of the population of *Acacia benthamii* within Neerabup National Park beyond the area of the alignment will be determined by the proponent, prior to commencement of site works, to establish the proportion of the population that will be impacted by the development. If the population is found to be significant on advice from CALM, appropriate management measures will be undertaken to the satisfaction of CALM.

### 3.3.6 Proposed Outcome

Given consideration of the above factors and proposed management measures, it is believed that the EPA's objective to "protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act, 1950*" can be met.

## 3.4 Terrestrial Fauna

### 3.4.1 EPA Objective

Maintain the abundance, species diversity and geographical distribution of terrestrial fauna.

### 3.4.2 Relevant Policies

*Wildlife Conservation Act, 1950*

### 3.4.3 Existing Environment

The Swan Coastal Plain bioregion is described by Thackway and Cresswell (1995) as a 'Low lying coastal plain, mainly covered with woodlands. It is dominated by *Banksia* or Tuart on sandy soils, *Allocasuarina obesa* on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. Three phases of marine sand dune development provide relief.' The bioregion predominantly supports Bassian (southern) fauna species combined with some Eyrean (arid zone) and Torresian (northern) elements, resulting in relatively high species richness. The bioregion supports few endemic vertebrate species.

With settlement and development of the bioregion, particularly in the Perth metropolitan area, regional and local extinction of numerous vertebrate species, particularly mammals, has occurred. Habitat clearance and modification, exotic predators, urbanisation, and altered fire regime are thought to have been the main contributing factors to faunal extinctions (Kitchener *et al.*, 1978; Storr *et al.*, 1978). Fauna communities within the study area must now survive within the context of the available habitat types, predator pressure, urban pressure and other

biophysical factors.

To date, fauna surveys undertaken within the area of the Neerabup National Park include the Neerabup National Parks Roads spring and winter biological surveys (*ecologia*, 1996; 1997) and the biological survey of Water Supply Reserve ↑34537 (Burbidge *et al.*, 1993). Several surveys have also been conducted in the wider Northern Swan Coastal Plain encompassing the Park. The largest and most comprehensive of these was undertaken by the Western Australian Museum in 1977-78 as part of a general fauna survey of the Northern Swan Coastal Plain (How, 1978). The study included Neerabup National Park as one of its seven terrestrial survey sites.

The available literature on species ranges, biology and habitat preferences were used to construct expected species lists for the project area (Appendix G). A total of 161 vertebrate fauna species are expected to occur within the project area, the majority of these being native birds, but with significant numbers of reptiles and mammals (Table 3.6). Introduced mammals and birds also occur in the area.

Table 3.6 Number of vertebrate fauna species that potentially occur within the study area.

Vertebrate Group	Number of Species
Native Mammals	18
Introduced Mammals	8
Native Birds	79
Introduced Birds	5
Reptiles	44
Amphibians	7
<b>TOTAL</b>	<b>161</b>

Native mammal species expected to occur within the project area include the Echidna *Tachyglossus aculeatus*, Western Grey Kangaroo *Macropus fuliginosus*, Western Brush Wallaby *Macropus irma*, Honey Possum *Tarsipes rostratus*, Southern Brown Bandicoot *Isodon obesulus*, seven bat species and two native rodents. Introduced mammal species include the Black Rat *Rattus rattus*, Fox *Vulpes vulpes*, Feral Cat *Felis catus*, House Mouse *Mus musculus* and Rabbit *Oryctolagus cuniculus*.

It is expected that approximately 79 native bird species may occur in the project area, including 45 passerines and 34 non-passerines. Passerines predominate because there are no wetland areas that generally support the non-passerine waterbirds. Families represented by numerous species include the raptors (Accipitridae and Falconidae), thornbills and allies (Pardalotidae), and the honeyeaters (Meliphagidae) (Appendix G). Five introduced bird species are expected to occur, these are predominantly doves but include also the Rainbow Lorikeet *Trichoglossus haematodus* and Laughing Kookaburra *Dacelo novaeguineae*.

Seven amphibian species and 44 reptile species including 32 lizards and 12 snakes are expected to occur in the project area. Frog species include the burrowing species Moaning

Frog *Heleioporus eyrei* and the unusual Turtle Frog *Myobatrachus gouldii*, and the widely ranging Motorbike Frog *Litoria moorei*. Lizard species include representatives of five families, the geckos, legless lizards, dragons, monitors and skinks. Common species include the Bobtail *Tiliqua rugosa*, Fence Skink *Cryptoblepharus plagiocephalus* and Marbled Gecko *Christinus marmoratus*. The coastal heaths and sandplains of the Swan Coastal Plain support a particularly rich reptile fauna. Snakes include common species such as the Dugite *Pseudonaja affinis* and Tiger Snake *Notechis scutatus*, and the uncommon Bardick *Echiopsis curta*.

Fauna habitats correspond closely to the vegetation associations described for the study area, but are generally broader and incorporate several associations. Fauna habitats for the area are Tuart Forest, Low Shrublands, Jarrah Woodland, and *Banksia* Woodland (Figure 3.4).

Tuart *Eucalyptus gomphocephala* forest occurs throughout the eastern half of the proposed Neerabup Road alignment and includes areas with varied understorey with a variety of understorey species including Grass Tree *Xanthorrhoea pressii* and Prickly Moses *Acacia pulchella*. The condition of the vegetation varied from significantly impacted to relatively good condition. The Tuart forest supports numerous passerine bird species including Striated Pardalote *Pardalotus striatus* that call from the canopy, parrots that feed on the Tuart nuts, Grey Fantail *Rhipidura fuliginosa* and honeyeaters. Tuarts also provide hollows for the Brushtail Possum *Trichosurus vulpecula*. Leaf litter beneath the trees provides suitable microhabitats for skinks and geckos.

Low Shrublands occurring in or near the Neerabup Road and Hester Avenue alignment areas are generally dominated by Parrot Bush *Dryandra sessilis* although these proteaceous shrublands support numerous plant species from the families proteaceae, myrtaceae, fabaceae, epacridaceae and others. Within the study area this habitat type occurs on shallow soils over limestone and includes a generally dense overstorey of *D. sessilis* and *Jacksonia sternbergiana* over a moderately dense lower shrub strata, with a variety of herbs and climbers. These densely vegetated areas support the Southern Brown Bandicoot *Isodon obesulus* and the nectivorous Honey Possum *Tarsipes rostratus*. Honeyeaters forage amongst the blossoms and also search for insects, and small passerine birds are abundant. Crevices in the limestone and abundant leaf litter support a variety of reptile species, but few frogs occur due to the impervious nature of the substrate.

Jarrah *Eucalyptus marginata* Woodland occurs patchily in the study area and much of the understorey within this habitat type is degraded. This habitat is characterised by sparse to open *E. marginata* over a sparse but relatively diverse shrub understorey including Grass Tree *Xanthorrhoea pressii*, *Acacia saligna* and *Hibbertia hypericoides* over a sparse low shrub stratum. These open areas are utilised by the Western Grey Kangaroo *Macropus fuliginosus* and microchiropteran bat species. Small passerine birds, parrots such as the Ringneck *Barnardius zonarius*, Rufous Whistler *Pachycephala rufiventris* and the Brown Goshawk *Accipiter fasciatus* are typical inhabitants of these areas. Leaf and bark litter provide refuge and foraging areas for lizard and snake species.

*Banksia* Woodland habitat in the study area is dominated by *Banksia attenuata* with the co-dominant species being either *B. menziesii* or *Allocasuarina fraseriana* with considerable variation in the species composition of the understorey. *Banksia* Woodland habitat supports the Western Grey Kangaroo *Macropus fuliginosus*, Scarlet Robin *Petroica multicolor*, Brown Honeyeater *Lichmera indistincta*, skinks, geckos and legless lizards, and burrowing frog species including the Moaning Frog *Heleioporus eyrei*.

#### 3.4.4 Potential Impacts

Potential impacts to fauna arising from the proposed freeway and railway include:

- loss and degradation of fauna habitat through native vegetation clearance;
- habitat fragmentation and disruption of fauna populations;
- barriers to fauna movement;
- road fauna deaths; and
- competition and predation by introduced fauna.

#### Loss and Degradation of Fauna Habitat

Vertebrate species richness and diversity is related to the diversity, species richness and condition of the vegetation of an area. Plants provide food resources in the form of nectar, leaves, buds and nuts, and support insects that are prey for animals higher in food chains. Plants also provide cover under bark and contribute to leaf litter, and are often roosting sites for birds. Hollows in limbs are used for nesting and shelter. Loss and degradation of vegetation communities will have ramifications for the fauna of these areas.

Clearance of vegetation may result in the direct loss of fauna habitat. Impacts to fauna include loss and degradation of habitat and essential resources such as cover and feeding areas. Habitat degradation has the potential to occur through factors associated with the road construction and presence of the proposed east-west connecting roads such as dust, introduction of weeds and feral fauna species and changes to ground and surface water movements. Direct mortality of fauna may also occur during initial clearing activities, particularly of less mobile ground dwelling species such as reptiles.

#### Habitat Fragmentation and Barriers to Movement

The proposed freeway and railway, once constructed will serve as an effective barrier to ground dwelling fauna movement between the remnant vegetation areas of Neerabup National Park and the coast. This has short-term ramifications for existing fauna, such as access to mates, food, water and shelter and longer-term (primarily genetic) ramifications. In addition, habitat fragmentation also increases edge effects such as increased exotic predator species and weed infestation.

Bushland corridors provide linkages between isolated fragments thereby facilitating the movement of individuals between communities. Connection of divided populations is important since it facilitates exchange of genetic material, permits social interactions between otherwise isolated individuals and populations, and maintains community structure and

integrity. However, these corridors may also provide an access route for exotic fauna including predatory species such as the Fox *Vulpes vulpes*, the Feral Cat *Felis catus* and other species that compete with native fauna such as the House Mouse *Mus musculus*.

The vegetation in the existing east-west corridor between Burns Beach and Neerabup National Park is of relatively poor condition, and the degree to which fauna utilise the corridor is unknown.

Species with larger home ranges will tend to be disadvantaged to a higher degree by habitat fragmentation and reduction in the area of suitable habitat. Generally speaking larger ground dwelling fauna species will have larger home ranges since they require greater quantities of resources, particularly food, but most small mammals move considerable distances in the course of nocturnal foraging. Studies on kangaroos in the wheatbelt indicate that they occupy home ranges from 60 - 200 ha, depending on habitat quality and sex (Arnold, 1990). Arnold (1990) found that as patch size increased absolute kangaroo abundance and the density of animals per hectare increased. Data on kangaroos on the Swan Coastal Plain is not available. Kangaroos demonstrated high fidelity to home ranges, and this is the case also for species such as the Bandicoot *Isoodon obesulus*, which can maintain populations only where there are suitable areas of dense vegetation. Reptile species such as the Bobtail *Tiliqua rugosa* have home ranges that may extend for several hectares, and snakes must move considerable distances in the mating season in order to locate mates.

Within the area of the proposed alignment, individuals whose home range is bisected by the alignment will be affected as will species that must move over greater distances in the breeding season. In most cases individuals with decreased area for movement will relocate or "spill over" into adjacent habitats, where their survival will depend on factors such as food availability, habitat space and predation pressure.

The proposed Freeway and railway will have a less significant direct impact on bird populations because of their ability to move between suitable habitats. Birds will generally cross barriers but this will depend on the species. If the availability of suitable habitats has decreased as a result of fragmentation, then the impact of this will be felt by the bird populations of the region regardless of their ability to move between areas, and populations will decline in numbers. Ultimately any population that is too small to maintain sufficient numbers for breeding will become locally extinct.

### Road Fauna Deaths

Increased road fauna deaths are likely to occur in areas where new roads are constructed, particularly affecting large macropods, nocturnal birds and mobile ground dwelling fauna. The wetter edges of the roads may also result in a higher diversity of grasses and weeds, which in turn attract herbivores such as kangaroos to the road edges.

### **3.4.5 Proposed Management**

#### **Loss and Degradation of Fauna Habitat**

The loss and degradation of fauna habitat will be minimised as far as possible. Clearing of vegetation and habitat will be minimised by limiting clearing to that which is absolutely essential through the demarcation by the proponent of a limit-of-works prior to commencement of site works. The amount of fauna habitat to be cleared will follow the detailed design and construction plans (yet to be developed). Ultimate clearing boundaries will be well defined in the field and staff will be educated as to the importance of adhering to these limits.

Rehabilitation and revegetation of the area in the vicinity of the freeway and railway will be undertaken by the proponent as soon as the roads have been constructed. Plant species native to the area will be used in revegetation procedures as these areas may then be utilised by fauna.

#### **Habitat Fragmentation and Barriers to Movement**

The original Amendment proposed to locate the rail car depot (Proposal 6) between Burns Beach Road and Neerabup Road. This design has recently been modified at the suggestion of the Department of Environmental Protection (DEP) and the depot is now proposed to be located between Hester Avenue and Lukin Drive. This relocation will effectively reduce the width of the alignment in the vicinity of Tamala Park from around 250 metres to almost 100 metres, thus minimising the degree of severance of the southern fauna corridor or east-west linkage.

Fauna underpasses may be useful in situations where they join areas of suitable habitat divided by roads. Access via underpasses potentially facilitates the maintenance of the integrity of local populations; however, sufficient data is lacking to enable judgement on the effectiveness of their use.

It is recommended that underpasses be of two types:

- (i) 3 m x 3 m box culverts, for large fauna such as kangaroos; and
- (ii) 300 mm diameter concrete pipes, for small fauna such as bobtail lizards and possums.

The usage of these types of underpasses addresses three areas of concern:

- (i) the lack of currently available knowledge of the optimal underpass design;
- (ii) the constraints imposed by the proposed road design in areas with limited fill requirements; and
- (iii) the requirement for large fauna, such as kangaroos, to maintain movement patterns.

The placement of the fauna underpasses will be determined by the constraints of the desired road design, and by an assessment of animal movements. The larger culvert fauna underpasses should be located in areas of maximal fill requirement or where topography allows. The lack of sufficient fill requirements due to topography prohibits the greater use of

culvert underpasses.

Underpass length shall be the minimum possible consistent with safe road design practices. The objective is to install culverts of minimum length to encourage utilisation. While kangaroos and other medium size fauna such as echidnas are highly mobile it is widely acknowledged that the longer the underpass, the lower the level of utilisation. Culvert underpasses require a base to be constructed from earth and rock fill to provide a natural substrate. Vegetation debris, rocks and small logs will be placed within the culvert, both on the base and the raised bench, to provide shelter from predators and a more secure natural passageway.

Smaller fauna underpasses constructed from 300mm diameter concrete pipes may be required on each alignment. Pipe underpass length will be the minimum possible consistent with safe road design practices. The pipes will be raised 20 cm above the general level of the surrounding terrain. The raised position and associated access ramps allows small fauna utilisation of the underpass during periods of seasonal inundation. A length of 50 cm of pipe will be left protruding at each end. The protruding pipe ends should be positioned on a raised earth embankment with a 1:6 slope for the access ramps on all three sides.

The Kwinana Freeway underpass study undertaken by *ecologia* (1995) is one of the few studies addressing the utilisation of these structures by fauna. The *ecologia* study indicated that underpass entrances were often frequented by fauna; however, few animals proceeded along the underpass beyond 1 to 2 m from the tunnel entrance. Four fauna species were found to use the underpasses during the period of the study, the Southern Brown Bandicoot *Isoodon obesulus*, Gould's monitor *Varanus gouldii*, the Bobtail *Tiliqua rugosa* and the Feral Cat *Felis catus* (*ecologia*, 1995). The Feral Cat was the only species that used the underpass regularly.

The potential for fauna underpasses on the alignment will be investigated by the proponent in consultation with CALM and the DEP prior to the detailed design phase of the freeway or railway. Underpasses will be installed where appropriate, as determined by further investigation and engineering capability.

### **Road Fauna Deaths**

The construction and use of the freeway and railway may increase road deaths and vehicle damage. In order to minimise impacts to local fauna populations, appropriate measures will be used to restrict fauna access into hazardous areas. Safe access between the remaining habitat patches on either side of the new alignments will be facilitated through installation of fauna underpasses.

The proponent will be responsible for surrounding the area of the alignment with exclusion fencing prior to construction, to the satisfaction of the local government. The fencing material will prevent passage of large and medium sized fauna. Fencing material similar to "ringlock" is adequate. The fence will be of a minimum erected height of 1.8 m, with a 90 cm angled strip at the top and a 1.5m apron at the base covered by soil 1 m deep. The apron will

be placed on the exterior side of the impact zone to prevent animals digging under the fence and entering the impact zone.

Exclusion fencing will be erected on both sides of the impact zone of the alignment. The fencing will be placed as close as possible to the road reserve boundary, and no more than 15m distant from the area of direct impact from construction activities. The objective is to encompass the minimum necessary impact zone area. Temporary fencing will enclose the ends of the impact zone to prevent access by fauna during construction.

The use of lighting along the freeway may assist in the reduction of road deaths of nocturnal terrestrial fauna species. Bright lighting would be expected to deter nocturnal species such as kangaroos and possums. It is unlikely that many species, with the exception of insectivorous bats and geckos, would be attracted to the lights. Lights would also aid drivers in seeing animals on the road.

### **Competition and Predation by Introduced Fauna**

In evaluating the potential for installation of fauna underpasses, consideration will be given to the potential for increased competition and predation by introduced fauna, as the *ecologia* study on utilisation suggested that the Feral Cat was the only species that used the underpasses regularly (*ecologia*, 1995).

If installed, monitoring fauna usage of the underpasses will be undertaken by the proponent to the satisfaction of CALM in order to collect a rigorous dataset with which to evaluate their effectiveness. The monitoring data will be used to modify underpass design if necessary and aid in the development of appropriate underpass designs that maximise fauna use and effectiveness.

### **3.4.6 Proposed Outcome**

Vegetation clearance during construction of the proposed freeway and railway and the impact of habitat fragmentation and barriers to fauna movement may result in the loss of individuals and fauna populations. This impact is not anticipated to be significant; however, as the majority of Neerabup National Park will remain intact and undisturbed. The areas of habitat proposed to be cleared for construction of the roads are considered to be adequately represented in the Neerabup National Park. In addition, revegetation and rehabilitation of areas in the vicinity of the alignment may provide additional resources or habitat for fauna.

It is acknowledged that the proposed Mitchell Freeway Transportation Corridor will sever both fauna corridors currently existing between Neerabup National Park and the Burns Beach Bushland and fauna habitat in Jindalee and Butler. This impact is not considered to be significant; however, due to the proposed future development of the northern corridor and the minimisation of the width of the alignment in the vicinity of the southern corridor resulting from relocation of the rail car depot (see environmental review for Proposal 6). In addition, techniques such as fauna underpasses and the erection of exclusion fencing will be

incorporated into the road design to facilitate fauna movement and to minimise the incidence of road fauna deaths. The installation of fauna underpasses adjacent to Tamala Park will help to maintain the east-west linkage between Neerabup National Park and the coast.

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "maintain the abundance, species diversity and geographical distribution of terrestrial fauna" can be met.

### 3.5 Subterranean Fauna

#### 3.5.1 EPA Objectives

- Maintain the abundance, species diversity and geographical distribution of subterranean fauna.
- Protect stygofauna, consistent with the provisions of the *Wildlife Conservation Act, 1950* and maintain the abundance, species diversity and geographic distribution of stygofauna.

#### 3.5.2 Relevant Policies

*Wildlife Conservation Act, 1950*

#### 3.5.3 Existing Environment

Subterranean fauna are principally invertebrates that dwell in subterranean habitats such as caves. Stygobites and troglobites are respectively the obligate aquatic and terrestrial components of subterranean fauna. Stygobites are found in groundwater and aquatic environments within caves, whereas troglobites occur exclusively in cave systems. Both stygobites and troglobites complete their entire life cycle underground and are totally dependent on these environments for their survival (EPA, 1997).

The term stygofauna is used to refer to aquatic subterranean dwelling fauna. The fauna dwelling in stygal habitats can be classified into a number of ecological categories depending on their degree of association and dependence upon the subterranean realm. Some species dwelling in stygal habitats may also occur in aquatic habitats elsewhere - these species are termed stygophiles. Some species spend only a part of their life cycle in stygal habitats, such as the aquatic larval or nymphal stages of certain insects which burrow into the sediments of surface water bodies but periodically return to surface waters to gather food, or to metamorphose into the adult form. These species are termed stygoxenes. Some species occur accidentally in the subterranean realm, such as those carried into caves by sinking streams for instance - these species are termed accidentals. The final ecological category are species which have an obligate dependence on stygal habitats for their survival. These species are termed stygobites.

Stygobites spend their whole life cycle underground and they have limited powers of dispersal

through surface waters. They typically have a restricted distribution, often being confined to a single cave system, or small part of an aquifer.

Stygobites display characteristic morphological specialisations to a subterranean existence, including a reduction or complete loss of body pigment and eyes. To compensate for the absence of vision, stygobites have evolved longer antennae and appendages, and other non-optic sensory organs may be enhanced, such as sensory hairs and sense of smell. Their bodies may become elongate or vermiform to enable them to move through minute pores between grains of sand.

Food supplies in subterranean waters are often limited, so underground habitats support comparatively few individuals compared with surface waters. Thus stygobites are rare animals which are difficult to collect and many are known from only a few specimens.

The term stygofauna is used throughout this report to refer to stygobites in the strict ecological sense, viz. subterranean aquatic fauna showing clear morphological specialisations to a subterranean existence.

The Australian stygofauna, like those elsewhere, is dominated by *Crustacea*, but gastropod molluscs, water mites, turbellarians, and fish are also present. The *Crustacea* are represented by a number of major groups including *Ostracoda* (including *Halocyprida*), *Copepoda* (especially cyclopoids and harpacticoids), *Remipedia*, *Mystacocarida* (marine interstitial only), *Synsacarida* (both *Anaspidacea* and *Bathynellacea*), *Isopoda* (*Phreatoicidea*, *Asellota*, *Flabellifera*), *Spelaeogriphacea*, *Amphipoda* (including crangonyctoids, melitids and hadziids), *Thermosbaenacea* and *Decapoda* (especially *Atyidae*) (eg., Poore and Humphreys, 1992, in press; Eberhard and Spate, 1995; Yager and Humphreys, 1996; Bradbury and Williams, 1997; Humphreys, in press, submitted).

An assessment of the likelihood of subterranean fauna being present within the area of Proposal 5 was undertaken. The assessment has two objectives;

- to establish the potential of the area to support troglodytic fauna. - The presence of troglodytic fauna depends on there being a cave deep enough, and with a permanently dark chamber, to have a limited connection with the surface; and
- to establish the potential of the area to support stygofauna. - If there is a conduit of the Gngara Mound underlying the area then stygofauna may be present. Since the flow of the aquifer is essentially radial, then it is likely that at least one conduit will be crossed. If there are no tree roots lining the conduit then the fauna diversity will be very low. Should two or more conduits be crossed it may be expected that the fauna in each will not show 100% congruence of species diversity.

### Troglodytic Fauna

An assessment of the likelihood of cave formation and hence the potential presence of troglodytic fauna was made using geological mapping, aerial photographs and site inspection

by foot. The area of Proposal 5 was examined for the presence of Tamala limestone outcrops. While there are numerous outcroppings of Tamala limestone, none are massive enough to indicate the presence of a cave. Tuart *Eucalyptus gomphocephala* trees are often associated with cave streams at Yanchep (Jasinska *et al.*, 1996; Jasinska & Knott, 1991; Jasinska, 1990). Whilst there are considerable stands of Tuarts in some locations, no cave entrances were located.

Historically there have been no records of caves in the area despite long term extensive human visitation and use (Knott, *pers comm.*).

The survey did not reveal any surface evidence of caves. However it is possible that caves without openings to the surface may exist though the likelihood is low based upon the karst landform assessment (Section 4.8). If any existed there would have to be some means of access to harbour a fauna.

### Stygofauna

Three bores are located within the area of Proposal 5 that may be sampled for stygofauna. Historically, a further four bores have been drilled in the area but are now abandoned with casings filled and are not able to be sampled (Table 3.7).

Table 3.7: Groundwater bores located in the proposal area.

Site ID	Easting	Northing	Bore Name	Status
2034-4-SE-0061	380051	6492838	Joondalup No 3A	Active
2034-4-SE-0074	380101	6493701	Artesian Monitoring 23	Active
2034-4-SE-0075	380102	6493701	Artesian Monitoring 23A	Active
2034-4-SW-0001	382244	6492862	Army F9	Abandoned, casing filled.
2034-4-SE-0062	380051	6492838	Joondalup No 3B	Abandoned, casing filled.
2034-4-SE-0064	380050	6492838	Joondalup No 3D	Abandoned, casing filled.
2034-4-SE-0143	379172	6495749	Cnr Merriwa Blvd & Tuross	Abandoned, casing filled.

Bores were sampled for fauna using a bailer to extract 10L of water from each bore and sieved using a plankton net with a mesh size of 106µm. This is the standard technique which has been used in other stygofauna surveys (eg. Humphreys, 1994). The material is washed using *in situ* water into a vial and transported to the laboratory and examined for fauna under a binocular dissecting microscope.

Bore Joondalup No 3A was not able to be located in the field. Bores Artesian Monitoring 23 and Bores Artesian Monitoring 23A were sampled. In addition two further bores, TPL 1A and TPL1B, located at the entrance to Tamala Park waste site were also sampled to provide more regional information.

No stygofaunal or aquatic organisms were found in any of the four samples. Collembolans occurred in two samples but these are terrestrial forms and may have been picked up

incidentally from the surface whilst the bores were being sampled. All samples yielded some debris but none of this material appeared to be faecal and no animal remains were evident. Although animals in groundwater are typically low in abundance, where they are present at least one or more specimens are usually recorded from a 10 L volume (Dr B. Knott, UWA, *pers. comm.*).

If stygofauna do exist in this area it must be in very low abundance. This is likely due to the depth of the water table, which is probably below the depth to which plant roots may commonly reach.

#### **3.5.4 Potential Impacts**

Impacts from construction activities may impact underground cave systems, which, in turn, may impact the habitat and ecosystem of subterranean fauna. Any changes to groundwater quantity or quality also has the potential to modify habitat and food sources of subterranean fauna as lowering of the water table has the potential to deprive stygofauna of water and or impact preferred root mat habitat (Jasinska *et al*, 1996).

The construction of the freeway and railway may impact groundwater quality. Without the provision of specific drainage structures, road/rail run-off and contaminant spills from road accidents or during construction may discharge into the soil and infiltrate into the groundwater. Run-off consists largely of hydrocarbons and heavy metals that are deposited on the road through traffic movement and then washed off following rain events.

In areas of cut where Tamala limestone occurs there is the potential to open hidden karst or cave landforms to the surface. Impact to these environments would be severely detrimental to troglodytic fauna on a local scale.

#### **3.5.5 Proposed Management**

As no evidence of caves was discovered in the proposal area and the proposal is unlikely to impact groundwater (see Section 3.9), it is unlikely that the construction of the freeway and railway will impact subterranean fauna. However, extensive geotechnical investigations will be required during the detailed design stage for both the rail line and freeway. These investigations, including drilling, will take place prior to construction and reveal the presence, if any occur, of any hidden karst or cave formations in the development area. If the presence of a cave is discovered, CALM will be notified and the appropriate actions undertaken to the satisfaction of CALM in consultation with the DEP.

The proponent will also ensure that care is taken during clearing for construction through the development of a Construction Management Plan. This will include investigation for the presence of subterranean fauna within any cave or karst landforms encountered in areas cleared or cut during construction. Should any subterranean fauna be found, an appropriate management plan will be developed in consultation with the DEP and CALM.

In addition, best practice drainage design will be utilised by the proponent to control potential impacts to the groundwater through as detailed in the Construction Management Plan. This is outlined in further detail in Section 4.2.

### 3.5.6 Proposed Outcome

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to "maintain the abundance, species diversity and geographical distribution of subterranean fauna including stygofauna and protect stygofauna, consistent with the provisions of the *Wildlife Conservation Act, 1950*" can be met.

## 3.6 Specially Protected (Threatened) Fauna

### 3.6.1 EPA Objective

Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*.

### 3.6.2 Relevant Policies

*Wildlife Conservation Act, 1950*

### 3.6.3 Existing Environment

As previously mentioned, many fauna studies have been undertaken in the North West Corridor, including the Neerabup National Park and the proposal area (Burbidge *et al.*, 1993; *ecologia*, 1997; How, 1978; Kinhill Stearns, 1983; Kitchener *et al.*, 1978).

Specially Protected (Threatened) Fauna represents fauna that is recognised as needing protection for various reasons. Fauna species that have been formally recognised as rare, threatened with extinction or as having high conservation value are protected by law under the Western Australian *Wildlife Conservation Act 1950*. Other species, recognised as needing protection generally due to declining or limited population sizes of those whose habitat is under threat, may be listed by CALM or recommended for protection through international agreements.

### Scheduled Species

Classification of rare and endangered fauna under the WA Wildlife Conservation (Specially Protected Fauna) Notice 1998 recognises four distinct schedules of taxa that are declared to be fauna in need of special protection. These are described below.

**Schedule 1** Fauna which is rare or likely to become extinct

**Schedule 2** Fauna which is presumed to be extinct

- Schedule 3** birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction
- Schedule 4** fauna in need of special protection, otherwise than for the reasons mentioned above.

Two Schedule 1 species potentially occur in the proposed road alignments. They are the Chuditch, *Dasyurus geoffroii*, and Carnaby's Cockatoo, *Calyptorhynchus latirostris* (ecologia, 1997; Kitchener *et al.*, 1978).

The Chuditch is a medium sized predator feeding on a variety of birds, mammals, insects and carrion (Strahan, 1983). It lives on the ground, climbs well and inhabits burrows. The Chuditch is generally uncommon throughout its range and is unlikely to be encountered, possibly extinct, in the project area. The last reported sighting in the Wanneroo region was at Yanchep National Park in 1972 (Kitchener *et al.*, 1978).

Carnaby's Cockatoo was recorded at Lake Jandabup in April 1993 (M. Craig, pers. comm.), Lake Gnangara (G. Little, pers. comm.) and adjacent to Neerabup National Park (ecologia, 1997). It undoubtedly occurs throughout the area, especially where stands of the introduced pines *Pinus pinaster* and *Pinus radiata* occur. This species is expected to occur in *Banksia* Woodland and Jarrah Woodland habitats.

Despite their apparently high numbers on the Swan Coastal Plain, particularly in areas such as nearby Yanchep National Park, Carnaby's Cockatoo is a threatened species since it is endemic to the south-west region and restricted to a small area within the south-west. Breeding areas in the wheatbelt have been greatly depleted as a result of vegetation clearance for agriculture. CALM guidelines for management of the area take into account the need to protect habitat such as nesting hollows and maintain unburned areas of limestone heathland as food sources for cockatoos through a mosaic (patch) burning system. Marri (*Eucalyptus calophylla*), is also a preferred habitat of the cockatoo and it is present in scattered patches within the study area.

Based on available literature on species ranges, biology and habitat preferences, no Schedule 2 species are expected to occur in the proposed road alignments. No Schedule 3 species are expected to occur either as there are no suitable wetland areas in the proposal area.

Two Schedule 4 species potentially occur in the proposed road alignments (Storr, Johnstone & Harold, 1978). These are the Peregrine Falcon, *Falco peregrinus* and the Carpet Python *Morelia spilota imbricata* (Kinhill Stearns, 1983).

The Peregrine Falcon is uncommon but widespread throughout Australia. It is a scarce visitor from January to May to the entire northern Swan Coastal Plain (Storr, Johnstone & Harold, 1978). It is nomadic, sedentary or partly so, and prefers coastal or inland cliffs and gorges, timbered watercourses, plains and open woodlands. Sightings of this species in the area have been made previously at Mindarie (Kinhill Stearns, 1983). The Peregrine Falcon is likely to occur in the area but should not be greatly affected by the proposed roads since it is a widely foraging species.

The southern subspecies of the Carpet Python, *M. spilota imbricata*, is widespread but uncommon in south-west Western Australia. This python is a semi-arboreal species that is most frequently recorded in woodland and forest areas where it seeks shelter in hollow logs. It feeds on small to medium sized mammals and lizards both in the trees and on the ground. This species has been recorded from Neerabup National Park and may occur in the project area.

### Priority Species

Threatened fauna species that are not specifically covered by the WA *Wildlife Conservation Act* are listed under four priority codes designated by CALM. The definition of these codes is outlined below.

<b>Priority 1</b>	Taxa with few, poorly known populations on threatened lands	Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
<b>Priority 2</b>	Taxa with few, poorly known populations on conservation lands	Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
<b>Priority 3</b>	Taxa with several, poorly known populations, some on conservation lands	Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
<b>Priority 4</b>	Taxa in need of monitoring	Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.

Two Priority 4 species potentially occur in the project area (Strahan, 1995). These are the Southern Brown Bandicoot, *Isodon obesulus*, and the Western Brush Wallaby *Macropus irma*.

The Southern Brown Bandicoot occurs in dense vegetation near wetlands. It is recorded widely but sporadically throughout the northern Swan Coastal Plain from Perth to Moore River (*ecologia*, 1997).

Since European settlement, the Southern Brown Bandicoot has undergone a range contraction which is largely the result of land clearance and introduced predators such as the fox (Strahan, 1995). The species prefers scrubby habitats or areas with low ground cover that are burnt

relatively frequently as this promotes an abundant supply of insect food. The Southern Brown Bandicoot is a nocturnal mammal which prefers to stay close to cover when searching for food. With its powerful foreclaws it digs small conical burrows in search of earth worms and other invertebrates. It may also eat fungus and other subterranean plant matter. By day the Southern Brown Bandicoot sleeps in nests constructed from grass and other plant material. Once a juvenile reaches maturity its survival depends on possession and defence of an adequate home range, the size of which may be as large as seven hectares. Only in times of plentiful food supply will territories overlap (Strahan, 1995).

The Neerabup National Park Roads Study (*ecologia*, 1997) failed to locate any evidence of populations of the Southern Brown Bandicoot, however individuals have been recorded previously in the Wanneroo area in 1993 and 1994. A CALM Bandicoot database search revealed no records of the species from within Neerabup National Park, however a sighting was recorded in the bushland adjacent to the study area, in Bushplan site #323. (T. Friend, pers. comm)

The Western Brush Wallaby, *Macropus irma*, is endemic to the south-west of Western Australia and is an uncommon species on the Swan Coastal Plain. It is a medium sized macropod that generally favours open forest or woodland that provide suitable grazing areas with adjacent scrubby areas for daytime shelter. Brush Wallaby juveniles are thought to be susceptible to predation by foxes and this may have led to a decline in populations in certain parts of the state (Strahan, 1995).

This species has been recorded from the Burns Beach bushland and from Neerabup National Park and is likely to occur in the project area.

### Special Agreements

A range of migratory species are protected under international agreements, specifically the Japan Australia and China Australia Migratory Bird Agreements (JAMBA and CAMBA). Within the project area, the only species that potentially occurs is the Fork-tailed Swift *Apus pacificus*, since the majority of species protected under these agreements utilise wetlands and there are no suitable habitats within the area. The Fork-tailed Swift is a visitor that rarely penetrates into the south-west and is unlikely to be affected by the proposed development.

### Other Species of Interest

Two species, the White-breasted Robin, *Eopsaltria georgiana* and the Honey Possum, *Tarsipes rostratus*, whilst not listed within the Wildlife Conservation (Specially Protected Fauna) Notice, are considered to be of local significance due to restricted distributions.

The White-breasted Robin is known from parts of the south coast through to the Darling Range north to Canning Dam (Storr, 1988) with occasional sightings further north at Bickley. There is also an isolated population from Lancelin to near Geraldton. In recent years it has only been found on the Swan Coastal Plain near Harvey and Busselton (Burbidge *et al.* 1993).

- \* White-browed Scrubwren *Sericornis frontalis*
- \* Splendid Fairy-wren *Malurus splendens*
- White-winged Fairy-wren *Malurus leucopterus*
- \* Scarlet Robin *Petroica multicolor*
- Hooded Robin *Melanodryas cucullata*
- \* Golden Whistler *Pachycephala pectoralis*
- \* Grey Shrike-thrush *Colluricincla harmonica*

### 3.6.4 Potential Impacts

Potential impacts to threatened fauna are similar to those affecting terrestrial fauna generally and have been described previously. They include:

- loss and degradation of habitat that supports threatened fauna;
- habitat fragmentation and disruption of threatened fauna populations; and
- loss of local populations of threatened fauna.

Loss of habitat is particularly detrimental to fauna species that have specific habitat requirements. Details of habitat requirements for scheduled and priority species are listed here since impacts to these areas are most likely to affect threatened fauna.

Eucalypts, particularly Jarrah *Eucalyptus marginata*, Marri *E. calophylla* and Tuart *E. gomphocephala* provide shelter, roosting and foraging areas for Carnaby's Cockatoo and are therefore vital for their continued survival. Limestone heathland (Low Shrubland habitat) also provides food sources for this species. The Chuditch, the other Schedule 1 species, prefers Eucalypt woodlands, but is likely to be locally extinct in the area.

The schedule 4 species, the Peregrine Falcon is likely to utilise open woodland habitats and the Carpet Python requires suitable shelter sites, usually in the form of hollow logs or under thick bushes.

The Southern Brown Bandicoot, a priority 4 species, prefers scrubby habitats or areas with low ground cover. On the Swan Coastal Plain it prefers vegetation fringing swamps and dense thickets including *Dryandra sessilis* and heath associations. The Western Brush Wallaby generally favours open forest or woodland.

Consideration of these habitat preferences suggests that Eucalypt woodlands, particularly with mature trees, and Low Shrubland habitat with dense vegetation are the primary habitat types likely to be utilised by threatened fauna. Both of these habitat types represent the majority of vegetation within the proposed alignment (Figure 3.4) and therefore approximately 90 hectares of potential threatened fauna habitat is proposed to be cleared as a result of this proposal.

### 3.6.5 Proposed Management

Significant vegetation associations and fauna habitats required by threatened fauna species

will be retained where possible. As outlined above, these include Eucalypt woodlands and Low Shrubland habitat.

Areas to be cleared shall be clearly demarcated by the proponent prior to commencement of site works and individual trees retained where possible following MRWA Specification No. 204 Environmental Management Requirements and the 300 Series regarding Earthworks.

A targeted fauna survey for scheduled and priority fauna species shall be undertaken by the proponent along the proposed alignments prior to commencement of any site works to the satisfaction of CALM. This survey will delineate usage of sites within the project area by rare fauna. Individuals will be relocated if their ranges lie within or overlap the area of the proposed alignment.

### **3.6.6 Proposed Outcome**

The loss and degradation of fauna habitats that support rare fauna species will be kept to a minimum, although it is recognised that these habitats are adequately represented within the Neerabup National Park.

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*" can be met.

## **3.7 Underground Wetlands**

### **3.7.1 EPA Objective**

Maintain the integrity, functions and environmental values of underground wetlands.

### **3.7.2 Existing Environment**

Underground wetlands, often referred to as 'karst wetlands', are identified in the Wetland Classification System (Commonwealth of Australia, 1996) as 'inland, subterranean karst wetlands'. In general, underground wetlands are formed where groundwater intersects karst. Karstic terrain is often host to subterranean fauna including terrestrial and aquatic (stygo fauna) species. Known populations of stygo fauna are located in Yanchep National Park, over 5km north of the northernmost portion of the Freeway extension. These fauna are highly specialised to living in subterranean conditions. As previously mentioned, studies conducted in the Yanchep National Park observed that stygo fauna have been found generally where a substantial root mat exists within the karst. Such mats provide a constant and abundant primary food source for the micro-ecosystems and generally occur only where Tuart Woodlands coincide with karstic formations (Jasinska, 1997). Dr Brenton Knott (UWA, Zoology Department), an expert on stygo fauna, also provided comment that in the Yanchep National Park, the connection between many of the cave streams and surface water is likely to

be a causal factor for the “karst wetlands” found.

A karstic assessment of the proposal area (Section 4.8) determined that the presence of karst landform within the Proposal 5 area is unlikely. In addition the absence of surface expression of water over the proposal area further lessens the probability of underground wetlands along the alignments.

### ***3.7.3 Potential Impacts***

The absence of karst landform and surface water expression along the freeway and rail line alignment indicates that there is not, as far as can be determined, any issues relating to the maintenance of values relevant to underground wetlands.

### ***3.7.4 Proposed Management***

As there is an apparent absence of underground wetlands there are no management issues to be addressed in relation to this type of environmental attribute.

The management measures proposed for the protection of subterranean fauna (see Section 3.5) and maintenance of groundwater quality (see Section 4.2) will also provide for the protection of underground wetlands should they occur in the development area.

### ***3.7.5 Proposed Outcome***

Given consideration of the above factors and the management measures proposed, it is believed that the EPA’s objective to “maintain the integrity, functions and environmental values of underground wetlands” can be met.

## **3.8 Landforms**

### ***3.8.1 EPA Objectives***

- Establish stable, sustainable landform consistent with surroundings.
- Maintain the environmental, scientific, cultural and recreational values of karst landforms.

### ***3.8.2 Relevant Policies***

- Interim Guide to the Geometric Design of Rural Roads (NAASRA, 1980)
- Australian Standard 1742-1986 to 1989: Manual of Uniform Traffic Control Devices
- AustRoads Guide to Traffic Engineering
- MRWA Specifications 204 Environmental Requirements (200-series Management Requirements, MRWA Tender Document System, 1999)
- MRWA Specifications 302 Earthworks (300-series Earthworks, MRWA Tender Document System, 1999)

### 3.8.3 Existing Environment

The proposed Amendment area is located on the Spearwood Dune Landform System formed about 40,000 years ago. This is the second youngest of a series of dune systems on the Swan Coastal Plain. Dunes formed near the coast as a result of deposits from the sea and were then eroded by winds that redeposited the sand, forming dunes further inland. Today, the Spearwood Dune Landform consists of gently to moderately inclined low hills and undulating plains.

The dunes are composed largely of infertile red/brown, yellow and pale yellow/grey sands with little structure. Limestone also occurs within the profile and is eventually deposited at the bottom of the dunes. If groundwater is present, the water can dissolve the limestone and form caves. Landforms with these subterranean passages and caves are called karst landforms.

The term 'karst' is used to describe landscapes that are commonly characterised by closed depressions (sinkholes), subterranean drainage and both horizontal and vertical caves. The term is applied to an entire geomorphic province, and not just to the characteristic features of the terrain. The factors that may contribute to the formation of karst landforms include geologic, pedologic (soil), climatic, topographic, hydrologic, biologic and temporal factors. The complex interaction between these factors determines the features exhibited by any particular karst landform (Alan Tingay & Associates, 1999).

Karst landscapes are formed principally by the selective chemical dissolution of limestone, or dolomitic rocks, by the percolation of ground waters and underground streams. The groundwater seeps along fractures and joints gradually creating sizeable passages. As this dissolution generally takes place beneath the ground the solution caves do not necessarily have entrances to the surface. The solubility of limestone is much enhanced if the waters contain dissolved carbon dioxide. Water moving through the atmosphere and soil scavenges this carbon dioxide becoming more acidic and thus more efficient at dissolving limestone. Studies in temperate climates suggests that two thirds or more of limestone solution takes place at the soil-rock interface where waters percolate through the soil into the rock mass (Hamilton-Smith et al., 1998).

In the Yanchep region, (which includes the area encompassed by Proposal 5 from a geological perspective), karst phenomena typically occur geographically within the broad low valley of the Spearwood dune system approximately 4 to 5km from the coast and within the Tamala Limestone in the unsaturated zone between the watertable and the surface.

Within this unsaturated zone the Tamala Limestone is massive but heavily jointed. The rock strength below the watertable is lower and vugs and voids are common. The broadened joints allow groundwater to percolate through the limestone to the groundwater table. As water percolates through the unsaturated zone it dissolves some of the limestone causing the joints to broaden until the surface sands collapse into the void, resulting in the formation of a sinkhole at the surface.

The next stage of the Karst cycle of development, after the development of sinkholes, is a

chain of shallow wetlands where collapse has occurred and subterranean streams have surfaced from beneath the remnant limestone. An example of such wetlands can be seen at Loch McNess in Yanchep National Park.

The alignment of the proposed Mitchell Freeway from Burns Beach Road to Romeo Road is located in areas predominantly comprised of sediments of the Spearwood Dune System. This includes Tamala limestone outcrop, subcrop and sands derived from the underlying Tamala limestone.

The area of Proposal 5 occurs to the west of the identified karstic zone that contains abundant karstic phenomena including caves, dolines and swallows (Yanchep GSWA Sheet 2034 IV). This zone contains the wetland chain that includes Loch McNess, Mindarie Lake, Carabooda Lake, Nowergup Lake and Neerabup Lake. The identified karstic zone is parallel to the Mitchell Freeway alignment, approximately 1.5 to 2km to the east.

An assessment of the geology and geomorphology of the area was carried out by a qualified geoscientist. The assessment included a review of all available information including aerial photographs, geological maps of the area (Yanchep GSWA Sheet 2034IV and Muchea GSWA Sheet 2034I & 2134IV), and a preliminary field assessment.

The preliminary field assessment involved observations through driving the alignments by 4WD and field traverses where vehicle access was not possible. The assessment was limited by the presence of thick vegetation over a large portion of the Kwinana Freeway and Neerabup Road alignments, which prevented a thorough evaluation.

The geomorphology of the area consists of rolling relic dunal landscape with outcrop and subcrop on the highs and sand filled, broad valleys in topographic lows. Karst scenery was not observed during the field assessment. However, surface dissolution of the outcrop and subcrop including small fissures (<1m) and cavities has occurred due to rainfall, though this is likely to be a shallow surface feature only.

Excavations associated with the Quinns Quarry (BCG Group), which is south of Quinns Road and directly east of the Freeway extension, showed cross-sections, shallow soils (<4m) overlying massive limestone, greater than 10m in thickness. Immediately south of the Quinns Quarry an area of quarried excavations contained a small outcrop of pinnacle structures (scattered over approximately 15m<sup>2</sup> with approximately 3m high pinnacles), which are interpreted to be at the top of the limestone and overlying sands contact. These features are considered to be erosional features, not collapse features, formed through wind erosion of limestone with the pinnacles associated with portions of limestone with a higher degree of cementation.

Based on the GSWA geological mapping of the area and the preliminary field study, it is evident that the presence of karst scenery within the alignments, such as caves, swallows and dolines, within the alignments is unlikely.

### 3.8.4 Potential Impacts

The construction of the alignment may impact the natural form of the terrain by being inconsistent with the surrounding landforms and leading to a noticeable visual impact.

The location of the alignment is situated across numerous low hills. The nature of a freeway means that the most direct and safest route is generally chosen. Therefore the natural topography of the terrain cannot be followed and cuts and fills to the terrain will be required.

Draft construction plans suggest that in the 3.4km between Burns Beach Road and Neerabup Road, 4 hills will be excavated to a maximum depth of 9 metres and 3 slopes and valleys will be filled to a maximum of 7 metres. The freeway and railway are likely to rise from 9m to 44 metres Australian Height Datum (AHD) over a distance of 700 metres from Burns Beach Road then gradually decline to 23 metres AHD at Neerabup Road. This information is based on draft profile drawings which are likely to be modified prior to construction.

From Neerabup Road the alignment is likely to rise again to 42 metres AHD over a distance of 1.6km. To achieve this incline, cuts will be necessary to a maximum depth of 5m and fills to a height of 8 metres. For the next 900 metres a hill will need to be excavated to a depth of 8 metres so the Freeway declines to meet Quinns Road, which is 33 metres AHD.

From Quinns Road the alignment has to cut through 3 hills and fill 2 slopes to reach Lukin Drive 2.5km to the north. Excavation at Lukin Drive may reach 11 metres, the maximum depth required to be cut along the whole alignment extension. This cut is likely to be extended into a set of 3 hills for 1km after Lukin Drive. Over the next 1.2km to Romeo Road, the Freeway and Railway gently dip and rise no greater than 8 metres, cutting through one hill 400 metres before Romeo Road, to a depth of 11 metres.

If the freeway and rail line are constructed over areas of karst formation, subsidence or collapse could occur. As there is an apparent absence of karst landform along the alignments there are unlikely to be potential impacts with respect to karst landforms.

### 3.8.5 Proposed Management

Criteria for route selection are set through *The Interim Guide to the Geometric Design of Rural Roads* (NAASRA, 1980). To minimise potential impacts upon the natural landforms, the initial planning and route selection for the freeway and railway alignment followed the dimension and form of the natural environment, whilst complying with engineering and safety standards such as the Australian Standard 1742: Manual of Uniform Traffic Control Devices and the AustRoads Guide to Traffic Engineering.

Construction of the freeway and railway will follow final construction profiles agreed to by relevant Government agencies. Contractors are required to comply with MRWA Specification 302-Earthworks, which will ensure that the resulting landforms are stable and sustainable. This specification stipulates procedures involved in topsoil removal and re-spreading; road widening; rock excavation; blasting and embankment construction. Under the MRWA

Specification 204-Environmental Management Requirements, contractors have to ensure that no damage to landforms outside the work area occurs and if it does, the area shall be rehabilitated at the contractor's cost and to the satisfaction of a qualified environmental practitioner.

The proposed landuse (road and rail construction) is suited to the geomorphology of the area provided the development is managed with careful consideration to the relevant geotechnical considerations such as drainage in valleys. As identified in Section 4.2, careful consideration will be given to drainage in the broad valley depressions during development of the proposed freeway and rail line. Drainage structures will be designed to maintain the rolling dunal geomorphology of the land where possible.

### **3.8.6 Proposed Outcome**

The nature of the surrounding Spearwood landform consists of a system of low gentle undulating hills. It is recognised that to construct the freeway and railway, cuts and fills to this natural landform will be required. However, the planned construction profile interrelates with the existing landform, as the design is based on conforming with the dimensions and form of the natural environment as far as practicable, whilst complying with safety and engineering standards.

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objectives to "establish stable, sustainable landform consistent with surroundings and to maintain the environmental, scientific, cultural and recreational values of karst landforms" can be met.

## **3.9 Aboriginal Culture and Heritage**

### **3.9.1 EPA Objectives**

- Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act 1972*; and
- Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.

### **3.9.2 Relevant Policies**

*Aboriginal Heritage Act, 1972*

### **3.9.3 Existing Environment**

Aborigines have lived within the Wanneroo area for more than 40,000 years, utilising the abundance of food and water along the chain of wetlands on the coastal plain. In winter the groups moved east away from the coastal weather, returning to the lakes in summer as inland

water supplies dried up.

In 1989 an Aboriginal Site Survey of the proposed Mitchell Freeway extension from Shenton Road to Romeo Road (therefore, including the Clarkson-Butler area) was carried out by Rory O'Connor, Gary Quartermaine and Corrie Bodney. It covered both ethnographic and archaeological aspects.

The ethnographic component of the survey covered a corridor 1km wide, that was 500m either side of the centre line of the proposed freeway alignment. The study consisted of examining the existing ethnographic database, a site visit accompanied by Aboriginal people, and consultation and discussion with relevant Aboriginal people, long-term residents and Wanneroo City Council staff.

No previously recorded ethnographic sites were discovered within the survey area and no sites of significance were known to the Aboriginal people consulted.

The archaeological survey covered a corridor 200m wide centred on the proposed alignment. Site inspections were carried out across the corridor every 200m. Access was possible to all sections of the corridor by 4WD vehicle and on foot. Visibility was restricted by groundcover vegetation but was good along tracks, firebrakes and other cleared areas. These exposed areas accounted for approximately 25% of the corridor area.

No archaeological sites were located or had been previously recorded within the study area.

In 1995, the Aboriginal Affairs Department advised Main Roads WA that, in view of the considerable time lapse between the 1989 report and current Main Roads WA plans with regard to the proposed Freeway extension, the persons consulted prior to release of the report should be consulted again, along with certain other parties.

Main Roads WA then approached the Balluruk Aboriginal Corporation and Nyungar Land Council, as both bodies have applied to the National Native Title Tribunal for determination of native title in regard to lands included in the proposed freeway extension alignment.

This further Aboriginal consultation was documented in a 1996 report by Rory O'Conner, which established that the conclusions drawn in the 1989 report, namely that Aboriginal heritage considerations should not be deemed an impediment to construction of the proposed Freeway extension from Burns Beach Road to Romeo Road, were valid.

In a letter dated 5 May 1999, the Aboriginal Affairs Department advised the Project Manager of the Urban Rail Planning Group that, while in principle the Department accepted the 1989 and 1996 reports, additional work should be undertaken to ensure no Aboriginal sites are disturbed during the development stage.

Further communication resolved this issue and Gary Quartermaine advised the Urban Rail Planning Group that the Aboriginal Affairs Department had agreed that no further

archaeological survey work was warranted. The requirement for archaeological monitoring of earthworks and excavations would be required; however, where major surface disturbance or excavations are undertaken.

Copies of relevant correspondence are in Appendix H, along with the 1989 and 1995 reports.

### ***3.9.4 Potential Impacts***

Clearing of the proposed alignment could destroy any unidentified archaeological sites.

### ***3.9.5 Proposed Management***

No archaeological sites have been located or are known to occur within the proposed alignment area and accordingly, no management measures are proposed.

In the event that a site is discovered during the construction activities, material will be properly salvaged and managed in accordance with Section 16 of the *Aboriginal Heritage Act, 1972*.

### ***3.9.6 Proposed Outcome***

As no sites of archaeological or ethnographic significance to the Aboriginal community occur within the proposed Mitchell Freeway Transportation Corridor alignment, it is believed that the EPA's objectives to "ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act 1972* and that changes to the biological and physical environment resulting from the project will not adversely affect cultural associations with the area" can be met.

## **3.10 Non-Aboriginal Heritage**

### ***3.10.1 EPA Objective***

Comply with statutory requirements in relation to areas of cultural or historical significance.

### ***3.10.2 Relevant Policies***

- *Australian Heritage Commission Act, 1975*
- *Heritage Act of Western Australia, 1990*
- *National Trust of Australia (WA) Act, 1964*

### ***3.10.3 Existing Environment***

The Heritage Council maintains an information database of heritage places within Western Australia. It includes places listed by local government authorities, the Register of the National Estate and the National Trust of Australia (WA).

The City of Wanneroo's Inventory of Heritage Places was obtained and a database search by the Heritage Council of Western Australia was undertaken. Neerabup Lake National Park was listed and it is assumed that this is a former name of the Neerabup National Park. The Park contains the 10<sup>th</sup> Light Horse Heritage Trail & the Yaberoo Budjara Heritage Trail.

The 10<sup>th</sup> Light Horse Heritage Trail is a permanent historical record of the last Australian Mounted Cavalry (AIF) camp. During World War II, six hundred men made their home in the bush of Wanneroo. Strategically placed between the ocean and the Pearce Air Base, the role of the AIF was to protect WA shores from the threat of a Japanese sea attack. The heritage trail has ten significant sites along its 1.2km length. The site also accommodates horse riding and provides picnic facilities for the community. These picnic facilities are listed in the City of Wanneroo's Inventory of Heritage Places (1994) as a Market Picnic Area.

The Yaberoo Budjara Heritage Trail is a 28km walking trail from Lake Joondalup through Neerabup National Park to Yanchep National Park. The trail is based on Yellagonga's tribe movements linking the linear lakes of the coastal plain, later used by Europeans as a stock route. Yellagonga's tribe's territory stretched from the Moore River to their camp on the Swan River. After the settlement of the Swan River by Europeans Yellagonga withdrew to Lake Monger, and again to Lake Joondalup after Europeans moved to Lake Monger.

#### ***3.10.4 Potential Impacts***

The south-west corner of Neerabup National Park includes part of the Yaberoo Budjara Heritage Trail around an old rehabilitated limestone quarry. This part of the trail will be severed by the alignment. The alignment north of Lukin Drive through the Park may also impinge upon the trail below Romeo Road; however, it should be noted that no site of interest is marked in this vicinity.

The 10<sup>th</sup> Light Horse Heritage Trail will not be affected by the proposed alignment.

#### ***3.10.5 Proposed Management***

The part of the Yaberoo Budjara Heritage Trail potentially affected by the Mitchell Freeway Transportation Corridor is proposed for rehabilitation and realignment by CALM. This will ensure that the heritage values of the trail are maintained subsequent to construction of the freeway and railway.

#### ***3.10.6 Proposed Outcome***

Given consideration of the above factors and the management measures proposed, it is believed that the EPA's objective to "comply with statutory requirements in relation to areas of cultural or historical" can be met.

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## STUDY TEAM

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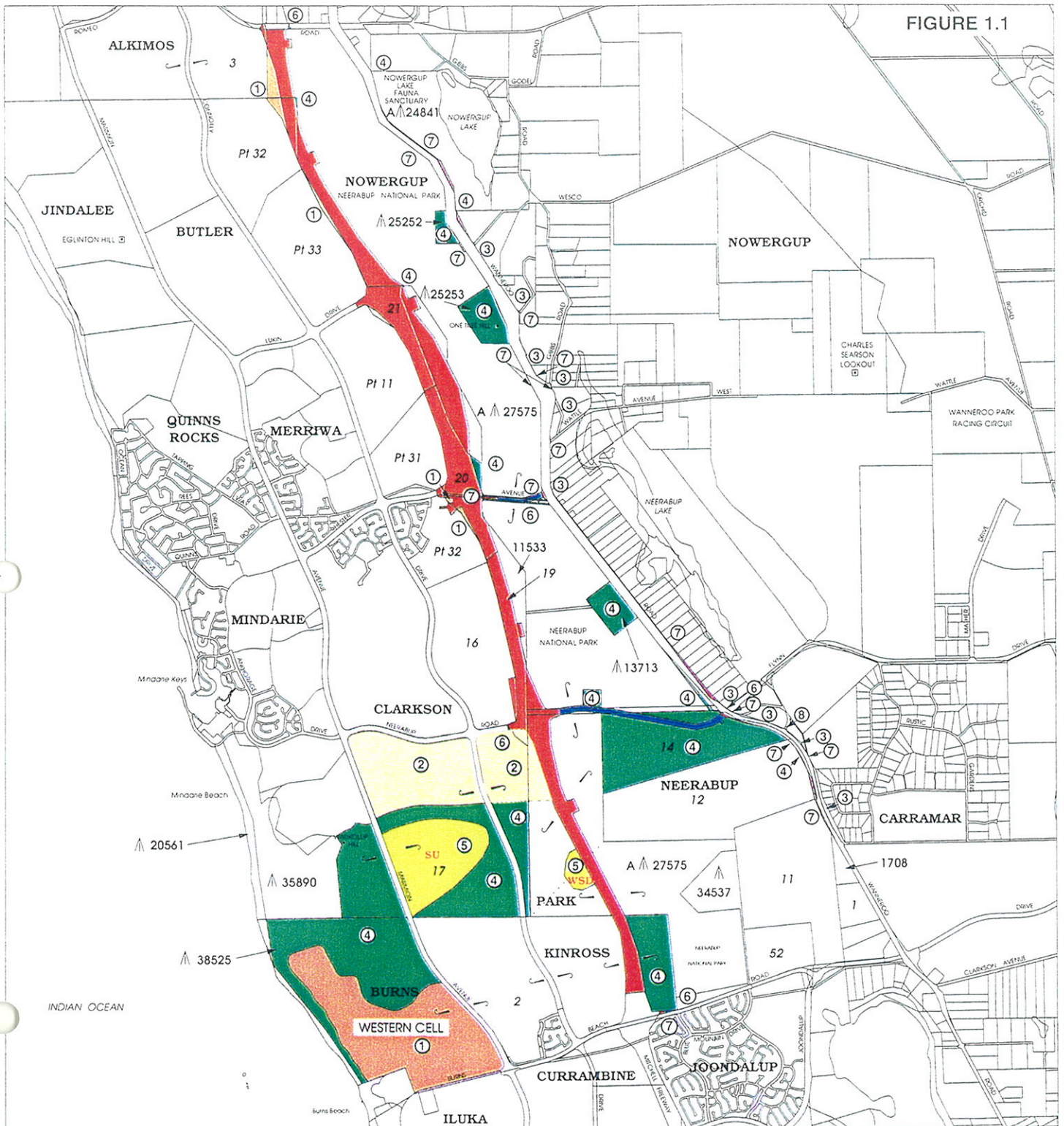
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C. Manning	B.Sc.	Research Assistant
M. Fitzgerald		Administrative Assistant

### Sub-Consultants

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**FIGURES**

FIGURE 1.1



## PROPOSED MAJOR MRS AMENDMENT 922/33 - CLARKSON-BUTLER

PROPOSED TO BE MODIFIED BY WAPC ON 14 SEPTEMBER 1999

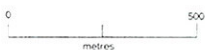
14th SEPTEMBER 1999



CUSTOMER  
FOCUS



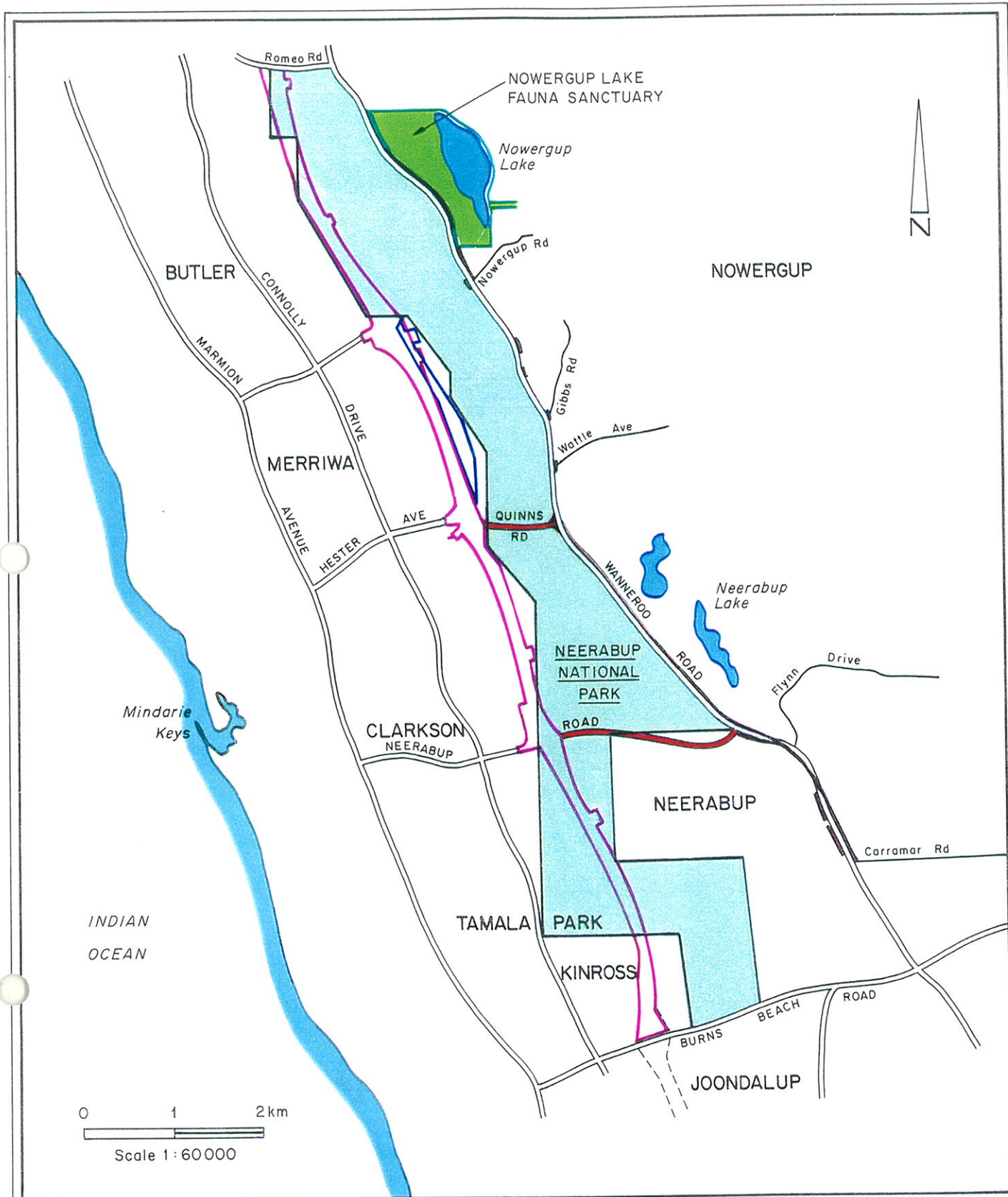
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### PROPOSED:

- ① URBAN ZONE
- ② URBAN DEFERRED ZONE
- ③ RURAL ZONE
- ④ PARKS & RECREATION RESERVATION
- ⑤ PUBLIC PURPOSES (SU & WSD) RESERVATION
- ⑥ OTHER REGIONAL ROADS RESERVATION
- ⑦ PRIMARY REGIONAL ROADS RESERVATION

### LEGEND

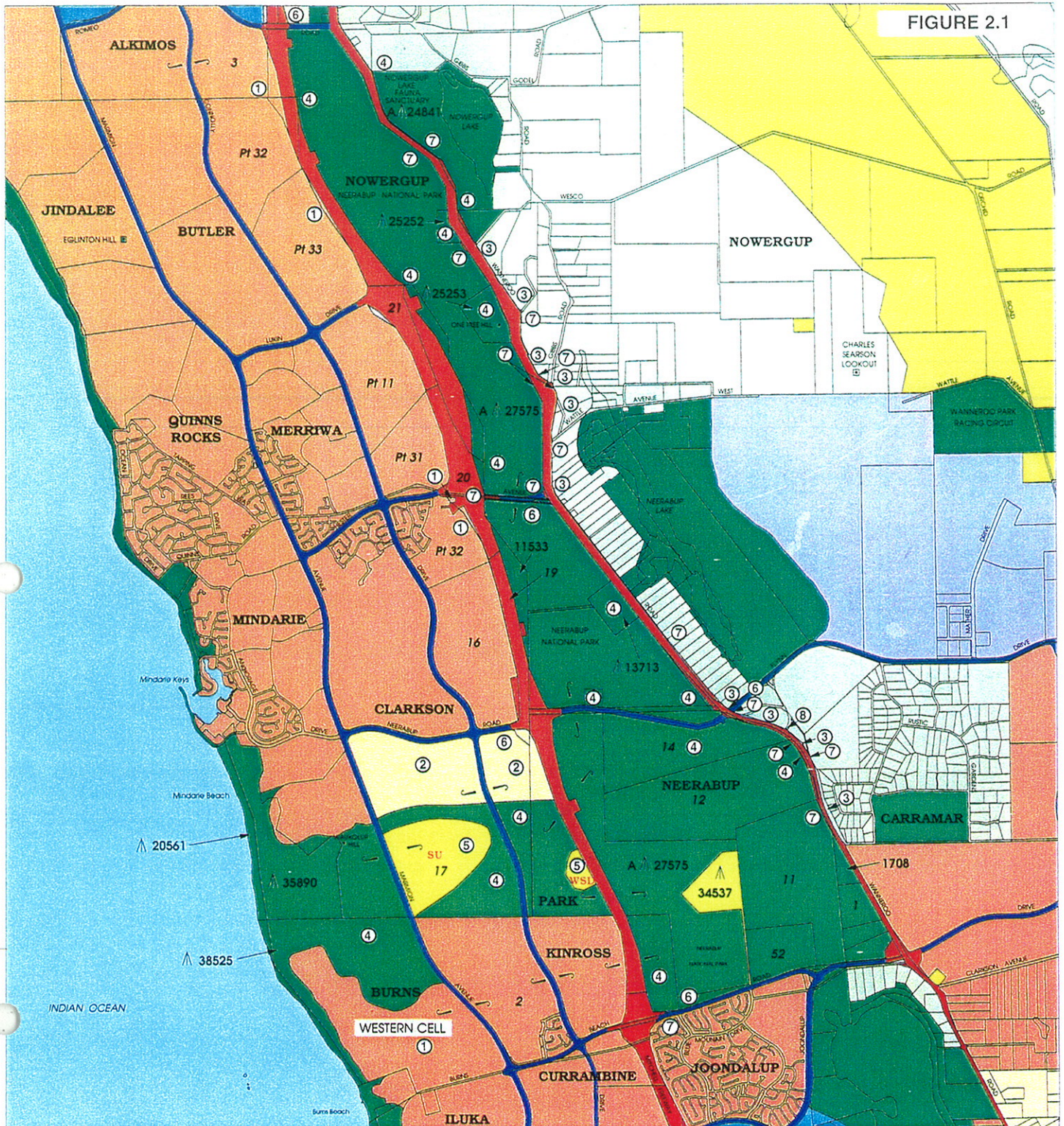


— Proposal 3   
 — Proposal 4   
 — Proposal 5   
 — Proposal 6

MRS AMENDMENT 922/33  
 Clarkson-Butler  
 LOCALITY PLAN

Figure 1.2

FIGURE 2.1



**PROPOSED MAJOR MRS AMENDMENT 922/33 - CLARKSON-BUTLER  
INCORPORATING MODIFIED AMENDMENT INTO MRS IF APPROVED**

14th SEPTEMBER 1999



SCALE 1:60000

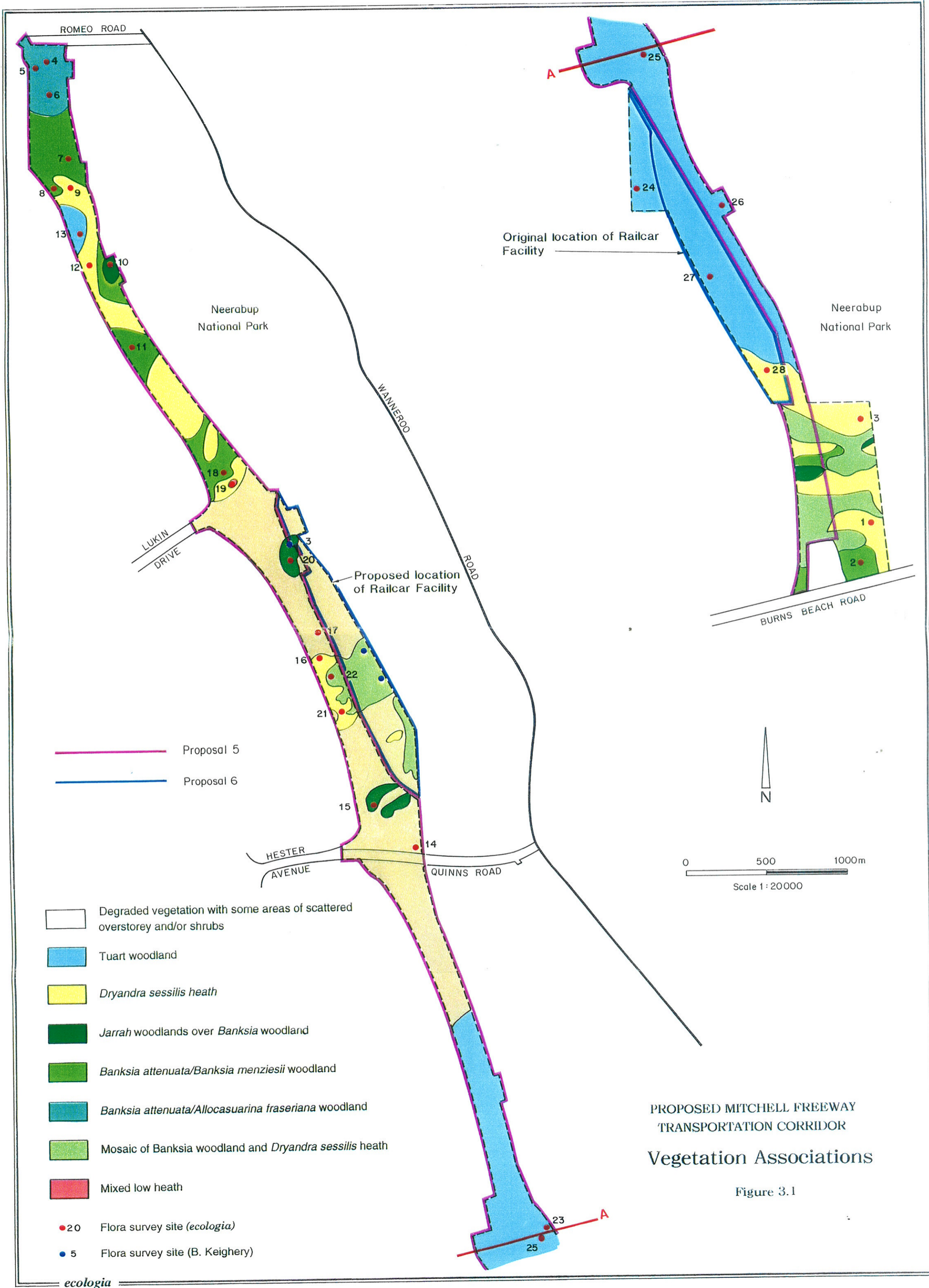


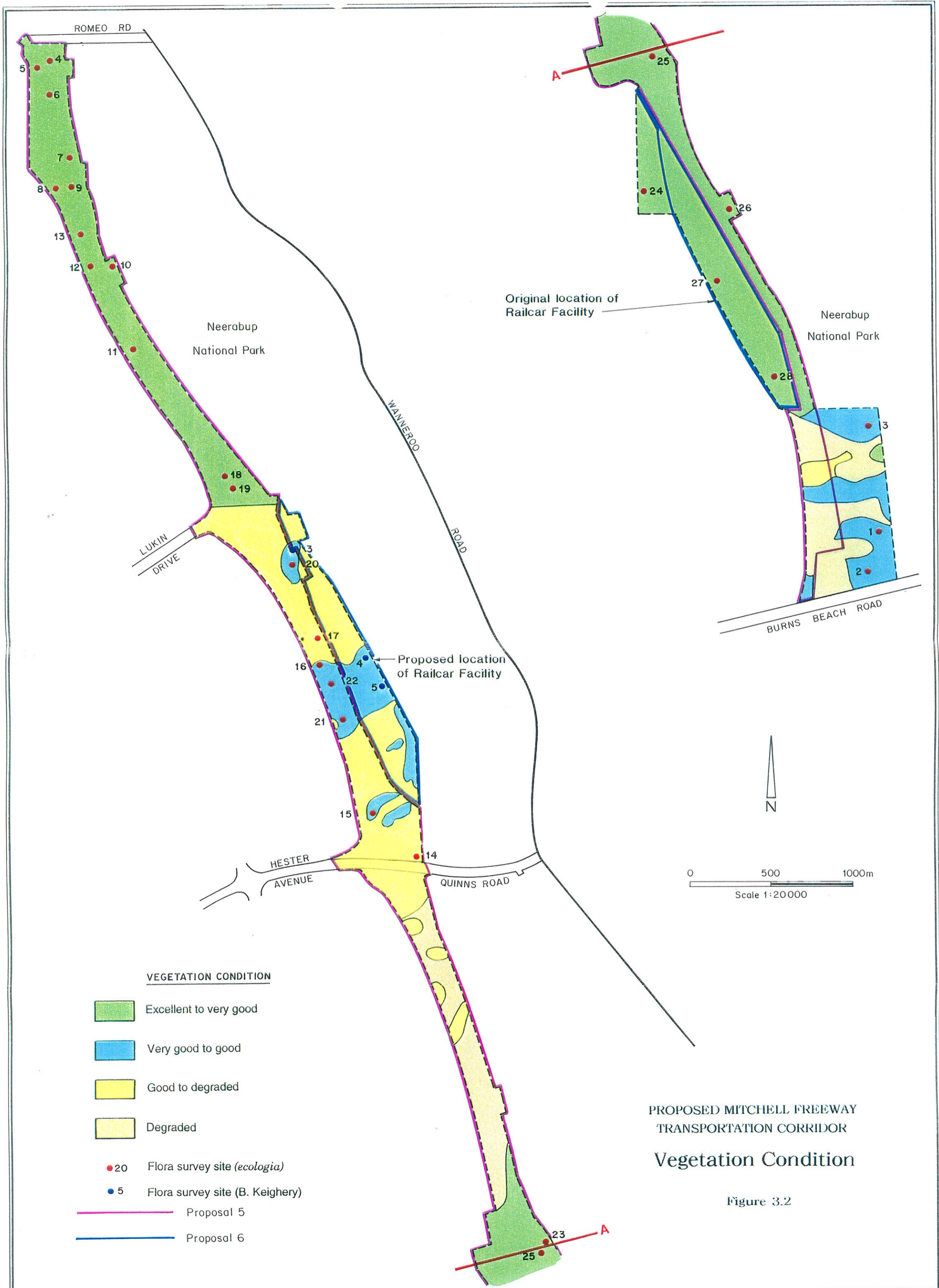
**PROPOSED:**

- ① URBAN ZONE
- ② URBAN DEFERRED ZONE
- ③ RURAL ZONE
- ④ PARKS & RECREATION RESERVATION
- ⑤ PUBLIC PURPOSES (SU & WSD) RESERVATION
- ⑥ OTHER REGIONAL ROADS RESERVATION
- ⑦ PRIMARY REGIONAL ROADS RESERVATION

**LEGEND**

- INDUSTRIAL ZONE
- CENTRAL CITY AREA ZONE
- STATE FORESTS RESERVATION





**VEGETATION CONDITION**

- Excellent to very good
- Very good to good
- Good to degraded
- Degraded

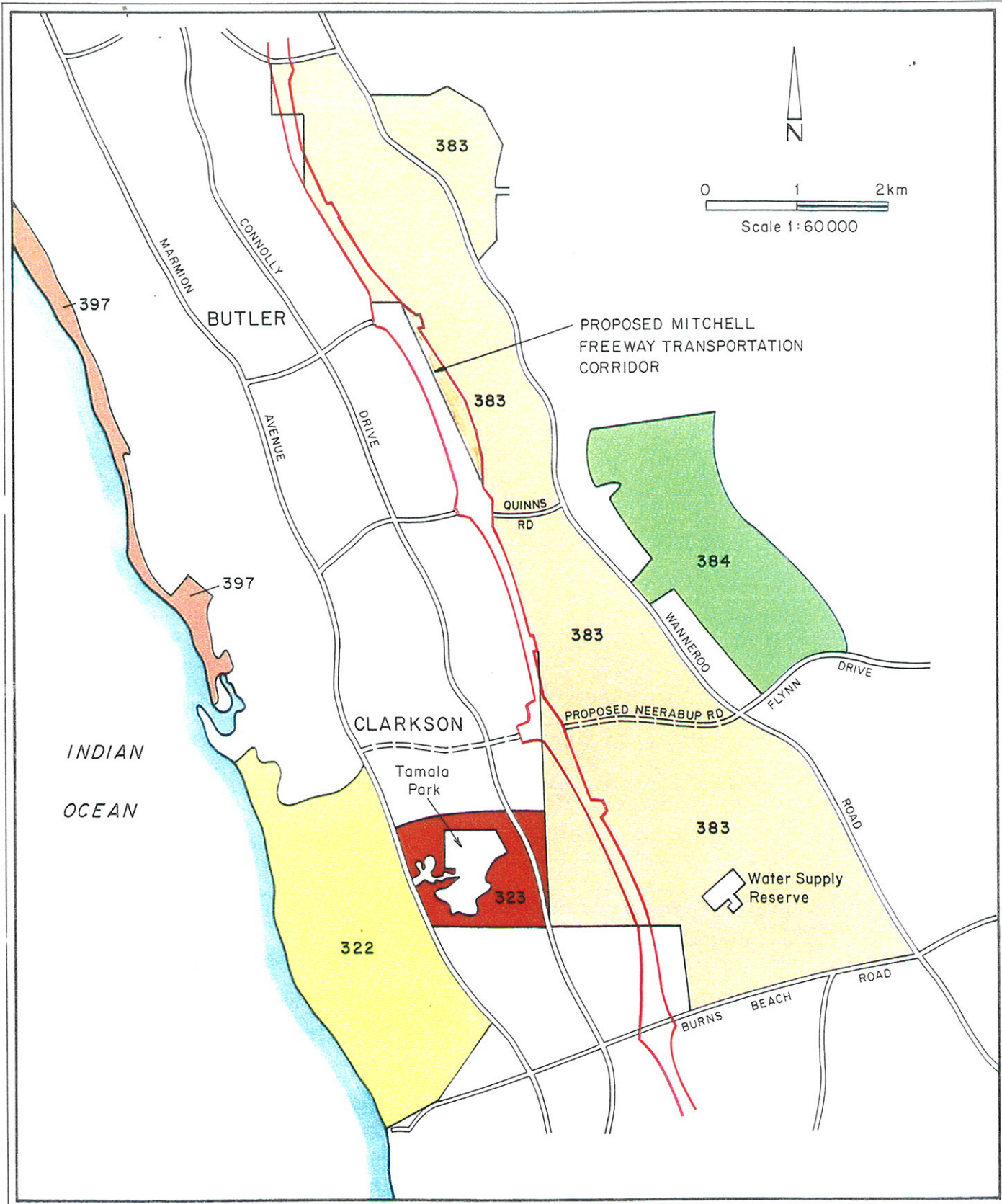
- 20 Flora survey site (*ecologia*)
- 5 Flora survey site (B. Keighery)

- Proposal 5
- Proposal 6

**PROPOSED MITCHELL FREEWAY  
TRANSPORTATION CORRIDOR**

**Vegetation Condition**

Figure 3.2

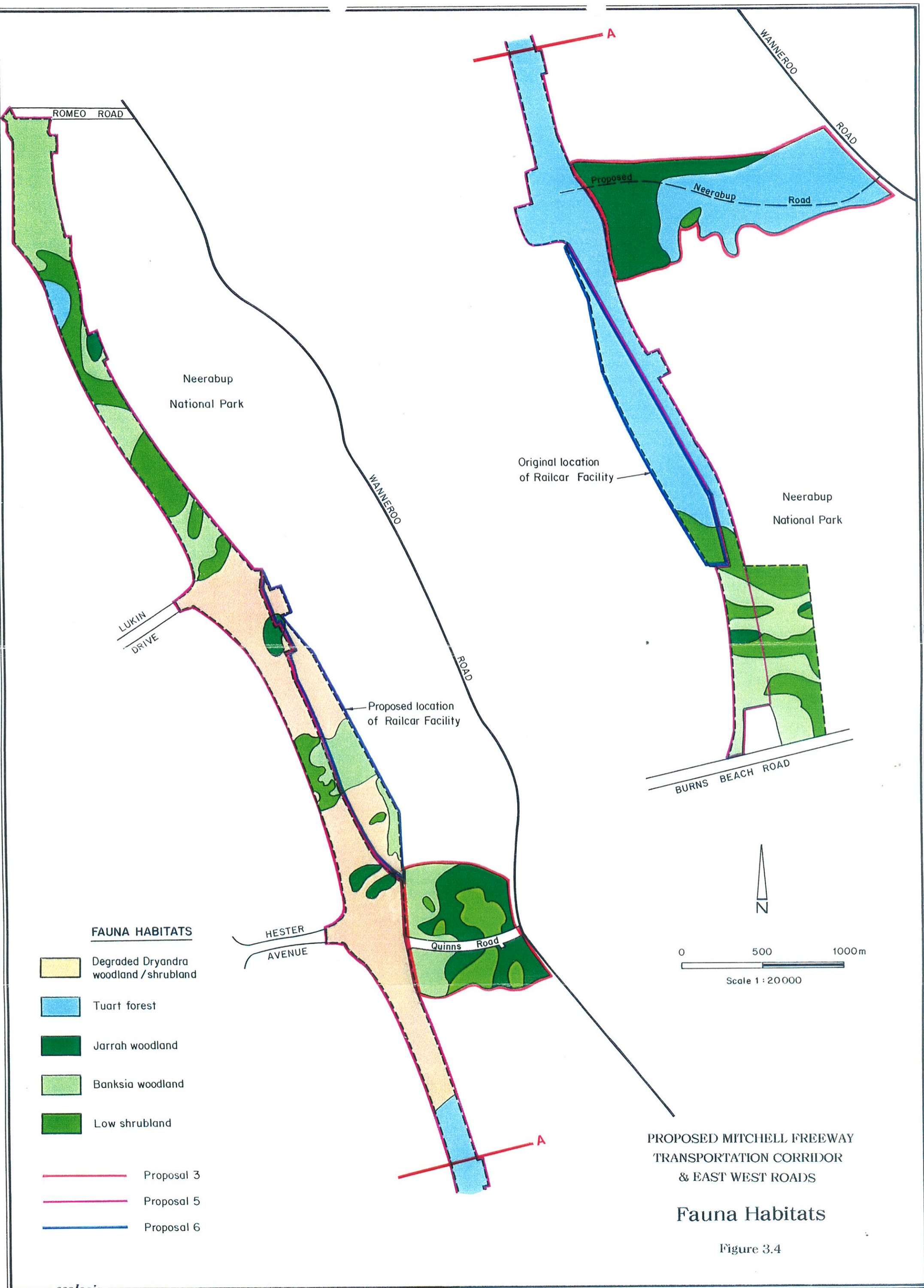


Proposed MRS Amendment 922/33 Clarkson-Butler

DRAFT BUSHPLAN SITES

[The Government of Western Australia, 1998]

Figure 3.3



## Flora species collected from the Mitchell Freeway extension Burns Beach Road to Romeo Road study area.

Classification and nomenclature according to Census of Australian Vascular Plants 1990.. R.J. Hnatiuk Australian Government Publishing Service

Key: \* = introduced species  
sp. = species

FAMILY	SPECIES
ZAMIACEAE	<i>Macrozamia reidleyi</i>
CUPRESSACEAE	<i>Callitris preissii</i>
POACEAE	<i>Amphipogon turbinatus</i>
	<i>Austrodanthonia ?caespitosa</i>
	* <i>Avena fatua</i>
	* <i>Briza maxima</i>
	* <i>Bromus ?diandrus</i>
	* <i>Ehrharta calycina</i>
	* <i>Stipa</i> sp.
CYPERACEAE	<i>Alexgeorgia nitens</i>
	<i>Desmocladius fasciculata</i>
	<i>Lepidosperma ?costale</i>
	<i>Lepidosperma pubisquamum</i>
	<i>Lepidosperma scabrum</i>
	<i>Lepidosperma</i> sp. C
	<i>Mesomelaena gracileps</i>
	<i>Mesomelaena pseudostygia</i>
	<i>Schoenus grandiflorus</i>
	<i>Schoenus latitans</i>
	<i>Tetraria octandra</i>
RESTIONACEAE	<i>Lyginia barbata</i>
DASYPOGONACEAE	<i>Acanthocarpus preissii</i>
	<i>Calectasia cyanea</i>
	<i>Lomandra hermarphrodita</i>
	<i>Lomandra maritima</i>
	<i>Lomandra odora</i>
	<i>Lomandra preissii</i>
	<i>Lomandra</i> sp. 1
	<i>Lomandra</i> sp. 2
	<i>Lomandra</i> sp. 3
XANTHORRHOEACEAE	<i>Xanthorrhoea preissii</i>
PHORMIACEAE	<i>Dianella revoluta</i>
ANTHERICACEAE	<i>Corynotheca ?micrantha</i>
	<i>Thysanotus patersonii</i>

COLCHICACEAE	<i>Burchardia ?congesta</i>
HAEMODORACEAE	<i>Conostylis aculeata</i> ssp. <i>cygnorum</i> <i>Conostylis candicans</i> <i>Conostylis teretifolia</i> ssp. <i>planescens</i> <i>Haemodorum paniculatum</i>
IRIDACEAE	* <i>Gladiolus caryophyllaceus</i> * <i>Homeria ?flaccida</i> <i>Orthrosanthus laxus</i> var. <i>laxus</i> <i>Patersonia ?occidentalis</i> * <i>Romulea</i> sp.
ORCHIDACEAE	<i>Burnetia nigricans</i> <i>Eriochilus dilatatus</i> <i>Microtis ?media</i> <i>Pterostylis vittata</i>
CASUARINACEAE	<i>Allocasuarina fraseriana</i> <i>Allocasuarina humilis</i>
PROTEACEAE	<i>Banksia attenuata</i> <i>Banksia grandis</i> <i>Banksia menziesii</i> <i>Dryandra lindleyana</i> <i>Dryandra sessilis</i> <i>Grevillea thelmanniana</i> <i>Grevillea vestita</i> <i>Hakea costata</i> <i>Hakea erinacea</i> <i>Hakea lissocarpa</i> <i>Hakea prostrata</i> <i>Hakea ruscifolia</i> <i>Hakea trifurcata</i> <i>Persoonia saccata</i> <i>Petrophile brevifolia</i> <i>Petrophile linearis</i> <i>Petrophile macrostachya</i> <i>Stirlingia latifolia</i> <i>Synaphea spinulosa</i> <i>Leptomeria pauciflora</i>
SANTALACEAE	
LORANTHACEAE	<i>Nuytsia floribunda</i>
POLYGONACEAE	* <i>Rumex crispus</i>
CHENOPODIACEAE	<i>Rhagodia baccata</i>
AMARANTHACEAE	<i>Ptilotus drummondii</i> <i>Ptilotus polystachyus</i>
GYROSTEMONACEAE	<i>Gyrostemon ramulosus</i>
RUBIACEAE	<i>Opercularia vaginata</i>
AIZOACEAE	<i>Carpobrotus ?edulis</i>
RANUNCULACEAE	<i>Clematis pubescens</i>
LAURACEAE	<i>Cassutha ?racemosa</i>
BRASSICACEAE	* <i>Lobularia maritima</i> * <i>Raphanus raphanistrum</i>

DROSERACEAE	<i>Drosera erythrorhiza</i>
	<i>Drosera sp.</i>
CRASSULACEAE	<i>Crassula ?thunbergiana</i>
MIMOSACEAE	<i>Acacia benthamii</i>
	<i>Acacia cochlearis</i>
	<i>Acacia cyclops</i>
	<i>Acacia huegeli</i>
	<i>Acacia lasiocarpa</i>
	<i>Acacia pulchella</i>
	<i>Acacia saligna</i>
	<i>Acacia wildenowiana</i>
FABACEAE	<i>Bossiaea eriocarpa</i>
	<i>Daviesia decurrens</i>
	<i>Daviesia triflora</i>
	<i>Gompholobium tomentosum</i>
	<i>Hardenbergia comptoniana</i>
	<i>Hovea trisperma</i>
	<i>Isotropis cuneifolia</i>
	<i>Jacksonia calcicola</i>
	<i>Jacksonia sternbergiana</i>
	<i>Kennedia prostrata</i>
	* <i>Lupinus sp.</i>
	* <i>Medicago sp.</i>
	<i>Nemcia capitata</i>
	<i>Templetonia retusa</i>
	* <i>Trifolium arvense var. arvense</i>
GERANIACEAE	* <i>Erodium sp.</i>
	* <i>Pelargonium capitatum</i>
OXALIDACEAE	* <i>Oxalis pes caprae</i>
POLYGALACEAE	<i>Comesperma sp.</i>
EUPHORBIACEAE	* <i>Euphorbia terracina</i>
	<i>Phyllanthus calycinus</i>
RHAMNACEAE	<i>Cryptandra myriantha</i>
	<i>Stenanthemum tridentatum</i>
STERCULIACEAE	<i>Trymalium ledifolium</i>
DILLENIACEAE	<i>Hibbertia subvaginata</i>
	<i>Hibbertia hypericoides</i>
	<i>Hibbertia racemosa</i>
VIOLACEAE	<i>Hybanthus floribundus</i>
THYMELAEACEAE	<i>Pimelea argentea</i>
	<i>Pimelea sp. 1</i>
MYRTACEAE	<i>Baeckea camphorosmae</i>
	<i>Baeckea robusta</i>
	<i>Calothamnus sanguineus</i>
	<i>Calytrix flavescens</i>
	<i>Corymbia calophylla</i>
	<i>Eucalyptus gomphocephala</i>
	<i>Eucalyptus marginata</i>

	<i>Eucalyptus todtiana</i>
	<i>Eucalyptus decipiens</i>
	<i>Melaleuca huegellii</i>
HALORAGACEAE	<i>Glischrocaryon ?aurea</i>
APIACEAE	<i>Eryngium</i> sp.
	<i>Xanthosia huegellii</i>
EPACRIDACEAE	<i>Astroloma ciliatum</i>
	<i>Astroloma</i> sp.
	<i>Conostephium pendulum</i>
	<i>Leucopogon oxycedrus</i>
	<i>Leucopogon parviflorus</i>
	<i>Leucopogon polymorphus</i>
	<i>Leucopogon propinquus</i>
PRIMULACEAE	* <i>Anagallis arvensis</i> var <i>arvensis</i>
GENTIANACEAE	?* <i>Centaurium erythraea</i>
SOLANACEAE	<i>Anthocercis littorea</i>
	* <i>Solanum sodomaeum</i>
OROBANCHACEAE	* <i>Orobanche minor</i>
MYOPORACEAE	<i>Eremophila glabra</i>
PLANTAGINACEAE	* <i>Plantago lanceolata</i>
RUBIACEAE	<i>Opercularia vaginata</i>
LOBELIACEAE	<i>Lobelia</i> sp.
GOODENIACEAE	<i>Dampiera alata</i>
	? <i>Dampiera linearis</i>
	<i>Lechenaultia biloba</i>
	<i>Lechenaultia linarioides</i>
	<i>Scaevola canescens</i>
STYLIDIACEAE	<i>Stylidium brunonianum</i> subspecies <i>minor</i>
	<i>Stylidium piluliferum</i>
	<i>Stylidium schoenoides</i>
ASTERACEAE	* <i>Arctotheca calendula</i>
	* <i>Conyza bonariensis</i>
	* <i>Dittrichia graveolens</i>
	* <i>Hypochoeris glabra</i>
	<i>Lagenifera huegellii</i>
	<i>Olearia axillaris</i>
	* <i>Sonchus oleraceus</i>
	* <i>Ursinia anthemoides</i>

## APPENDIX D

### Flora Composition Matrix of Survey Sites











## APPENDIX E

Vegetation Units  
Mapped within the  
Mitchell Freeway  
Transportation Corridor

## 1. Tuart Woodland

This association is part of the Cottesloe Complex - Central and South and occurs on deep sands over limestone. This vegetation community has an understorey ranging from completely degraded (Quadrat 24) to excellent condition (within the Neerabup National Park).

Most of this community on the private property is highly degraded. It comprises scattered to open *Eucalyptus gomphocephala* to 30 metres and sparse *Eucalyptus marginata* over sparse shrubs *Xanthorrhoea preissii* and *Macrozamia reidleyi* over sparse, low *Acacia pulchella*. Small pockets of *Banksia attenuata*, *Allocasuarina fraseriana* and *Banksia grandis* occur sporadically throughout. Similarly, remnants of the original understorey *Daviesia triflora*, *Dryandra lindleyana*, *Hibbertia racemosa*, *Petrophile brevifolia* and *Petrophile linearis* persist. The grass *\*Ehrharta calycina* and herb *\*Lupinus* sp. dominates the understorey with scattered sedges *Desmocladius fasciculata* and *Mesomelaena fasciculata*. Car bodies and litter are scattered throughout.

A small area of this vegetation community outside of Neerabup National Park is in good to very condition and comprises open *Eucalyptus gomphocephala* to 30 metres over open shrubs *Hakea prostrata*, *Acacia pulchella*, *Dryandra sessilis*, *Hakea lissocarpha*, *Melaleuca systina*, *Xanthorrhoea preissii*, *Allocasuarina humilis*, *Leucopogon propinquus*, *Bossiaea eriocarpa*, *Macrozamia reidleyi*, *Acacia saligna*, *Hakea trifurcata*, *Isotropis cuneifolia*, *Jacksonia calcicola*, *Kennedia prostrata*; over scattered herbs and climbers *Burchardia ?congesta*, *Conostylis candicans*, *Haemodorum paniculatum*, *\*Hypochaeris glabra*, *\*Lupinus* sp., *\*Medicago* sp., *\*Romulea rosea*; sparse grasses *\*Bromus diandrus*, *\*Ehrharta calycina* and *Tetraria capillaris* over sparse sedges *Desmocladius fasciculata* and *Lepidosperma pubisquameum*.

The Tuart forest within Neerabup National Park is for the most part in excellent condition with scattered *Eucalyptus gomphocephala* over sparse *Eucalyptus marginata* and sparse to open *Allocasuarina fraseriana*, *Banksia attenuata*, *Banksia grandis* and *Acacia saligna*; over sparse *Jacksonia sternbergiana*, *Hakea lissocarpha* and *Xanthorrhoea preissii*. The low, open shrub stratum comprises a mixture of *Hibbertia hypericoides*, *Petrophile brevifolia*, *Bossiaea eriocarpa*, *Hovea trisperma*, *Leucopogon propinquus*, *Rhagodia baccata*, *Acacia lasiocarpa*, *Petrophile linearis*, *Daviesia triflora*, *Gompholobium tomentosum* and *Hibbertia racemosa*; over scattered herbs *Burnetia nigricans*, *\*Carpobrotus edulis*, *Conostylis aculeata* ssp. *cygnorum*, *Drosera* sp., *\*Homeria ?flaccida*, *\*Hypochaeris glabra*, *\*Ursinia anthemoides*, *\*Medicago*, *Eryngium* sp., *Lagenifera huegelli*, *Drosera erythrohiza*, *Hardenbergia comptoniana*, *\*Gladiolus caryophyllaceus*, *Pterostylis vittata*, *Stylidium* sp., *Thysanotus patersonii*, scattered grasses *\*Briza maxima* and open sedges *Desmocladius fasciculata*, *Lepidosperma pubisquameum* and *Mesomelaena pseudostygia*.

## 2. Dryandra sessilis heath

Most of this vegetation community within the study site is in a relatively intact state, although the smaller herbaceous understorey species have generally been invaded or in some places

replaced by weedy herbs. The soils are sands of variable depth over limestone. The species composition varies depending on the soil depth, sometimes with scattered, emergent *Banksia menziesii*, *Banksia attenuata* or *Nuytsia floribunda*; but more typically a dense to moderately open heath of *Dryandra sessilis* and *Jacksonia sternbergiana* to 2.5 metres over sparse to open *Acacia pulchella*, *Calothamnus quadrifidus*, *Hakea trifurcata* and *Xanthorrhoea preissii*. The moderately dense lower shrub strata includes *Dryandra lindleyana*, *Grevillea thelmanniana*, *Hibbertia hypericoides* over sparse to open herbs and climbers including \**Carpobrotus edulis*, *Clematis pubescens*, *Conostylis aculeata* ssp. *cygnorum*, *Dampiera linearis*, \**Gladiolus caryophyllaceus*, \**Hypochaeris glabra*, *Lagenifera huegelli*, *Lomandra ?odora*, *Lomandra priesii*, *Pterostylis vittata*, *Thysanotus patersonii* and \**Ursinia anthemoides*. The grasses \**Briza maxima*, \**Ehrharta calycina*, *Tetraria capillaris* provided a scattered to sparse cover with scattered sedges *Desmocladius fasciculatus* and *Lepidosperma pubisquameum*.

### 3. Jarrah Woodland over Banksia Woodland

Most of this vegetation community on the private property is highly degraded (Figure 1). This community comprises sparse to open *Eucalyptus marginata* over sparse *Trymalium* sp., *Xanthorrhoea preissii*, *Acacia pulchella*, *Acacia saligna*, *Hibbertia hypericoides* and *Templetonia biloba*. A sparse, low shrub stratum of *Dryandra lindleyana*, *Grevillea bipinnatifida*, *Hovea trisperma* and *Kennedia prostrata* are interspersed by sparse herbs and climbers including *Burchardia* sp., \**Hypochaeris glabra* and *Corynotheca ?micrantha*. *Lepidosperma pubisquameum* provides a moderately dense sedge cover in places. In other parts of the community the understorey is almost completely cleared (Quadrat 26).

In one area within the private property and another within Neerabup National Park the *Eucalyptus marginata* and *Banksia attenuata* open woodland in excellent condition. This community, and in particular Quadrat 20 is one of the least disturbed in the study area.

This community comprises an open cover of mature *Eucalyptus marginata* over scattered *Acacia pulchella*, *Allocasuarina humilis*, *Hakea lissocarpa*, *Hakea ruscifolia* and *Xanthorrhoea preissii* over an open to moderately dense cover of low shrubs including herbs and climbers including *Astroloma pallidum*, *Bossiaea eriocarpa*, *Calytrix flavescens*, *Conostephium pendulum*, *Gompholobium tomentosum*, *Hibbertia hypericoides*, *Hovea trisperma*, *Petrophile linearis*, *Petrophile brevifolia* and *Stirlingia latifolia*. Herbs and climbers provide scattered cover and include *Burchardia ?congesta*, *Burnetia nigricans*, \**Carpobrotus edulis*, *Conostylis teretifolia* ssp. *planescens*, *Dianella revoluta*, *Drosera erythrorhiza*, *Drosera* sp., *Haemodorum paniculatum*, \**Gladiolus caryophyllaceus*, *Hardenbergia comptoniana*, \**Hypochaeris glabra*, *Lomandra preissii*, \**Medicago* sp. and *Pterostylis vittata* over scattered grasses *Stipa* sp. and sparse sedges *Alexgeorgia nitens*, *Desmocladius fasciculatus*, *Lepidosperma scabrum*, *Mesomelaena psuedostygia* and *Schoenus grandiflorus*.

#### 4. *Banksia attenuata* and *Banksia menziesii* woodlands

*Banksia attenuata* and *Banksia menziesii* woodlands in very good to excellent condition, with few weeds occur near Burns Beach Road and between the proposed Lukin Drive and Romeo Road. The vegetation comprises sparse to open *Banksia menziesii* and *Banksia attenuata* to 5 metres, over scattered *Xanthorrhoea preissii* to 2 metres over sparse to open *Acacia pulchella*, *Jacksonia sternbergiana* and *Xanthorrhoea preissii*. Low shrubs provide sparse to moderately dense cover and include *Acacia pulchella*, *Calothamnus quadrifidus*, *Conostephium pendulum*, *Gompholobium tomentosum*, *Hibbertia hypericoides*, *Leucopogon polymorphus*, *Petrophile brevifolia*, *Petrophile linearis* and *Scaevola canescens*. Herbs and climbers were relatively sparse *Burnetia nigricans*, *Conostylis aculeata* ssp. *cygnorum*, *Drosera* sp., *Drosera erythrorhiza*, *Conostylis candicans*, *Conostylis teretifolia* ssp. *planescens*, *Dianella revoluta*, *Lagenifera huegellii*, *\*Gladiolus caryophyllaceus*, *\*Hypochaeris glabra*, *\*Medicago* sp. and *\*Ursinia anthemoides* with scattered grasses *\*Briza maxima* and *\*Ehrharta calycina*; and scattered to moderately dense *Desmocladius fasciculatus*, *Mesomelaena pseudostygia* and *Schoenus latitans*.

#### 5. *Banksia attenuata* and *Allocasuarina fraseriana* woodlands

*Banksia attenuata* and *Allocasuarina fraseriana* woodland occurs in the northern-most part of the study area adjoining Romeo Road. The entire community is in very good to excellent condition. It comprises scattered to sparse *Allocasuarina fraseriana* to 15 metres over scattered to open *Banksia attenuata*, *B. menziesii* and *Eucalyptus tottiana*; over scattered *Jacksonia sternbergiana*, *Grevillea vestita* and *Xanthorrhoea preissii* to 2 metres and moderately dense, low shrubs including *Acacia huegellii*, *Astroloma pallidum*, *Bossiaea eriocarpa*, *Gompholobium tomentosum*, *Hakea lissocarpha*, *Jacksonia calcicola*, *Macrozamia reidleyi*, *Nemcia capitata*, *Persoonia saccata*, *Petrophile brevifolia*, *Petrophile linearis*, *Scaevola canescens*, *Synaphea spinulosa*. Herb and climber covered varied greatly from scattered to moderately dense and included *Buchardia ?congesta*, *\*Carpobrotus ?edulis*, *Cassytha ?racemosa*, *Conostylis aculeata* spp. *cygnorum*, *Conostylis candicans*, *Corynotheca ?micrantha*, *Dianella revoluta*, *Drosera erythrorhiza*, *Erodium* sp., *\*Gladiolus caryophyllaceus*, *Hovea trisperma*, *\*Hypochaeris glabra*, *Kennedia prostrata*, *Lomandra preissii*, *Opercularia vaginatum*, *Thysanotus dichotomus*, *\*Ursinia anthemoides*; over scattered grasses *Amphipogon turbinatus*, *\*Briza maxima*, *\*Ehrharta ?calycina*, *Stipa* sp. And scattered to moderately dense sedges *Alexgeorgia nitens*, *Desmocladius fasciculatus*, *Lepidosperma pubisquamum* and *Mesomelaena pseudostygia*.

#### 6. Mosaic of *Banksia* woodland and *Dryandra sessilis* heath

A relatively large proportion of the study area outside of the Neerabup National Park comprises highly degraded *Banksia* woodland and *Dryandra sessilis* heath. The shrub and herbaceous layers have largely been replaced by weeds or are just bare ground.

## Detailed flora survey sites for the Mitchell Freeway extension Burns Beach Road to Romeo Road Study Area.

### Explanation of codes

*	= Introduced species
	= Priority species
subsp.	= sub species
var.	= variety

### *Vegetation Condition*

Pristine	Vegetation pristine; no disturbance evident at all. Excellent Strata essentially intact; some signs of human non native disturbance; e.g. feral scats, litter, minor tracks.
Good	One or more strata significantly impacted; e.g. grazing, some weeds, some vegetation removal.
Poor	One or more strata severely impacted; e.g. dense weed invasion, substantial logging or tracks.
Degraded	Native vegetation largely or totally removed.

### *Density (Vegetation, leaf litter, wood litter)*

Scattered	0-2% total cover
Sparse	2-10%
Open	10-30%
Moderately dense	30-70%
Dense	70-100%

### *Fire History*

Recent	0-2 years (completely devoid of vegetation or vegetation re-seeding/reshooting. Eucalypts and shrubs may have juvenile foliage from rootstock and/or branches. Shrubs, spinifex, herbs and grasses may evident as seedlings)
Moderate	2-5 years (burn scars on shrubs and trees still obvious, shrubs and spinifex may not be fully mature but species composition resembles original vegetation)
Old	5 years + (Vegetation mature but burn scars evident on trees, no evidence of fire damage on shrubs, grasses, herbs and spinifex)
None evident	No burn scars evident. Vegetation mature.

**Quadrat 1:** *Dryandra sessilis* shrubland to 2.5 m over dense low shrubland to 1 m

Date: 5-6-99

Location: ca. 12 metres north of track running parallel to Burns Beach Road adjacent to Neerabup National Park See figure 4.1

Topography:	Hill crest
Slope:	Gentle - Southern aspect
Surface soil:	Sand - yellow on surface, brown below
Soil Texture:	No structure
Rock Type:	Limestone - occ. emergent solution pipes
Surface Layer Stones:	Thin humus
Leaf litter:	20%, 1 cm mainly under shrubs
Wood litter:	Moderate
Condition:	Very good
Disturbance details:	Grazed in past
Fire History	None evident
Total vegetation cover:	70/10% (overstorey/understorey)
Shrubs > 2 m	10 - 30%: <i>Dryandra sessilis</i>
Shrubs 1 - 2 m	0 - 2%: <i>Dryandra sessilis</i>
Shrubs 0.5-1 m	30 - 70%: <i>Hibbertia hypericoides</i>
Shrubs 0-0.5 m	10 - 30 %: <i>Hibbertia hypericoides</i> , <i>Dryandra lindleyana</i> , <i>Gompholobium tomentosum</i>
Herbs/ climbers	10-30%: <i>*Ursinia anthemoides</i> , <i>Cassytha ?racemosa</i> , <i>Drosera</i> sp., <i>Drosera erythrorhiza</i> , <i>Hypochaeris glabra</i> , <i>*Erodium</i> sp., <i>Eryngium</i> sp., <i>*Gladiolus caryophyllaceus</i> , <i>*Isotropis cuneifolia</i> , <i>Lomandra hermaphrodita</i> , <i>Lobelia</i> sp., <i>*Medicago</i> sp., <i>*Dittrichia graveolens</i>
Soft grasses	2 - 10%: <i>*Briza maxima</i> , <i>*Ehrharta calycina</i> , <i>Tetraria capillaris</i>
Sedgelike	0 - 2%: <i>Lepidosperma</i> sp. C

**Quadrat 2:** Scattered *Banksia* woodland to 4.5 m

Date:	5-6-99
Topography:	Hill crest
Slope:	Flat
Surface soil:	Yellowish brown sand
Soil texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	None evident
Leaf litter:	30% Cover, 0 - 1 cm deep
Distribution:	Mainly under shrubs

Wood litter:	Sparse
Condition:	Very good
Disturbance details:	Adjacent to tracks, grazing and public access in past
Fire History	None evident
Total vegetation cover:	75/25 % (overstorey/understorey)
Trees <5 m	2-10 %: <i>Banksia attenuata</i> , <i>Banksia menziesii</i>
Shrubs >2 m	0 -2 %: <i>Xanthorrhoea preissii</i>
Shrubs 1-2 m	2 -10 %: <i>Acacia pulchella</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	2 -10 %: <i>Hibbertia hypericoides</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	30 -70%: <i>Conostephium pendulum</i> , <i>Hibbertia hypericoides</i>
Herbs/Climbers	2 - 10%: <i>Burnetia nigricans</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Drosera</i> sp., <i>Drosera erythrorhiza</i> , <i>Conostylis</i> <i>candicans</i> , <i>Conostylis teretifolia</i> ssp. <i>planescens</i> , <i>Lagenifera huegellii</i> , * <i>Gladiolus caryophyllaceus</i> , * <i>Ursinia anthemoides</i>
Soft grass	0- 2%: * <i>Briza maxima</i>
Sedgeliike	0 - 2%: <i>Desmocladius fasciculatus</i> , <i>Mesomelaena pseudostygia</i> , <i>Schoenus latitans</i>

**Quadrat 3 :** *Dryandra sessilis*/*Jacksonia sternbergiana* heath to 3 m over *Hibbertia hypericoides* and *Xanthorrhoea preissii*.

Date:	13-6-99
Location:	
Topography:	Hill crest
Slope:	Flat
Surface soil:	Thin layer of coarse yellow sand over dark brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	Emergent limestone
Leaf litter:	60% 1 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Very good
Fire History	Very old
Total vegetation cover:	50%/20% (overstorey/understorey)
Shrubs > 2 m	10 -30%: <i>Dryandra sessilis</i> , <i>Jacksonia sternbergiana</i>
Shrubs 1 - 2 m	10 -30%: <i>Dryandra sessilis</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	2 -10%: <i>Hibbertia hypericoides</i>
Shrubs 0-0.5 m	30 -70%: <i>Hibbertia hypericoides</i> , <i>Dryandra lindleyana</i> , <i>Leucopogon propinquus</i>
Herbs/Climber	10-30%: <i>Drosera erythrorhiza</i> , * <i>Homeria ?flaccida</i> , * <i>Hypochaeris glabra</i> , * <i>Erodium</i> sp., * <i>Gladiolus</i> <i>caryophyllaceus</i> , * <i>Medicago</i> sp., * <i>Dittrichia graveolens</i> .

		<i>*Ursinia anthemoides</i>
Soft grasses	0 - 2 %:	<i>*Briza maxima, *Ehrharta calycina</i>
Sedgeliike	0 -2%:	<i>Mesomelaena pseudostygia, Schoenus latitans</i>
<b>Quadrat 4:</b>		<i>Banksia attenuata</i> open woodland with <i>Allocasuarina fraseriana</i>
Date:		6-6-99
Topography:		Undulating plain
Slope:		Flat
Surface soil:		Yellowish - brown
Soil texture:		Sand - no structure
Rock Type:		None apparent
Surface Layer Stones:		None
Leaf litter:		30% Cover , 0 - 5 cm Depth
Distribution:		Mainly under shrubs
Wood litter:		Moderate
Condition:		Excellent
Disturbance details:		Some rubbish dumping, few weeds
Fire History		Very old
Total vegetation cover:		95.5 % bare ground
Trees 5 - 15 m	2 -10%:	<i>Allocasuarina fraseriana</i>
Trees < 5 m	0 - 2%:	<i>Banksia attenuata, B. menziesii</i>
Shrubs > 2 m	0 - 2%:	<i>Jacksonia sternbergiana, Grevillea vestita</i>
Shrubs 1-2 m	30 - 70 %:	<i>Acacia pulchella, Grevillea vestita, Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30%:	<i>Macrozamia reidleyi, Persoonia saccata</i>
Shrubs 0-0.5 m	10 -30%:	<i>Bossiaea eriocarpa, Gompholobium tomentosum, Hakea lissocarpa, Jacksonia calcicola, Nemcia capitata, Petrophile brevifolia, Petrophile linearis, Scaevola canescens, Synaphea spinulosa</i>
Herbs/Climbers	2 - 10%:	<i>Burchardia ?congesta, *Carpobrotus ?edulis, Cassytha ?racemosa, Conostylis aculeata spp. cygnorum, Conostylis candicans, Corynotheca ?micrantha, Dianella revoluta, Droseraerythrorhiza, Erodium sp., *Gladioluscaryophylluceus, Hovea trisperma, *Hypochaeris glabra, Kennedia prostrata, Lomandra preissii, Opercularia vaginatum, Thysanotus dichotomus, *Ursinia anthemoides</i>
Soft grasses	0 -2%:	<i>Amphipogon turbinatus, *Briza maxima, *Ehrharta ?calycina, Stipa sp.</i>
Sedgeliike	10 -30%:	<i>Alexgeorgia nitens, Desmocladius fasciculatus, Lepidosperma pubisquamum, Lepidosperma sp. C., Mesomelaena pseudostygia</i>

<b>Quadrat 5 :</b>	Low shrubland
Date:	6-6-99
Topography:	Hill slope
Slope:	Gentle - Northern eastern aspect
Surface soil:	Yellow sand over dark brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Leaf litter:	2% 0.5 cm
Distribution:	Mainly under shrubs
Wood litter:	Negligible
Condition:	Very good
Fire History	None evident
Total vegetation cover:	not recorded
Shrubs 1-2 m	10 - 30%: <i>Acacia pulchella</i> , <i>Acacia saligna</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30%: <i>Calothamnus quadrifidus</i> , <i>Grevillea vestita</i>
Shrubs 0-0.5 m	10 - 30%: <i>Hakea trifurcata</i>
Herbs/Climbers	0 -2%: <i>*Hypochaeris glabra</i> , <i>*Ursinia anthemoides</i>
Soft Grasses	0 - 2% Young seedlings only
Sedgeliike	0 - 2%: <i>Lepidosperma pubisquamum</i> , <i>Lepidosperma scabrum</i>

**Quadrat 6 :** *Banksia attenuata*, *Allocasuarina fraseriana* open woodland to 6 m

Date:	6-6-99
Topography:	Hill slope
Slope:	Gentle - Northern aspect
Surface soil:	Yellow sand over dark brown sand
Soil Texture:	No structure
Leaf litter:	70% 1 -5 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Excellent
Disturbance details	Few herbaceous weeds
Fire History:	Old
Total vegetation cover:	80% (15% bare ground)
Trees 5 - 15 m	0 -2 %: <i>Allocasuarina fraseriana</i>
Trees < 5 m	2 -10%: <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i>
Shrubs > 2m	0 -2 %: <i>Jacksonia sternbergiana</i>
Shrubs 1-2 m	30-70 %: <i>Acacia pulchella</i> , <i>Jacksonia sternbergiana</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30 %: <i>Acacia pulchella</i> , <i>Jacksonia sternbergiana</i> , <i>Petrophile brevifolia</i>
Shrubs 0 - 0.5 m	0 - 20 %: <i>Acacia huegellii</i> , <i>Astroloma pallidum</i> , <i>Nemcia capitata</i> , <i>Petrophile linearis</i> , <i>Phyllanthus calycinus</i> , <i>Pimelea</i> sp. 1.

Herbs/Climbers	30 - 70%:	<i>Scaevola canescens</i> <i>Burchardia ?congesta</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Conostylis teretifolia</i> ssp. <i>planescens</i> , <i>Dianella revoluta</i> , <i>Drosera erythrorhiza</i> , * <i>Gladiolus caryophyllaceus</i> <i>Haemodorum paniculatum</i> , <i>Hardenbergiacomptoniana</i> , <i>Kennedia prostrata</i> , * <i>Pelargonium capitatum</i> , <i>Pterostylis vittata</i> , * <i>Ursinia anthemoides</i>
Soft Grasses	0 - 2%	* <i>Briza maxima</i> , * <i>Ehrharta ?calycina</i>
Sedgeline	10 - 30%:	<i>Alexgeorgia nitens</i> , <i>Desmocladius fasciculata</i> , <i>Lepidosperma pubisquamum</i> , <i>Mesomelaena pseudostygia</i> , <i>Schoenus latitans</i>
<b>Quadrat 7 :</b>		Very open <i>Banksia attenuata</i> , <i>B. menziesii</i> woodland to 4 m over sparse shrubs to 1 m and moderately dense shrubs to 0.5 metre
Date:		6-6-99
Topography:		Hill slope
Slope:		Gentle - Southern southern western aspect
Surface soil:		Orange brown sand
Soil Texture:		No structure
Leaf litter:		2% <0.5 cm
Distribution:		General
Wood litter:		Sparse
Condition:		Excellent
Disturbance details:		Few weedy herbaceous annuals
Fire History		None evident
Shrubs 0.5-1 m	2 - 10 %:	<i>Acacia pulchella</i> <i>Allocasuarina humilis</i>
Shrubs 0-0.5 m	10 - 30%:	<i>Calytrix flavescens</i> , <i>Hibbertia hypericoides</i> , <i>Gompholobium tomentosum</i> , <i>Cryptandra myricantha</i> , <i>Leucopogon polymorphus</i> , <i>Baekkea comphorosmae</i> , <i>Nemcia capitata</i>
Herbs/Climbers	2 - 10 %:	<i>Burnetia nigricans</i> , * <i>Carpobrotus edulis</i> , <i>Cassytha ?racemosa</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Conostylis teretifolia</i> ssp. <i>planescens</i> , <i>Eriochilus dilatatus</i> , * <i>Gladiolus caryophyllaceus</i> , <i>Glischrocaryon aurea</i> , <i>Kennedia prostrata</i> , <i>Lagenifera huegelli</i> , <i>Lomandra odora</i> , <i>Lomandra preissii</i> , * <i>Medicago</i> sp., <i>Patersonia occidentalis</i> , <i>Pterostylis vittata</i> , * <i>Ursinia anthemoides</i>
Soft Grasses	0 - 2%:	* <i>Briza maxima</i>
Sedgeline	0 - 2%:	<i>Desmocladius fasciculata</i> , <i>Lepidosperma pubisquamum</i> , <i>Mesomelaena Pseudostygia</i>

**Quadrat 8 : Scattered *Gyrostemon ramulosus* woodland**

Date:	6-6-99
Topography:	Hill slope
Slope:	Moderate to gentle - E
Surface soil:	Yellow sand over dark brown sand
Soil Texture:	No structure
Rock Type:	No rock evident
Surface Layer Stones:	
Leaf litter:	1% < 0.5 cm
Distribution:	Mainly under shrubs
Wood litter:	Sparse
Condition:	Good
Disturbance details:	Post fire – mainly bare ground and emergent weedy grasses
Fire History	Recent – very hot fire has killed many of the trees and shrubs
Total vegetation cover:	40% (40% bare ground)
Trees 5 – 15 m	10 – 30%: <i>Gyrostemon ramulosus</i>
Trees < 5m	0 – 2%: <i>Gyrostemon ramulosus</i>
Shrubs 1-2 m	2 -10%: <i>Jacksonia sternbergiana</i>
Shrubs 0.5-1 m	2 - 10%: <i>Hibbertia hypericoides</i> , <i>Jacksonia sternbergiana</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	2 - 10%: <i>Hibbertia hypericoides</i> , <i>Jacksonia calcicola</i> , <i>Phyllanthus calycinus</i>
Herbs/Climbers	0 - 2%: <i>*Arctotheca calendula</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Dianella revoluta</i> , <i>*Erodium</i> sp., <i>*Gladiolus caryophyllaceus</i> , <i>*Hypochaeris glabra</i> , <i>Lomandra</i> sp. 3, <i>*Lupinus</i> sp., <i>*Sonchus oleraceus</i>
Soft Grasses	0 - 2% <i>*Ehrharta calycina</i>
Sedgelike	0 - 2%: <i>Schoenus latitans</i>

**Quadrat 9 : Closed heath**

Date:	6-6-99
Topography:	Hill slope
Slope:	Gentle - W
Surface soil:	Yellow sand over brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	Emergent limestone boulders
Leaf litter:	5% up to 10cm depth
Distribution:	Mainly under shrubs
Wood litter:	Sparse
Condition:	Excellent
Disturbance details:	Few herbaceous weeds
Fire History	Very old

Total vegetation cover:	not recorded
Shrubs > 2m	0 - 2%: <i>Hakea prostrata</i> , <i>Xanthorrhoea preissii</i>
Shrubs 1-2 m	10 – 30%: <i>Acacia pulchella</i> , <i>Dryandra sessilis</i> , <i>Trymalium ledifolium</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	30 - 70%: <i>Calothammus quadrifidus</i> , <i>Hakea lissocarpha</i> , <i>Hibbertia hypericoides</i> , <i>Jacksonia calciola</i>
Shrubs 0-0.5 m	2 - 10%: <i>Calothammus quadrifidus</i> , <i>Dryandra lindleyana</i> , <i>Hibbertia hypericoides</i> , <i>Jacksonia calcicola</i> , <i>Petrophile brevifolia</i> , <i>Phyllanthus calycinus</i> , <i>Scaevola canescens</i>
Herbs/Climbers	0 - 2%: <i>*Carpobrotus edulis</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Drosera erythrorhiza</i> , <i>*Gladiolus caryophyllaceus</i> , <i>Hardenbergia comptoniana</i> , <i>*Hypochaeris glabra</i> , <i>Lomandra preissii</i> , <i>Lomandra</i> sp. 1, <i>*Medicago</i> sp., <i>*Ursinia anthemoides</i>
Soft Grasses	0 - 2% Seedlings only
Sedgeline	0 - 2%: <i>Desmocladus fasciculata</i> , <i>Lepidosperma pubisquamum</i> , <i>Mesomelaena pseudostygia</i>

### Quadrat 10 : Open Jarrah forest

Date:	6-6-99
Topography:	Hill crest
Slope:	Flat
Surface soil:	Brown sand
Soil Texture:	No structure
Rock Type:	not evident
Surface Layer Stones:	
Leaf litter:	40%; 1 – 6 cm depth
Distribution:	General
Wood litter:	Moderate
Condition:	Excellent
Disturbance details:	?Grazed in past
Fire History:	Old – very hot fires – trees blackened to 8 m

Total vegetation cover:	85% (1% bare ground)
Trees 5 – 15 m	10 – 30%: <i>Eucalyptus marginata</i>
Trees < 5 m	2 – 10%: <i>Eucalyptus marginata</i> , <i>Banksia attenuata</i>
Shrubs 1-2 m	10 - 30%: <i>Acacia pulchella</i> , <i>Macrozamia reidleyi</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30%: <i>Acacia pulchella</i> , <i>Allocasuarina humilis</i> , <i>Hakea lissocarpha</i> , <i>Hakea trifurcata</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	10 - 30%: <i>Conostephium pendulum</i> , <i>Gompholobium tomentosum</i> , <i>Hakea lissocarpha</i> , <i>Hibbertia hypericoides</i> , <i>Hovea trisperma</i> , <i>Leucopogon polymorphus</i> , <i>Leucopogon propinquus</i> , <i>Petrophile brevifolia</i> , <i>Petrophile linearis</i>
Herbs/Climbers	2 - 10%: <i>Caladenia</i> sp., <i>Cassytha ?racemosa</i> , <i>Chaemascilla corymbosa</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Conostylis teretifolia</i> ssp. <i>planescens</i> , <i>Drosera</i>

		<i>erthrorhiza</i> , <i>Kennedia prostrata</i> , * <i>Gladiolus caryophyllaceus</i> , <i>Hardenbergia comptoniana</i> , * <i>Hypochaeris glabra</i> , <i>Lagenifera huegelli</i> , <i>Lomandra hermaphrodita</i> , <i>Lomandra preissii</i> , <i>Pterostylis vittata</i> , * <i>Ursinia anthemoides</i> , <i>Xanthosia huegellii</i>
Soft Grasses	10 - 30%	* <i>Briza maxima</i> , * <i>Ehrharta calycina</i>
Sedgelike	0 - 2%:	<i>Desmocladius fasciculata</i> , <i>Mesomelaena pseudostygia</i>

**Quadrat 11 :** *Banksia attenuata*, *Banksia grandis* scattered woodland

Date:	9-6-99
Topography:	Hill crest
Slope:	Gentle - E
Surface soil:	Yellowish brown sand
Soil Texture:	No structure
Rock Type:	Not evident
Surface Layer Stones:	Massive low outcrops
Leaf litter:	5% 0 – 2 cm
Distribution:	Mainly under shrubs
Wood litter:	Plentiful
Condition:	Excellent
Disturbance details:	adjacent areas are recovering from a fire
Fire History	Moderate

Total vegetation cover:	65% (15% bare ground)
Trees 5 – 15 m	2 – 10 %: <i>Banksia grandis</i> , <i>Nuytsia floribunda</i>
Trees < 5 m	10 – 30 %: <i>Banksia attenuata</i>
Shrubs 1-2 m	10 – 30 %: <i>Acacia pulchella</i> , <i>Allocasuarina humilis</i> , <i>Hakea costata</i> , <i>Hakea ruscifolia</i>
Shrubs 0.5-1 m	2 - 10 %: <i>Acacia pulchella</i> , <i>Allocasuarina humilis</i>
Shrubs 0-0.5 m	10 - 30%: <i>Baeckea camphorosmae</i> , <i>Calytrix flavescens</i> , <i>Cryptandra myriantha</i> , <i>Hibbertia hypericoides</i> , <i>Gompholobium tomentosum</i> , <i>Leucopogon polymorphus</i> , <i>Nemcia capitata</i>
Herbs/Climbers	2 -10 %: * <i>Carpobrotus edulis</i> , <i>Dianella revoluta</i> , * <i>Hypochaeris glabra</i> , * <i>Crassula ?thunbergiana</i> , * <i>Raphanus raphanistrum</i> , <i>Trachymene caerulea (dead)</i> , * <i>Erodium sp.</i> , <i>Kennedia prostrata</i> , * <i>Medicago sp.</i> , <i>Conostylis candicans</i> , * <i>Euphorbia terracina</i> , * <i>Trifolium arvense var. arvense</i>
Soft Grasses	0 - 2%
Sedgelike	0 - 2%: * <i>Ehrharta calycina</i> <i>Desmocladius fasciculata</i>

**Quadrat 12 : Low dense heath to 1 m**

Date:	9-6-99
Topography:	Hill slope
Slope:	Moderate- North - western aspect
Surface soil:	Dark brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	Massive low outcrops
Leaf litter:	1% < 1 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Excellent
Fire History	None evident
Total vegetation cover:	90% (10% bare ground)
Shrubs 1-2 m	0 -2 %: <i>Anthocercis littorea, Hakea trifurcata</i>
Shrubs 0.5-1 m	10 - 30 %: <i>Hakea trifurcata, Dryandra sessilis, Melaleuca systina</i>
Shrubs 0-0.5 m	10 - 30%: <i>Grevillea thelmanniana, Dryandra lindleyana, Acacia lasiocarpa, Jacksonia calcicola, Gompholobium tomentosum</i>
Herbs/Climbers	2 -10 %: <i>*Carpobrotus edulis, Dianella revoluta, *Hypochaeris glabra, *Crassula ?thunbergiana, *Raphanus raphanistrum, Trachymene caerulea, *Erodium sp., Kennedia prostrata, *Medicago sp., Conostylis candicans, *Euphorbia terracina, *Trifolium arvense var. arvense</i>
Soft Grasses	0 - 2% <i>*Ehrharta calycina</i>
Sedgelike	0 - 2%: <i>Desmocladius fasciculata</i>

**Quadrat 13 : Open Tuart forest**

Date:	9-6-99
Topography:	Valley
Slope:	Gentle - Northern western aspect
Surface soil:	Orange sand over brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	Loose small limestone rocks
Leaf litter:	10% 0 - 2 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Very good
Fire History	Old
Total vegetation cover:	60% (30% bare ground)
Trees 5 - 15 m	10 - 30%: <i>Eucalyptus gomphocephala</i>

Trees < 5 m	2 - 10%:	<i>Eucalyptus gomphocephala</i>
Shrubs > 2 m	2 - 10%:	<i>Hakea prostrata</i>
Shrubs 1-2 m	10 - 30 %:	<i>Acacia pulchella, Dryandra sessilis, Hakea lissocarpha, Melaleuca systina, Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	2 - 10 %:	<i>Allocasuarina humilis, Leucopogon propinquus, Bossiaea eriocarpa, Macrozamia reidlei</i>
Shrubs 0-0.5 m	2 - 10%:	<i>Acacia saligna, Hakea trifurcata, Isotropis cuneifolia, Jacksonia calcicola, Kennedia prostrata</i>
Herbs/Climbers	0 -2%:	<i>Burchardia ?congesta, Conostylis candicans, Haemodorum paniculatum, *Hypochaeris glabra, *Lupinus sp., *Medicago sp., *Romulea rosea</i>
Soft Grasses	2 - 10%	<i>*Bromus diandrus, *Ehrharta calycina</i>
Sedgeliike	2 -10%:	<i>Desmocladius fasciculata, Lepidosperma pubisquamum, Lepidosperma sp. C, Tetraria capillaris</i>

**Quadrat 14 :** *Banksia menziesii* woodland

Date:	11-6-99
Topography:	Hill slope
Slope:	Gentle - Southern aspect
Surface soil:	Yellow/brown sand
Soil Texture:	Coherent - with humus
Rock Type:	Not evident
Leaf litter:	50% 2 - 15 cm
Distribution:	General
Wood litter:	Negligible
Condition:	Excellent (almost pristine)
Fire History	None evident
Total vegetation cover:	95% (5% bare ground)
Trees < 5 m	0 - 10%: <i>Banksia menziesii</i>
Shrubs > 2 m	0 - 2%: <i>Hakea lissocarpha</i>
Shrubs 1-2 m	10 - 30 %: <i>Acacia pulchella, Acacia triflora, Hakea lissocarpha, Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30 %: <i>Allocasuarina humilis, Bossiaea eriocarpa, Daviesia, Hibbertia hypericoides,</i>
Shrubs 0-0.5 m	10 - 30%: <i>Astroloma pallidum, Dryandra lindleyana, Petrophile macrostachya</i>
Herbs/Climbers	0 -2%: <i>*Anagalis arvensis, Burchardia ?congesta, Drosera erythrorhiza, *Erodium sp., *Gladiolus caryophyllaceus, Hovea trisperma, *Hypochaeris glabra, Lomandra sp. 1, *Medicago sp., Microtus ?uniflora, *Pelargonium capitatum, Thysanotus patersonii, *Ursinia anthemoides</i>
Grasses	0 - 2%
Sedgeliike	30 - 70%:
	<i>*Avena fatua, *Bromus diandrus, *Ehrharta calycina, *Lagurus ovatus</i>
	<i>Desmocladius fasciculata, Lepidosperma pubisquamum, Lepidosperma scabrum, Mesomelaena pseudostygia, Schoenus latitans</i>

<b>Quadrat 15 :</b>	<i>Dryandra sessilis</i> heath to 2 m
Date:	11-6-99
Topography:	Hill slope
Slope:	Moderate - NW
Surface soil:	Yellow sand
Soil Texture:	No structure
Rock Type:	Emergent limestone solution pipes
Surface Layer:	Occasional stones/rocks
Leaf litter:	10% 1 -2 cm
Distribution:	Mainly under shrubs
Wood litter:	Sparse
Condition:	Good
Fire History	Very old
Total vegetation cover:	65% (5% bare ground)
Trees < 5 m	0 - 2%: <i>Allocasuarina fraseriana</i>
Shrubs > 2m	10 - 30%: <i>Dryandra sessilis, Jacksonia sternbergiana</i>
Shrubs 1-2 m	10 - 30 %: <i>Dryandra sessilis</i>
Shrubs 0.5-1 m	10 - 30 %: <i>Calothamnus quadrifidus, Dryandra sessilis, Hakea lissocarpa</i>
Shrubs 0-0.5 m	2 - 10%: <i>Dryandra lindleyana, Grevillea thelmanniana, Hibbertia hypericoides, Nemcia capitata, Melaleuca systina</i>
Herbs/Climbers	2 - 10%: <i>Dianella revoluta *Gladiolus caryophyllaceus, Lomandra sp. 1, *Lupinus sp.</i>
Soft Grasses	30 - 70% <i>*Bromus diandrus, *Ehrharta calycina, Stipa sp.</i>
Sedgelike	2 - 10%: <i>Desmocladus fasciculata, Lepidosperma pubisquamum</i>
<b>Quadrat 16 :</b>	<i>Banksia attenuata</i> woodland scattered to 6 m over open shrubs
Date:	11-6-99
Topography:	Undulating plain
Slope:	Flat
Surface soil:	Yellow sand over dark brown sand
Soil Texture:	No structure
Rock Type:	Probably limestone at depth
Surface Layer Stones:	none
Leaf litter:	2% 0 - 1 cm
Distribution:	General
Wood litter:	Moderate
Condition:	Excellent
Fire History	Old
Total vegetation cover:	60% (10% bare ground)
Trees 5 - 15 m	2 - 10%: <i>Banksia attenuata</i>
Trees < 5 m	0 - 2 %: <i>Banksia attenuata</i>
Shrubs > 2 m	2 - 10%: <i>Acacia saligna, Jacksonia sternbergiana, Xanthorrhoea</i>

		<i>preissii</i>
Shrubs 1-2 m	2 - 10 %:	<i>Hakea prostrata</i> , <i>Jacksonia sternbergiana</i> , <i>Macrozamia reidlei</i>
Shrubs 0.5-1 m	10 - 30 %:	<i>Hakea trifurcata</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	10 - 30%:	<i>Gompholobium tomentosum</i> , <i>Hakea trifurcata</i> , <i>Hibbertia hypericoides</i> , <i>Jacksonia calcicola</i>
Herbs/Climbers	0 - 2%:	<i>Burchardia ?congesta</i> , <i>Burnetia nigricans</i> , * <i>Carpobrotus edulis</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Corynotheca ?micrantha</i> , <i>Drosera erythrorhiza</i> , * <i>Hypochaeris glabra</i> , <i>Lagenifera huegelli</i> , <i>Lomandra</i> sp. 1, * <i>Romulea rosea</i> , <i>Thysanotus patersonii</i>
Soft Grasses	0 - 2%	* <i>Briza maxima</i>
Sedgelike	30 - 70%:	<i>Desmocladius fasciculatus</i> , <i>Lepidosperma pubisquamem</i> , <i>Mesomelaena pseudostygia</i> , <i>Tetraria capillaris</i>

**Quadrat 17 :** *Acacia pulchella* heath to 1.5 m with emergent *Xanthorrhoea preissii* to 2.5 m and occ. *Nuytsia floribunda* to 2.5 m

Date:	11-6-99
Topography:	Hill slope
Slope:	Gentle - Northern aspect
Surface soil:	Brown sand
Soil Texture:	No structure
Rock Type:	Limestone
Leaf litter:	2% < 1 cm
Distribution:	Mainly under shrubs
Wood litter:	Moderate
Condition:	Excellent
Fire History	Very old

Total vegetation cover:	60% (10% bare ground)	
Trees < 5 m	0 - 2 %:	<i>Banksia attenuata</i> , <i>Nuytsia floribunda</i>
Shrubs > 2 m	0 - 2 %:	<i>Dryandra sessilis</i> , <i>Xanthorrhoea preissii</i>
Shrubs 1-2 m	30 - 70 %:	<i>Acacia pulchella</i> , <i>Dryandra sessilis</i>
Shrubs 0.5-1 m	10 - 30 %:	<i>Calothamnus quadrifidus</i> , <i>Dryandra sessilis</i> , <i>Leucopogon polymorphus</i>
Shrubs 0-0.5 m	10 - 30%:	<i>Hakea costata</i> , <i>Hakea lissocarpha</i> , <i>Hakea serruriae</i> , <i>Hakea trifurcata</i> , <i>Leucopogon oxycedrus</i>
Herbs/Climbers	2 - 10%:	* <i>Carpobrotus edulis</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , * <i>Gladiolus caryophyllaceus</i> , <i>Gompholobium tomentosum</i> , * <i>Hypochaeris glabra</i> , <i>Lagenifera huegelli</i> , <i>Pterostylis vittata</i> , <i>Thysanotus patersonii</i> , * <i>Ursinia anthemoides</i>
Sedgelike	0 - 2%:	<i>Schoenus grandiflorus</i>

**Quadrat 18 :** *Banksia menziesii* and *B. attenuata* woodland to 5 m over open shrubland over moderately dense shrubland

Date: 12-6-99  
 Topography: Valley  
 Slope: Gentle - Southern aspect  
 Surface soil: Yellow sand over dark brown sand  
 Soil Texture: No structure  
 Rock Type: Not evident  
 Leaf litter: 5% < 2 cm  
 Distribution: General  
 Wood litter: Sparse  
 Condition: Excellent  
 Fire History: Old

Total vegetation cover: 60% (20% bare ground)  
 Trees < 5 m 2 - 10%: *Banksia attenuata*, *Banksia menziesii*  
 Shrubs > 2 m 0 - 2%: *Xanthorrhoea preissii*  
 Shrubs 1-2 m 0 - 2%: *Jacksonia sternbergiana*, *Xanthorrhoea preissii*  
 Shrubs 0.5-1 m 0 - 2%: *Xanthorrhoea preissii*  
 Shrubs 0-0.5 m 10 - 30%: *Acacia pulchella*, *Calothamnus quadrifidus*,  
*Conostephium pendulum*, *Gompholobium tomentosum*,  
*Hibbertia hypericoides*, *Petrophile brevifolia*, *Petrophile linearis*, *Scaevola canescens*  
 Herbs/Climbers 0 - 2%: *\*Burnetia nigricans*, *Conostylis aculeata* ssp. *cygnorum*,  
*Conostylis teretifolia* ssp. *planescens*, *Dianella revoluta*,  
*Drosera erythrorhiza*, *\*Gladiolus caryophyllaceus*  
*\*Hypochaeris glabra*, *Hybanthus floribundus*,  
*\*Medicago* sp., *\*Pelargonium capitatum*, *Drosera* sp.,  
*\*Sonchus oleraceus*, *\*Ursinia anthemoides*  
 Soft Grasses 0 - 2% *\*Briza maxima*, *\*Ehrharta calycina*  
 Sedgelike 10 - 30%: *Desmocladius fasciculatus*, *Mesomelaena pseudostygia*,  
*Schoenus latitans*

**Quadrat 19:** Low species rich heath to 1m

Date: 12-6-99  
 Topography: Rocky outcrop  
 Slope: Gentle (several aspects)  
 Surface soil: Thin yellow sandy loam layer over dark brown sandy loam  
 Soil Texture: Coherent  
 Rock Type: Limestone  
 Leaf litter: 1% < 1 cm  
 Distribution: General  
 Wood litter: Sparse  
 Condition: Excellent  
 Fire History: None evident

Total vegetation cover:	75% (5% bare ground)
Shrubs 0.5-1 m	10 - 30 %: <i>Acacia huegelli</i> , <i>Leucopogon propinquus</i> , <i>Melaleuca huegelli</i> , <i>Pimelea argentea</i> , <i>Templetonia retusa</i>
Shrubs 0-0.5 m	30 - 70%: <i>Acacia lasiocarpa</i> , <i>Cryptandra myriantha</i> , <i>Daviesia triflora</i> , <i>Dryandra lindleyana</i> , <i>Gompholobium tomentosum</i> , <i>Grevillea thelmanniana</i> , <i>Leptomeria pauciflora</i>
Herbs/Climbers	0 -2%: <i>Drosera</i> sp., <i>Cassytha ?racemosa</i> , * <i>Gladiolus caryophyllaceus</i> , * <i>Hypochaeris glabra</i> , <i>Lomandra maritima</i> , * <i>Lupinus</i> sp., <i>Orobanche minor</i> , <i>Stylidium schoenoides</i>
Soft Grasses	0 - 2% * <i>Lolium</i> sp.
Sedgeliike	2 -10%: <i>Desmocladius fasciculata</i> , <i>Lepidosperma ?costale</i> , <i>Lepidosperma pubisquameum</i>

**Quadrat 20 : Open Jarrah woodland to 15 m**

Date:	12-6-99
Topography:	Valley
Slope:	Gentle - Eastern aspect
Surface soil:	Dark brown sandy loam
Soil Texture:	Coherent
Rock Type:	Not evident
Leaf litter:	30% 1 -10 cm
Distribution:	General
Wood litter:	Moderate
Condition:	Excellent
Fire History	Old

Total vegetation cover:	80% (2% bare ground)
Trees 5 - 15 m	10 - 30%: <i>Eucalyptus marginata</i>
Trees < 5 m	0 -2 %: <i>Eucalyptus marginata</i>
Shrubs 1-2 m	0 - 2 %: <i>Allocasuarina humilis</i> , <i>Hakea ruscifolia</i>
Shrubs 0.5-1 m	2 - 10 %: <i>Acacia pulchella</i> , <i>Hakea lissocarpa</i> , <i>Hakea ruscifolia</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	30 - 70%: <i>Astroloma pallidum</i> , <i>Bossiaea erocarpha</i> , <i>Calytrix flavescens</i> , <i>Conostephium pendulum</i> , <i>Gompholobium tomentosum</i> , <i>Hibbertia hypericoides</i> , <i>Hovea trisperma</i> , <i>Petrophile linearis</i> , <i>Petrophile brevifolia</i> , <i>Stirlingia latifolia</i>
Herbs/Climbers	2 - 10%: <i>Burchardia ?congesta</i> , <i>Burnetia nigricans</i> , * <i>Carpobrotus edulis</i> , <i>Conostylis teretifolia</i> ssp. <i>planescens</i> , <i>Dianella revoluta</i> , <i>Drosera</i> sp., <i>Drosera erythrorhiza</i> , <i>Haemodorum paniculatum</i> , * <i>Gladiolus caryophyllaceus</i> , <i>Hardenbergia comptoniana</i> , * <i>Hypochaeris glabra</i> , <i>Lomandra preissii</i> , * <i>Medicago</i> sp., <i>Orthrosanthus latus</i> , <i>Pterostylis vittata</i>

Soft Grasses	0 - 2%	<i>Stipa</i> sp., <i>Grass indeterminate</i>
Sedgeliike	2 - 10%:	<i>Alexgeorgia nitens</i> , <i>Desmocladius fasciculatus</i> , <i>Lepidosperma scabrum</i> , <i>Mesomelaena psuedostygia</i> , <i>Schoenus grandiflorus</i> , <i>Tetraria octandra</i>

**Quadrat 21 :** **Moderately dense heath to 2.5 m**

Date:	12-6-99
Topography:	Hill crest
Slope:	Flat
Surface soil:	Deep yellow sand
Soil Texture:	No structure
Rock Type:	Limestone
Surface Layer Stones:	occ. emergent small limestones
Leaf litter:	1% < 1 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Excellent
Fire History	Old
Total vegetation cover:	80% (5% bare ground)
Shrubs > 2 m	2 -10%: <i>Dryandra sessilis</i> , <i>Hakea prostrata</i> , <i>Xanthorrhoea preissii</i>
Shrubs 1-2 m	2 - 10%: <i>Calothamnus quadrifidus</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30 %: <i>Calothamnus quadrifidus</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	10 - 30%: <i>Hibbertia hypericoides</i> , <i>Melaleuca systina</i>
Herbs/Climbers	0 -2%: * <i>Gladiolus caryophyllaceus</i> , * <i>Hypochaeris glabra</i> , * <i>Medicago</i> sp., * <i>Pelargonium capitatum</i>
Soft Grasses	0 - 2% Indeterminate seedlings only
Sedgeliike	2 - 10%: <i>Desmocladius fasciculatus</i> , <i>Mesomelaena pseudostygia</i>

**Quadrat 22 :** **Mixed heath**

Date:	12-6-99
Topography:	Hill slope
Slope:	Gentle - Eastern aspect
Surface soil:	Yellow sand over dark brown sand over yellow sand (ants nests)
Soil Texture:	No structure
Rock Type:	Not evident
Leaf litter:	5% 0 - 2 cm
Distribution:	Mainly under shrubs
Wood litter:	Sparse
Condition:	Very good
Fire History	None evident
Total vegetation cover:	not recorded

Shrubs > 2 m	0 -2 %:	<i>Dryandra sessilis</i>
Shrubs 1-2 m	2 - 10 %:	<i>Calothamnus quadrifidus</i> , <i>Hakea lissocarpha</i> , <i>Hakea trifurcata</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	10 - 30 %:	<i>Allocasuarina humilis</i> , <i>Calothamnus quadrifidus</i> , <i>Hibbertia hypericoides</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	10 - 30%:	<i>Calothamnus quadrifidus</i> , <i>Dryandra lindleyana</i> , <i>Hibbertia hypericoides</i> , <i>Hovea trisperma</i>
Herbs/Climbers	2 - 10 %:	* <i>Carpobrotus edulis</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Drosera</i> sp., <i>Drosera erythrorhiza</i> , * <i>Hypochaeris glabra</i> , * <i>Gladiolus caryophyllaceus</i> , * <i>Medicago</i> sp., * <i>Pelargonium capitatum</i> , * <i>Ursinia anthemoides</i>
Soft Grasses	0 - 2%	Indeterminate seedlings only
Sedgeliike	10 - 30%:	<i>Mesomelaena pseudostygia</i> , <i>Desmocladius fasciculatus</i>

**Quadrat 23 :** *Allocasuarina fraseriana*, *Banksia attenuata*, *Banksia menziesii* woodland to 8 m with occ. *Eucalyptus todtiana*

Date:	6-6-99
Topography:	Hill slope
Slope:	Gentle - Southern aspect
Surface soil:	Grey sand over dark brown sand
Soil Texture:	No structure
Rock Type:	Not evident
Leaf litter:	2% 0.5 cm
Distribution:	General
Wood litter:	Sparse
Condition:	Very good
Fire History	Very old hot fire

Total vegetation cover: 25% (2% bare ground)

Trees 5 - 15 m	2 -10%:	<i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Eucalyptus todtiana</i>
Trees < 5 m	10 - 30%:	<i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Eucalyptus todtiana</i>
Shrubs 0.5-1 m	2 - 10%:	<i>Hibbertia hypericoides</i> , <i>Petrophile linearis</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	10 - 30%:	<i>Hibbertia hypericoides</i> , <i>Petrophile linearis</i> , <i>Stirlingia latifolia</i>
Herbs/Climbers	0 -2%:	<i>Burnetia nigricans</i> , <i>Dianella revoluta</i> , <i>Drosera erythrorhiza</i> , * <i>Gladiolus caryophyllaceus</i> , <i>Lagenifera huegelli</i> , <i>Pterostylis vittata</i> , * <i>Ursinia anthemoides</i>
Soft Grasses	0 - 2%	* <i>Briza maxima</i> , * <i>Ehrharta calycina</i>
Sedgeliike	0 - 2%:	<i>Alexgeorgia nitens</i> , <i>Desmocladius fasciculata</i> , <i>Lygima barbata</i>

**Quadrat 25 :** *Banksia attenuata/B. menziesii/Allocasuarina fraseriana to 6 m occ. Eucalyptus tottiana*

Date:	13-6-99
Topography:	Hill slope
Slope:	Gentle - Southern western aspect
Surface soil:	Grey coarse sand over brown sand
Soil Texture:	No structure
Rock Type:	Not evident
Leaf litter:	80% 1 -30 cm (under <i>Allocasuarina</i> )
Distribution:	General
Wood litter:	Sparse
Condition:	Excellent
Fire History	Very old
Total vegetation cover:	40% (5% open ground)
Trees 5 - 15 m	10 - 30%: <i>Allocasuarina fraseriana, Banksia attenuata, Banksia menziesii</i>
Trees < 5 m	2 - 10%: <i>Banksia attenuata, Banksia menziesii</i>
Shrubs 1-2 m	0 - 2 %: <i>Xanthorrhoea preissii</i>
Shrubs 0-0.5 m	30 - 70%: <i>Acacia lasiocarpa, Bossiaea eriocarpa, Conostephium pendulum, Daviesia triflora, Gompholobium tomentosum, Hibbertia hypericoides, Leucopogon propinquus, Petrophile linearis, Stirlingia latifolia</i>
Herbs/Climbers	0 -2%: <i>Conostylis aculeata ssp. cygnorum, Drosera erythrorhiza, *Hypochaeris glabra, *Gladiolus caryophyllaceus, Lagenifera huegelli, Pterostylis vittata, *Ursinia anthemoides</i>
Soft Grasses	0 - 2% <i>*Briza maxima</i>
Sedgeliike	0 - 2%: <i>Alexgeorgia nitens, Desmocladius fasciculata, Lyginia barbata, Mesomelaena pseudostygia</i>

**Quadrat 26 :** *Eucalyptus marginata, Allocasuarina fraseriana and Acacia saligna*

Date:	13-6-99:
Topography:	Hill slope
Slope:	Gentle
Surface soil:	Thin yellow sand layer over brown sand
Soil Texture:	No structure
Rock Type:	Not evident
Leaf litter:	75% 3 - 10 cm
Distribution:	General
Wood litter:	Moderate
Condition:	Excellent
Fire History:	Very old

Total vegetation cover:	70% (2% open ground)	
Trees 5 - 15 m	30 - 70%:	<i>Acacia saligna</i> , <i>Allocasuarina fraseriana</i> , <i>Eucalyptus marginata</i> .
Shrubs 1-2 m	2 - 10%:	<i>Hakea lissocarpa</i> , <i>Macrozamia preissii</i> , <i>Xanthorrhoea preissii</i>
Shrubs 0.5-1 m	2 - 10 %:	<i>Hibbertia hypericoides</i>
Shrubs 0-0.5 m	30 - 70%:	<i>Acacia pulchella</i> , <i>Bossiaea eriocarpa</i> , <i>Dryandra lindleyana</i> , <i>Hibbertia hypericoides</i> , <i>Isotropis cuneifolia</i> , <i>Petrophile brevifolia</i>
Herbs/Climbers	10 - 30%:	<i>Burnetia nigricans</i> , <i>Conostylis aculeata</i> ssp. <i>cygnorum</i> , <i>Drosera erythrorhiza</i> , <i>*Homeria ?flaccida</i> , <i>*Hypochaeris glabra</i> , <i>Lagenifera huegelli</i> , <i>Hardenbergia comptoniana</i> , <i>Pterostylis vittata</i>
Soft Grasses	0 - 2%	<i>*Ehrharta calycina</i>
Sedgelike	0 - 2%:	<i>Desmocladius fasciculata</i> , <i>Lepidosperma ?pubisquamum</i> , <i>Mesomelaena pseudostygia</i>

## APPENDIX G

### Vertebrate Fauna Species that Potentially Occur within the Proposed Mitchell Freeway Transportation Corridor

#### MAMMALS

#### BIRDS

#### AMPHIBIANS AND REPTILES

#### ABBREVIATIONS

- R1 Schedule 1 species
- P1 Priority 1 species
- P2 Priority 2 species
- P3 Priority 3 species
- P4 Priority 4 species
- 3 Reduced distribution on  
Swan Coastal Plain
- 5 Reduced populations  
on Swan Coastal Plain

**MAMMALS**

Scientific Name	Common Name	Status
<u>NATIVE MAMMALS</u>		
TACHYGLOSSIDAE		
<i>Tachyglossus aculeatus</i>	Echidna	
PERAMELIDAE		
<i>Isoodon obesulus</i>	Southern Brown Bandicoot	P4
DASYURIDAE		
<i>Dasyurus geoffroii</i>	Chuditch	R1
<i>Sminthopsis griseoventer</i>	Grey-bellied Dunnart	
PHALANGERIDAE		
<i>Trichosurus vulpecula</i>	Common Brushtail Possum	
BURRAMYIDAE		
<i>Cercartetus concinnus</i>	Western Pygmy-possum	
TARSIPEDIDAE		
<i>Tarsipes rostratus</i>	Honey-possum	
MACROPODIDAE		
<i>Macropus fuliginosus</i>	Western Grey Kangaroo	
<i>Macropus irma</i>	Western Brush Wallaby	P4
MOLOSSIDAE		
<i>Nyctinomus australis</i>	White-striped Mastiff Bat	
<i>Mormopterus planiceps</i>	Little Mastiff-bat	
VESPERTILIONIDAE		
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat	
<i>Nyctophilus gouldii</i>	Gould's Long-eared Bat	
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	
<i>Chalinolobus morio</i>	King River Eptesicus	
MURIDAE		
<i>Pseudomys albocinereus</i>	Ash-grey Mouse	
<i>Rattus fuscipes</i>	Bush Rat	
<u>INTRODUCED MAMMALS</u>		
<i>Felis catus</i>	Feral Cat	
<i>Canis familiaris</i>	Domestic Dog	
<i>Vulpes vulpes</i>	Fox	
<i>Oryctolagus cuniculus</i>	European Rabbit	
<i>Mus musculus</i>	House Mouse	
<i>Rattus norvegicus</i>	Brown Rat	
<i>Rattus rattus</i>	Black Rat	
<i>Ovis aries</i>	Sheep	

**BIRDS**

Scientific Name	Common Name	Status
<b>DROMAIIDAE</b>		
<i>Dromaius novaehollandiae</i>	Emu	
<b>ACCIPITRIDAE</b>		
<i>Elanus axillaris</i>	Black-shouldered Kite	
<i>Haliastur sphenurus</i>	Whistling Kite	4
<i>Accipiter fasciatus</i>	Brown Goshawk	4
<i>Accipiter cirrhocephalus</i>	Collared Sparrowhawk	4
<i>Aquila audax</i>	Wedge-tailed Eagle	4
<i>Hiraaetus morphnoides</i>	Little Eagle	4
<i>Circus assimilis</i>	Spotted Harrier	
<i>Circus aeruginosus</i>	Swamp Harrier	
<b>FALCONIDAE</b>		
<i>Falco peregrinus</i>	Peregrine Falcon	R4, 4
<i>Falco longipennis</i>	Australian Hobby	
<i>Falco berigora</i>	Brown Falcon	4
<i>Falco cenchroides</i>	Australian Kestrel	
<b>TURNICIDAE</b>		
<i>Turnix varia</i>	Painted Button-quail	4
<b>COLUMBIDAE</b>		
<i>Phaps chalcoptera</i>	Common Bronzewing	3
<i>Ocyphaps lophotes</i>	Crested Pigeon	
<b>CACATUIDAE</b>		
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	R1, 4
<i>Cacatua roseicapilla</i>	Galah	
<b>PSITTACIDAE</b>		
<i>Purpureicephalus spurius</i>	Red-capped Parrot	
<i>Platycercus icterotis</i>	Western Rosella	4
<i>Barnardius zonarius</i>	Port Lincoln Ringneck	
<i>Neophema elegans</i>	Elegant Parrot	
<b>CUCULIDAE</b>		
<i>Cuculus pallidus</i>	Pallid Cuckoo	
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	
<i>Chrysococcyx basalis</i>	Horsfield's Bronze-cuckoo	
<i>Chrysococcyx lucidus</i>	Shining Bronze-cuckoo	
<b>STRIGIDAE</b>		
<i>Ninox novaeseelandiae</i>	Southern Boobook	
<b>TYTONIDAE</b>		
<i>Tyto alba</i>	Barn Owl	
<b>PODARGIDAE</b>		
<i>Podargus strigoides</i>	Tawny Frogmouth	
<b>AEGOTHELIDAE</b>		
<i>Aegotheles cristatus</i>	Owlet-nightjar	
<b>APODIDAE</b>		
<i>Apus pacificus</i>	Fork-tailed Swift	
<b>ALCEDINIDAE</b>		
<i>Todiramphus sanctus</i>	Sacred Kingfisher	
<b>MEROPIDAE</b>		
<i>Merops ornatus</i>	Rainbow Bee-eater	

HIRUNDINIDAE		
<i>Cheramoeca leucosternum</i>	White-backed Swallow	
<i>Hirundo neoxena</i>	Welcome Swallow	
<i>Hirundo nigricans</i>	Tree Martin	
<i>Hirundo ariel</i>	Fairy Martin	
MOTACILLIDAE		
<i>Anthus novaeseelandiae</i>	Richard's Pipit	
CAMPEPHAGIDAE		
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	
<i>Lulage sueurii</i>	White-winged Triller	
PETROICIDAE		
<i>Petroica multicolor</i>	Scarlet Robin	3
<i>Melanodryas cucullata</i>	Hooded Robin	3
<i>Eopsaltria georgiana</i>	White-breasted Robin	3
PACHYCEPHALIDAE		
<i>Pachycephala pectoralis</i>	Golden Whistler	3
<i>Pachycephalus rufiventris</i>	Rufous Whistler	
<i>Colluricincla harmonica</i>	Grey Shrike-Thrush	3
<i>Oreocica gutturalis</i>	Crested Bellbird	
DICRURIDAE		
<i>Rhipidura fuliginosa</i>	Grey Fantail	
<i>Rhipidura leucophrys</i>	Willie Wagtail	
MALURIDAE		
<i>Malurus splendens</i>	Splendid Fairy-wren	3
<i>Malurus leucopterus</i>	White-winged Fairy-wren	3
PARDALOTIDAE		
<i>Calamanthus fuliginosus</i>	Striated Calamanthus	
<i>Sericornis brevirostris</i>	Weebill	3
<i>Sericornis frontalis</i>	White-browed Scrubwren	3
<i>Gerygone fusca</i>	Western Gerygone	
<i>Acanthiza apicalis</i>	Inland Thornbill	3
<i>Acanthiza inornata</i>	Western Thornbill	3
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	3
<i>Pardalotus punctatus</i>	Spotted Pardalote	
<i>Pardalotus striatus</i>	Striated Pardalote	
NEOSITTIDAE		
<i>Daphoenositta chrysoptera</i>	Varied Sittella	3
MELIPHAGIDAE		
<i>Anthochaera carunculata</i>	Red Wattlebird	
<i>Anthochaera chrysoptera</i>	Little Wattlebird	4
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	
<i>Lichenostomus virescens</i>	Singing Honeyeater	
<i>Melithreptus lunatus</i>	White-naped Honeyeater	4
<i>Lichmera indistincta</i>	Brown Honeyeater	
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	4
<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	4
<i>Acanthorhynchus superciliosus</i>	Western Spinebill	
DICAETIDAE		
<i>Dicaeum hirundinaceum</i>	Mistletoe Bird	
ZOSTEROPIDAE		
<i>Zosterops lateralis</i>	Silvereye	
ARTAMIDAE		
<i>Artamus cinereus</i>	Black-faced Woodswallow	4

<i>Artamus cyanopterus</i>	Dusky Woodswallow	4
<i>Cracticus torquatus</i>	Grey Butcherbird	
<i>Cracticus nigrogularis</i>	Pied Butcherbird	
<i>Gymnorhina tibicen</i>	Australian Magpie	
CORVIDAE		
<i>Corvus coronoides</i>	Australian Raven	

INTRODUCED BIRDS

<i>Columba livia</i>	Feral Pigeon
<i>Streptopelia chinensis</i>	Spotted Turtle-dove
<i>Streptopelia senegalensis</i>	Laughing Turtle-dove
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet
<i>Dacelo novaeguineae</i>	Laughing Kookaburra

**REPTILES AND AMPHIBIANS**

Scientific Name	Common Name	Status
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Amphibians

## MYOBATRACHIDAE

<i>Crinia georgiana</i>	Quacking Frog
<i>Crinia insignifera</i>	
<i>Heleioporus eyrei</i>	Moaning Frog
<i>Heleioporus psammophilus</i>	
<i>Limnodynastes dorsalis</i>	Banjo Frog
<i>Myobatrachus gouldii</i>	Turtle Frog
<i>Litoria moorei</i>	Motorbike Frog

Reptiles

## Lizards

## GEKKONIDAE

<i>Christinus marmoratus</i>	Marbled Gecko
<i>Crenadactylus ocellatus</i>	Clawless Gecko
<i>Diplodactylus polyophthalmus</i>	
<i>Diplodactylus spinigerus</i>	Western Spiny-tailed Gecko
<i>Underwoodisaurus milii</i>	Thick-tailed Gecko

## PYGOPODIDAE

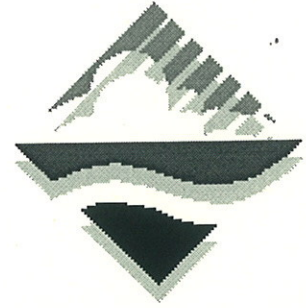
<i>Aclys concinna</i>	
<i>Aprasia repens</i>	Fry's worm lizard
<i>Delma fraseri</i>	
<i>Delma grayii</i>	
<i>Lialis burtonis</i>	Burton's Snake Lizard
<i>Pletholax gracilis</i>	
<i>Pygopus lepidopodus</i>	Common Scaly-foot

## AGAMIDAE

<i>Pogona minor</i>	Western Bearded Dragon
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<i>Tympanocryptis adelaidensis</i>		
VARANIDAE		
<i>Varanus gouldii</i>	Gould's Monitor	
<i>Varanus tristis</i>	Black-headed Monitor	
SCINCIDAE		
<i>Cryptoblepharus plagiocephalus</i>	Fence Skink	
<i>Ctenotus fallens</i>		
<i>Ctenotus gemmula</i>		
<i>Ctenotus impar</i>		
<i>Ctenotus leseurii</i>		
<i>Cyclodomorphus branchialis</i>	Gunther's Skink	
<i>Egernia napoleonis</i>		
<i>Hemiergis quadrilineata</i>		
<i>Lerista elegans</i>		
<i>Lerista lineopunctulata</i>		
<i>Lerista praepedita</i>		
<i>Menetia greyii</i>	Grey's Skink	
<i>Morethia lineoocellata</i>		
<i>Morethia obscura</i>		
<i>Tiliqua occipitalis</i>	Western Blue-tongued Lizard	
<i>Tiliqua rugosa</i>	Bobtail	
Snakes		
TYPHLOPIDAE		
<i>Ramphotyphlops australis</i>		
BOIDAE		
<i>Morelia spilota imbricata</i>	Carpet Python	R4
ELAPIDAE		
<i>Demansia psammophis</i>	Yellow-faced Whipsnake	
<i>Drysdalia coronata</i>	Crowned Snake	
<i>Echiopsis curtus</i>	Bardick	
<i>Notechis scutatus</i>	Tiger Snake	
<i>Pseudonaja affinis</i>	Dugite	
<i>Simoselaps bertholdi</i>	Jan's Banded Snake	
<i>Simoselaps bimaculatus</i>	Black-naped Snake	
<i>Simoselaps calonotus</i>	Black-striped Snake	
<i>Simoselaps semifasciatus</i>	Southern Shovel-nosed Snake	
<i>Suta gouldii</i>	Black-headed Snake	

# Facsimile Message



**ATTENTION:** Terresa Gepp / Rob Towers  
**ORGANISATION:** CALM Wanneroo  
**FROM:** Gary Whisson  
**DATE:** 8/6/99  
**TELEPHONE:** 9222 7171  
**PAGES:** 3 following  
**SUBJECT:** Draft Veg Report Rail Yards Neerabup National Park

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## MESSAGE:

Teresa

As discussed the attached is an initial draft from Bronwen, with some additions I have made, for your comment.

It will also need to be accompanied by a aerial photograph based map identifying the areas involved (not attached).

It would be useful to know the deadline for NPNCA, and any comment or timing advice you may get from speaking to Neil Hammer.

Gary Whisson  
Manager  
Conservation Branch

**Department of Environmental Protection**  
Westralia Square, 141, St Georges Terrace, Perth, Western Australia, 6000.  
Facsimile: (08) 9322 1598 Telephone: (08) 9222 7000

## **A comparison of the two areas in Neerabup National Park proposed for rail yards**

### **Vegetation Associations of Neerabup National Park**

The principal vegetation associations of Neerabup National Park are shrublands or heaths and woodlands. The vegetation is very dependant on the soils. Shrublands or heaths are found on the Tamala Limestone ridges and associated soils and woodlands on the deeper sands.

#### **Shrublands or Heaths**

In the areas with exposed Tamala Limestone and shallow soils there is a series of dense shrublands dominated by *Xanthorrhoea preissii*, *Hakea trifurcata*, *Calothamnus quadrifidus*, *Melaleuca acerosa*, *Dryandra sessilis*, *Melaleuca huegelii* and *Acacia lasiocarpa*. One or all of the species may be dominant in different areas, forming a mosaic of shrubland and heath communities. These communities vary over small distances, and the type and density of the dominants is closely related to the time since the last fire. A series of sedges and herbs are also characteristic of these communities, including *Conostylis aculeata*, *Mesomelaena pseudostygia* and *Loxocarya flexuosa*.

#### **Woodlands**

A series of trees are characteristic of these woodlands: Tuart (*Eucalyptus gomphocephala*), Jarrah (*E. marginata*), *Banksia attenuata*, *B. menziesii*, *Allocasuarina fraseriana* and *Jacksonia sternbergiana*. Marri (*E. calophylla*) is also present but is less common than the other species. These woodlands are generally mapped according to the dominant tree species.

##### *Banksia* Woodlands

*Banksia attenuata*, *B. menziesii*, *Allocasuarina fraseriana* and *Nuytsia floribunda* are the most common trees in these woodlands. The understorey is characterised by species such as *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Hakea trifurcata*, *Hibbertia hypericoides*, *Leucopogon polymorphus*, *Daviesia divaricata* and *Allocasuarina humilis*. *Mesomelaena pseudostygia* and *Loxocarya flexuosa* are also characteristic. Most of the Park is mapped as *Banksia* Woodland by Keighery *et al.* 1997. While Tuart and Jarrah are scattered through much of the area their cover is generally low.

##### Jarrah Woodlands to Forest over *Banksia* Woodland

Jarrah (*Eucalyptus marginata*) generally occurs as an emergent over the two *Banksia* species and *Allocasuarina fraseriana*. However in some areas Jarrah is the only tree and it forms a Jarrah Woodland or Forest. The areas of Jarrah and Jarrah/Marri Woodland to Forest are scattered and not readily mapped. The principal understorey shrubs are similar to those in the *Banksia* Woodlands, being *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Hibbertia hypericoides* and *Daviesia triflora*. The sundew, *Drosera erythrorhiza*, is common in the understorey, as is *Mesomelaena pseudostygia*.

#### Tuart Woodland

In a series of areas Tuart occurs at great enough density to form a woodland to forest. Associated understorey species are *Jacksonia sternbergiana*, *Grevillea vestita*, *Macrozamia riedlei* and *Xanthorrhoea preissii*.

The majority of Neerabup National Park is in very good condition. In general the limestone heaths and the *Banksia* and Jarrah Woodlands are in the best condition, while the Tuart Woodlands are the most disturbed.

#### **Methods and Limitations**

The two areas being considered for the location of the rail yards were surveyed on 4th August 1999 by Bronwen Keighery (DEP), Teresa Gepp (CALM) and Sally Madden (DEP). Tracks in both areas were traversed and vegetation compared with descriptions from Keighery *et al.* (1997) and *ecologia* 1999. As the annual natives and weeds were immature an assessment of condition in relation to these species is limited.

#### **Vegetation Associations of the Proposed Location (SW corner National Park)**

Two associations predominate in this area

- *Banksia* Woodlands dominated by *Banksia* ~~attenuata~~ *attenuata*, *B. menziesii*, *Allocasuarina fraseriana* and *Eucalyptus todtiana* trees. Tuart and Jarrah are scattered through much of the area.
- Tuart Woodland to Open Forest.

A small area of dense shrublands dominated by combinations of *Hakea trifurcata*, *Dryandra sessilis* and *Baeckea robusta* occurs near the southern boundary.

The majority of this area is in very good to excellent condition.

## **Vegetation Associations of the Alternative Location** (between Lukin Drive and Hester Ave)

Three associations are found in this area:

- *Banksia* Woodlands dominated by *Banksia attenuata*, *B. menziesii*, *Allocasuarina fraseriana* and *Eucalyptus todtiana* trees
- Jarrah Woodlands sometimes over *Banksia* Open Woodland
- dense shrublands dominated by *Xanthorrhoea preissii*, *Hakea trifurcata*, *Calothamnus quadrifidus* and *Dryandra sessilis*. One or all of the species may be dominant in different areas, forming a mosaic of shrubland and heath communities.

Over half of the area is in a completely degraded to degraded condition. The areas of *Banksia* Woodland and Jarrah Woodland were mostly in this condition but several areas were in good to very good condition. The dense shrublands on the shallow soils over Tamala Limestone were generally in good to very good condition.

### **Comparison of the two areas**

It is evident from the above descriptions that the southern area is in the best condition and has the most value in conservation terms as part of the Park.

The southern area also has additional values as part of a regional bushland corridor (greenway) between Neerabup National Park and the coast. The values of this corridor would be assisted by relocating the additional width of clearing associated with the rail yards to the more disturbed alternative site.

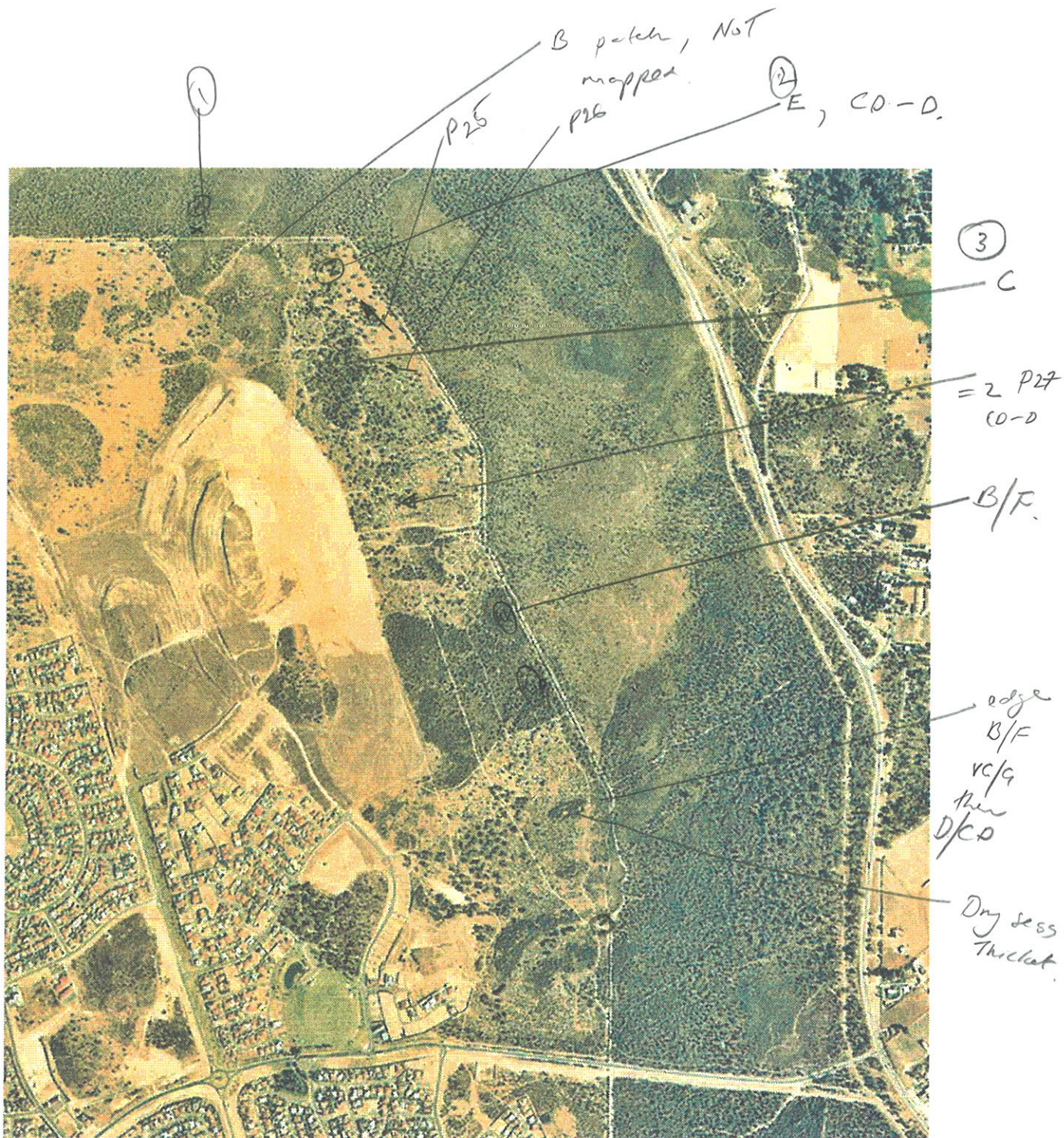
### **Use of seed and topsoil salvaged from areas to be cleared for regeneration**

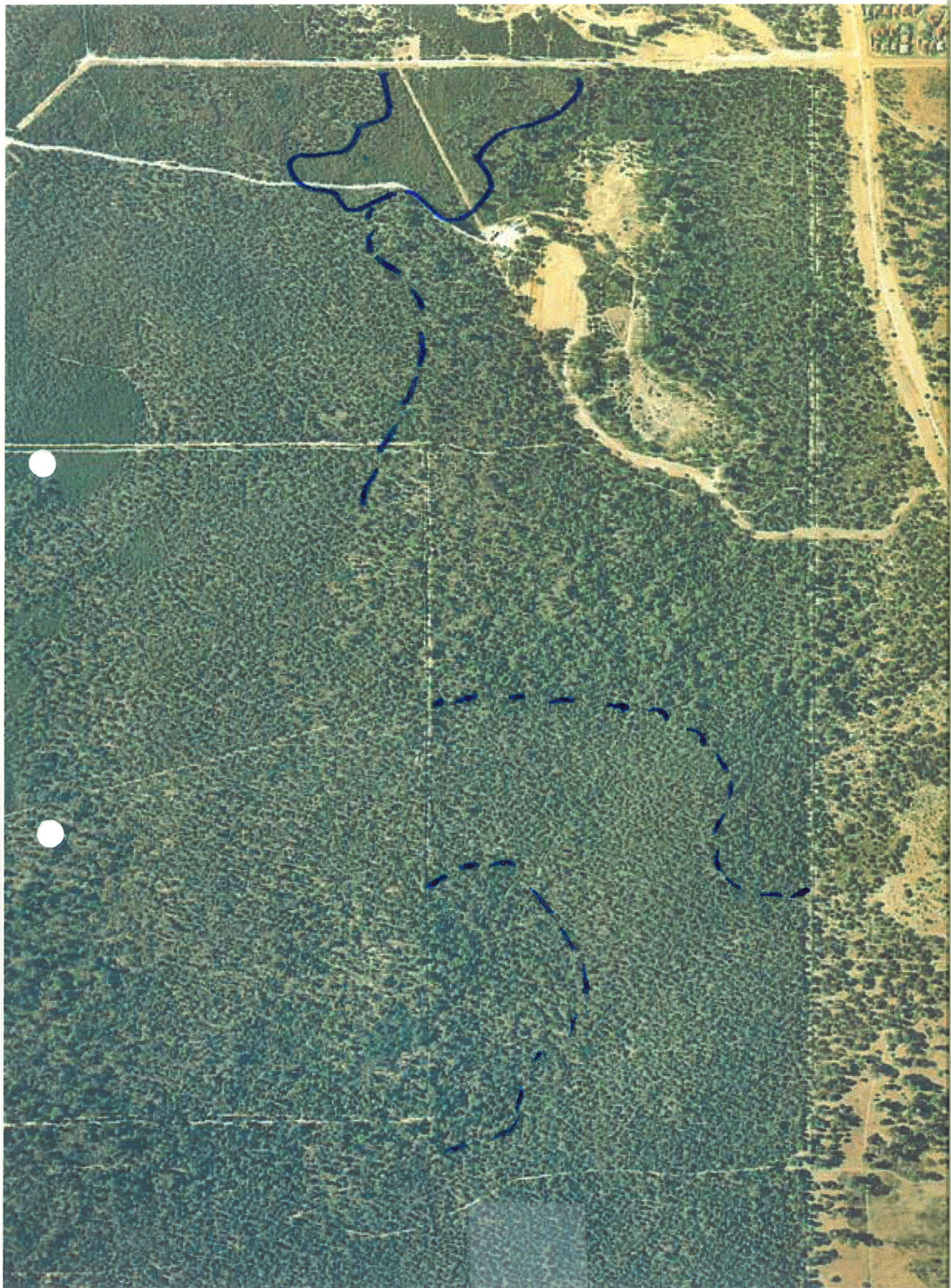
The freeway/rail proposal involves very significant disturbance to and excision from Neerabup National Park. While additions are proposed in compensation these are generally areas that were previously recommended for inclusion in the park through the System 6 report in 1983.

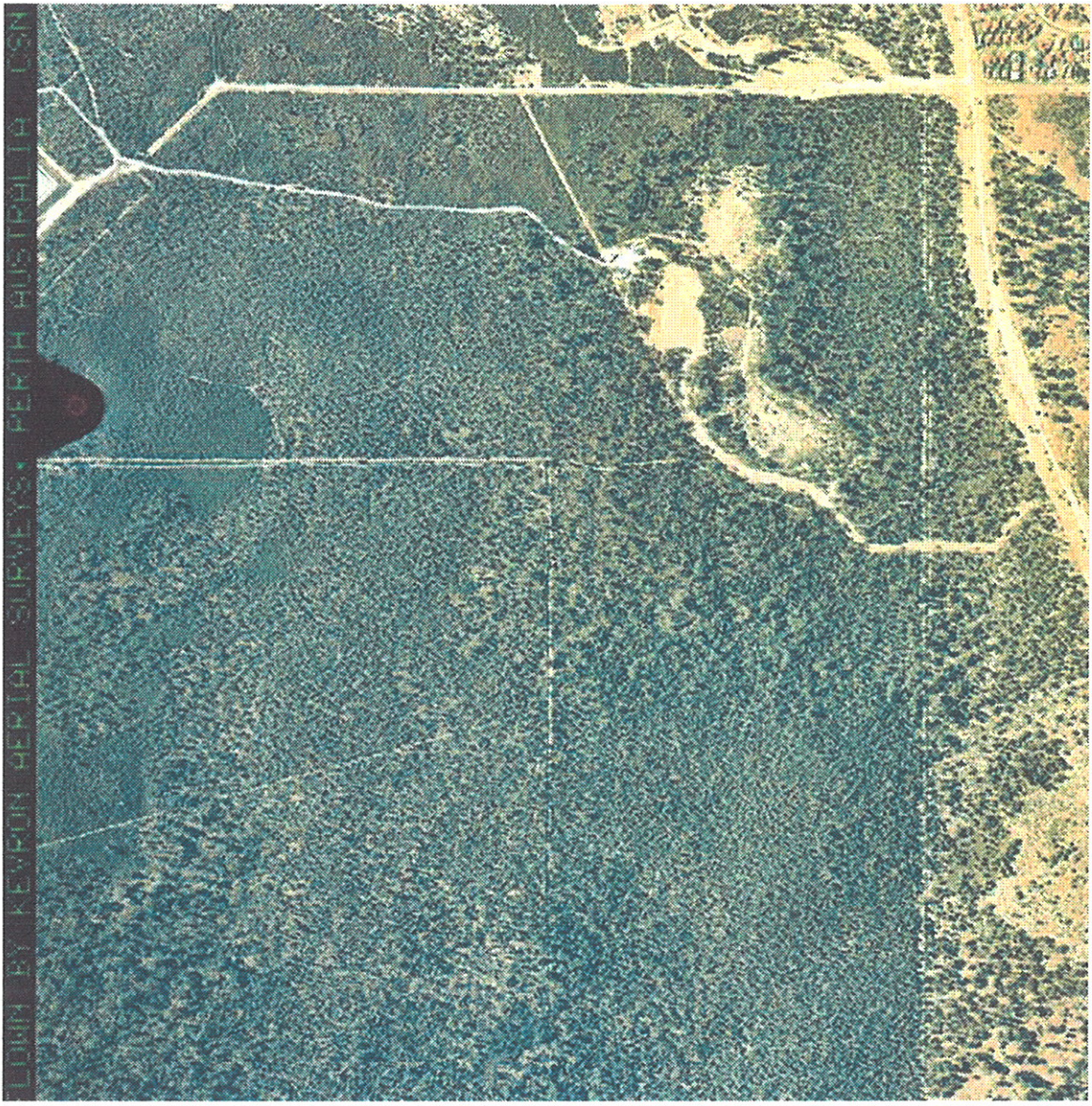
There would be considerable value in off-setting some of these conservation losses if the development program included a commitment to harvest seed and topsoil/mulch from the areas of bushland in good condition that need to be cleared as part of the freeway/rail development and using this material as part of a coordinated program to help regenerate the degraded portions of the National Park that would have supported equivalent communities in the area adjacent to the proposed Freeway between Lukin Drive and Hester Avenue.

4/8/99.

Veg Assoc = Ecologia 1999 (A-G)







COMPTON PERFORMING SURVEYS, PERTH AIRFIELD, CAN.



BK2

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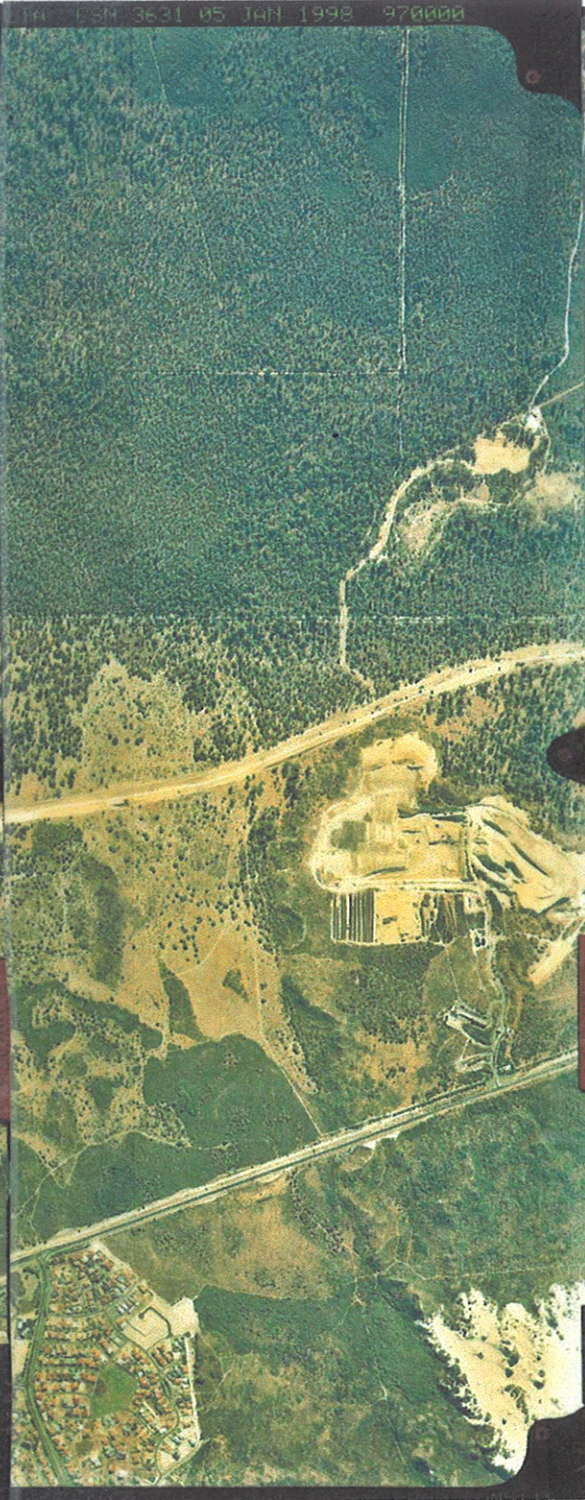
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TP ASN 3631 05 JAN 1998 970000

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ENVIRONMENTAL & LANDSCAPE AUDIT  
OF THE SOUTHWEST, NORTHWEST & NORTHEAST CORRIDORS  
PERTH METROPOLITAN AREA

STAGE 1 INTERIM REPORT:  
THE NORTHWEST CORRIDOR STUDY

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THE SOUTHWEST, NORTHWEST AND  
NORTHEAST CORRIDORS PERTH  
-- BY V & C SEMENIUK RESEARCH  
GROUP...  
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*Prior to 1991, After 1989*

FORMAT FOR CORRIDGE CHAPTERS

1. REGIONAL SETTING, & LANDSCAPE/ECOLOGICAL UNITS IN THE CORRIDOR
2. REPRESENTATIVE & REMNANT AREAS
  - Wetlands
  - Quindalup Dunes
  - Spearwood Dunes
3. DATA BASE & LITERATURE
  - Maps
  - Tables
  - Text
4. ASSESSMENT
5. WATER MANAGEMENT PARAMETERS
6. CONCLUSIONS & RECOMMENDATIONS

## 1. INTRODUCTION

Urbanisation of the Southwest, Northwest and Northeast Corridors of Metropolitan Perth has been proceeding incrementally and inexorably with population growth over the past two decades, and currently the Department of Planning and Urban Development (DPUD) has produced revised Concept Plans for this urban development. These Concept Plans define the extent of the proposed urban areas, the regional open spaces, and the major transport and service infrastructures for all corridors. The Concept Plans are intended to be the basis of future consultation and negotiation with various interested parties and government bodies such that in time the plans will become more refined to the stage where they become approved as Structure Plans. These Structure Plans will provide the basis for future zoning of urban land in the Metropolitan Region Scheme.

However, at present, the allocation of urban areas, regional open spaces, reserves and resource development within the Concept Plans is based on landscape and environmental considerations that were mostly formulated at least a decade or more ago. Yet much more information about the natural environment, both in terms of landscape and flora/fauna, has been obtained in recent years by a variety of organisations, and this information largely has not been assessed and incorporated into the recent planning. This is particularly so where some landscape and vegetation elements had not been assessed as environmentally significant in the 1970's, during the formulation of System Six recommendations, but now with more information, specific areas previously (unintentionally) ignored would be assessed as significant.

The relevance of the preamble above is that, with this increase in knowledge of the natural history of the Swan Coastal Plain, it is now timely to review the terrain of the Southwest, Northwest and Northeast Corridors of the Perth Metropolitan Region, and in the light of the recent information, carry out an environmental and landscape audit to identify sensitive and significant areas for conservation or management. In this manner the modern/recent information can be fully integrated into the Concept Plans, and planning can proceed without endangering environmentally significant areas.

To this objective DPUD has invited V & C Semeniuk Research (VCSRG) to carry out an environmental and landscape audit of the Southwest, Northwest and Northeast corridors. The environmental audit was commissioned to take place in three stages, with the Northwest Corridor being the first area to be completed. It is anticipated that when the study of all three corridors is

Finalised later this year, there will be a final report that fully outlines the philosophy of approach, the methodology, and results of the audit. However at this stage, with results on the individual corridor areas needed for planning as they become available, interim reports are presented as a particular stage of the study is completed. The first stage of the study presents the results of the Northwest Corridor. This interim report on the environmental audit of the Northwest Corridor area thus provides some background to the study, outlines the methodology and the data base, and presents the results, recommendations and an outline of the procedures and justification for the recommendations.

## 1. OBJECTIVES OF THE STUDY

The objectives of the study, as listed in the Brief for Consultants, are as follows:

1. to provide preliminary guidance to DFUD on the protection of environmental, wildlife and landscape conservation values associated with urban development proposals for the northwest, southwest and northeast corridors; and
2. to develop indicative parameters that ensure that the design of urban areas, drainage systems and management of water resources is consistent with the protection of designated environmental and wildlife values.

In detail the first objective involves ensuring that the proposals for urbanisation in the Southwest, Northwest and Northeast Corridors, as reflected on the current Concept Plans, is consistent with good environmental and conservation principles, and that the design of the urban areas, and the drainage required to service it, are to standards that will safeguard the long term sustainability of designated conservation areas. To achieve this objective it may be necessary to rank environmental and conservation issues, as they are affected by urbanisation, in order of importance, with an assessment of the impact of the Concept Plan proposals on them, and then if necessary to recommend any modifications to the Concept Plans required to protect priority areas for conservation [- this includes wetland and upland ecosystems, and an evaluation of System Six areas], or to establish criteria governing urban planning in proximity to conservation areas, confirmation or re-definition of conservation areas on the Concept Plans, and management criteria for conservation areas in the urban context of the Concept Plans.

Once the information has been collated and assessed it will be necessary to make initial determinations on areas within the corridors suitable for:

the conservation of environmental and wildlife values only  
the conservation of environmental and wildlife values but  
where further detailed investigations are required to  
determine the extent of regional and local values  
urban development but where regional and/or urban drainage  
management programmes are likely to apply; and  
unconstrained urban development.

## 2. BACKGROUND TO STUDY

Reserves for purposes of conservation are intended to preserve occurrences of rare and endangered flora and fauna, examples of vegetation assemblages, examples of landscape ecology, areas of scientific interest such as geological features, areas for research and education purposes, or to provide sanctuaries and security for a range of fauna and flora (Frith 1973, Lunney & Recher 1979, Messer & Mosley 1980, Anon 1982, Leigh et al 1984). Indeed the various reserves in Southwestern Australia have been established for a range of the above reasons. However, as can be gleaned from the recently published literature, there still is inadequate conservation of the variety of geomorphic, habitats and vegetation systems in the Quindalup Dunes, Spearwood Dunes and wetlands in the areas of the Southwest, Northwest and Northeast Corridors (see recent Banksia Woodland Symposium published by the Royal Society of WA; see Semeniuk et al (1989) for discussion of conservation status of the Quindalup Dunes; see CA Semeniuk (1989) for recent treatment of the complex and variable wetlands of the Swan Coastal Plain.

In the Quindalup Dunes, for example, there is an inadequate number of reserves in this coastal system based on criteria of diversity of landform, scientific interest, representativeness, vegetation and relative lack of disturbance (Semeniuk et al, 1989). Where reserves are present in the Quindalup Dunes in the Perth region, there has been a tendency for undue emphasis in preserving the more seaward assemblages at the expense of the more landward assemblages. It is also clear that there is a diverse array of landforms and vegetation within the full extent of the Quindalup Dunes from Dongara to Dunsborough, and it is thus not surprising that the few reserves, as presently distributed, are inadequate to cover and secure sufficient representation of this variability (Semeniuk et al, 1989). The essential features of the Quindalup Dunes that warrant conservation are different for each coastal sector throughout the southwestern coastal zone because each coastal sector is different in its landscape forms and its vegetation. As pointed out in the scientific literature, the features of the Quindalup Dunes at the large scale that are specific or typical of the Southwest, Northwest and Northeast Corridors that as yet are not reserved are:

Southwest Corridor: the cusped beachridge plain centred on Seaber Point and Rockingham, of the Cape Bouvard-Triple Island Sector; and  
Northwest Corridor: the perched dunes and accretionary coasts of the Whitford-Lancelin Sector

On the smaller scale, recent work by Cresswell & Bridgewater (1988) and Semeniuk et al (1989) showed that these coastal systems, once largely considered as monotonous and repetitive coastal dunes and generally mapped as a single vegetation unit, in fact contained diverse landscapes each with a richly differing vegetation assemblage that occurred in distinct and incomparable sectors along the coastal zone of the Swan Coastal Plain.

The same discussion as presented for the Quindalup Dunes could be applied and argued for wetland systems, and for Banksia woodland and tuart woodland systems on the Spearwood Dunes. In the case of wetlands, for instance, many researchers recently have expanded our knowledge of these systems, and upgraded their importance. For instance, CA Semeniuk (1987, 1988) showed that there is a large variety (some 53 different categories) of wetlands that occur within the Darling System, that could not and should not be compared to each other, as they represented in most cases markedly different types. This variability in wetlands has not as yet been secured in reserves. Similarly, Cresswell & Bridgewater (1988) and CA Semeniuk et al (1990) in studies of wetland vegetation showed that there was a variable and complex vegetation system and assemblages within the wetlands hitherto as yet unrecognised, and again, as yet not fully represented in reserves.

The international importance of many of these areas mentioned above, however, has not been addressed or incorporated into any planning or re-assessment in recent years.

Thus it is evident from the literature alone that there still is a need for conservation of yet unrepresented typical areas as well as a need for conservation of unique areas of Quindalup Dunes, wetlands and tracts of the Spearwood Dunes, and this should be based on their landform, scientific interest, representativeness, vegetation and relative lack of disturbance. From the literature it also is evident that some of the areas that are still not secured in reserves are of international importance.

As outlined in the Introduction, the allocation of urban areas, regional open spaces, reserves and resource development within the Southwest, Northwest and Northeast Corridors of the Perth Metropolitan Region Scheme is based on landscape and environmental considerations that were mostly formulated at least a decade or more ago. With the increased amount of natural history information, obtained in recent years, it would be prudent to review this data base, so that it can be assessed and if necessary incorporated into the planning process. Thus

It is possible/probable that some landscape and vegetation units formerly not recognised as significant would now be considered as significant and would need to be re-assessed in the planning process. An additional factor to be addressed concerns the fact that as development and urbanisation has proceeded elsewhere in the North Metropolitan Region, alienation of natural areas has occurred to such an extent that any remaining areas of natural history become progressively more significant because they may represent the only remnant of a specific landscape/ecological unit in the region. This factor has to be viewed in the context of preservation of any remnant ecological units in the Southwest, Northwest and Northeast Corridor.

#### 4. METHODOLOGY

##### 4.1 PHILOSOPHY OF APPROACH

It is useful here to briefly outline the basic philosophy of approach adopted by VCSRG in this study. The approach is schematically outlined in the flow chart in Fig. 1. Firstly, the area of study is separated into two categories, viz., 1. wetlands and 2. uplands, because these two systems require somewhat different, though overlapping, sets of management strategies for their protection.

Upland areas, once they are recognised as significant, would require design of relatively simple management strategies involving fencing, fire control, access control, etc, and in the case of coastal areas, shore management and dune management. Upland areas do not generally require management of the environment involving groundwater (extraction, disposal and pollution).

On the other hand, wetlands, in addition to requiring similar and obvious management strategies such as fencing or fire control in their protection as mentioned above for uplands, also require a different range of more detailed, complex and specific management strategies linked to water, both in immediate proximity of a given wetland, and at the larger scale of regional groundwater systems. Because wetlands are windows to the water table, or are "sump" sites for any of the adjoining groundwater mounds, their quality is then intimately linked to the longevity and environmental quality of water from the surrounding areas. As a result, more than with uplands, the urban areas surrounding wetlands have to be carefully managed in order to maintain the environmental quality of a wetland system for its aquatic life, fauna, migrating avifauna and vegetation if it is to be within an urban area, or even adjoining an urban area.

As evident in the flow chart, in many respects, the procedures of information-gathering and evaluation used in the

environmental audit of wetlands in this study are similar to those used for upland vegetation, in that resource information is collected, remnant vegetation is mapped, the significance of the system is assessed, etc. However, the main difference in approach between wetlands and uplands used in the compilation of an environmental audit relates to the stage when a given wetland or upland area is recommended for conservation because of its significance. At this stage, in order to preserve or manage the environmental quality of some newly recommended conservation areas, or to manage the on-going environmental quality of already existing reserves, management recommendations have to be forwarded that may alter some of the design of the urban structure plan. For example, urban areas with input of drainage water and nutrients from lawn may have to be placed a certain minimum distance from a significant wetland, resulting in the potential modification of the urban boundary and the re-design of water disposal options. In these situations, a range of more complicated environmental and water management strategies have to be addressed for the wetland settings, whereas a more simple range of management strategies have to be covered for the upland settings.

#### 4.2 DETAILS OF METHODOLOGY

The approach VCSRG adopted to achieve the stated objectives largely follows that outlined as Procedures in the Brief for Consultants. The study resolved into a number of tasks, namely:

- Task 1: collection, collation and analysis of existing environmental information;
- Task 2: collection and analysis of supplementary data obtained through additional field surveys;
- Task 3: map production, and reporting on areas recommended for conservation; and
- Task 4: recommendations on water management parameters for regional drainage systems;

Task 1: Collection, collation and analysis of existing environmental information

The collection, collation and analysis of existing environmental information involved liaison with, and collect of data from, Government and Local Authorities, research organisations, publicly available consultancy reports and ERMPs, and published scientific papers. The information obtained from DPUD, EPA, CSIRO, CALM, Dept Agriculture, Geological Survey, WAWA, WA Museum, RAOU, DOLA, and local shires.

In detail this task involved accessing of up-to-date information from a variety of landform/landscape, soil, vegetation and land-use maps, the use of aerial photographs to locate and map remnant vegetation, and the review and accessing of relevant information from the variety of reports and papers held by the

various bodies and organisations listed above. There were a number of subtasks which, as summarised and modified from the brief for Consultants, are:

1. geomorphological base mapping
2. remnant vegetation mapping
3. map, classify and assess condition of wetlands
4. map System Six areas, other reserves and land tenure
5. map areas of basic raw materials affecting conservation
6. examine relationships between landscape and vegetation, and evaluate significant areas not represented on CMV estate
7. map/analyse groundwater data as it affects wetland conservation

The data obtained in this way were used to produce a map of the main landscape units, of remnant vegetation areas, wetland areas, and other environmentally significant areas in order to identify those landscapes, ecologic and other environmentally significant or sensitive areas within the region of the Southwest, Northwest and Northeast Corridors. The recognition of areas of conservation significance were based on criteria of:

1. representativeness of ecologic, species and landscape aspects,
2. scientific importance,
3. linkages to adjoining ecologic units,
4. potential habitats for rare species, and
5. usefulness for education and research.

The environmental evaluation schemes, or assessment schemes, designed by Semenick (1986a) and modified for the Swan Coastal Plain by the Water Resources Council (1989), were used to assess conservation areas.

Within this task there also was need for some liaison with the various Government and Local Authorities and State and Commonwealth research bodies to obtain their input and specific knowledge in order to ensure that no areas or specific features were omitted. This task also involved, as a subset of analysis, the assessment of impacts of urbanisation, water extraction, drainage, resource extraction, and other associated development effects on identified pre-existing and any new conservation areas arising from recommendations of this study.

#### Task 2: Collection and analysis of supplementary data through additional field surveys

There was need to collect some additional field data in this study, although it had been recognised and recommended by the steering committee of the study that field surveys should be kept to a minimum. It was necessary to conduct these brief field surveys on three counts: firstly, after completing Task 1, to ground-truth and assess the environmental quality of any remnant vegetation and wetlands recognised as potentially

of which is, secondly, to ground-truth the vegetation patterns on the wetlands using the wetland vegetation classification scheme of Semeniuk et al (1990), because this scheme helps to discriminate between the various wetland types, and, thirdly, to assess the environmental significance of wetlands using the selection criteria of Semeniuk (1988a), Water Resources Council (1987), and the I.P.A. (1990).

#### Task 2: Map production, and reporting of areas recommended for conservation

This task involved presenting most of the results of the study as a map(s) and a report. The maps show distribution of recommended conservation areas within the context of present land tenure / land use and the current Concept Plans. The report outlines the data base, indicates how the objectives of the study have been achieved, describes the selected conservation areas in their landscape setting, presents the rationale for the selection of the conservation areas, and presents the recommendations for management of the selected conservation areas within an urban context with potential guidelines for aspects such as buffer zones and water management practices.

#### Task 3: Recommendations on water management parameters for regional drainage systems

This task involved liaison with personnel from WAPA, Dept of Environment, CSIRO and Geological Survey of WA to compile a range of water management parameters for regional drainage systems in view of the fact that water will be available wetland and other ecosystems within the overall riparian zone. As such, the objective of this task was to attempt to set water level and water quality guidelines in order to safeguard designated conservation areas.

#### 5. DATA BASE

The data base on which the foundations of this study was built was quite large. Four main avenues were used to obtain information for this study. These were:

1. Maps, aerial photographs, and reports of various Government and Local Authorities and research organisations; these included research, flora, and fauna sections of CALM, the Western Australian Herbarium, the CSIRO, EPA, Dept Agriculture, DPUD, Geological Survey, WAWA, WA Museum, RACU, DOLA, and local shires;

2. Publicly available consultancy reports and ERMPs, and published scientific papers;
3. Liaison with the various Government and Local Authorities and State and Commonwealth research bodies to obtain their specific knowledge; and

#### 5. CRITERIA FOR CONSERVATION

The assessment of the conservation significance of a natural system is difficult to achieve at the best of times. Conservationists would argue all natural systems are important. Engineers and developers pointing to the monetary benefits of their actions to the broader community would argue that a proposed impact on some natural systems is necessary. To rationally assess the significance of a natural system, an ecologist/environmental scientist must utilise a set of conservation/assessment guidelines that are acceptable to the broader community.

The approach adopted here is well known internationally: firstly determine the resources at risk by developing an inventory of types of natural systems in the study area; secondly, note the extent, rarity, representativeness of the natural system; thirdly, assess the ecological/environmental functions of the system; fourthly, determine the processes, internal and external, to the system that maintain and regulate it so that impacts can be adequately assessed; fifthly, identify the types and scale of impacts and how they would interfere with the natural system; finally, assess the significance of the natural system against the significance of any proposed development or potential impacts.

Any attempt to develop a procedure to implement conservation criteria to assess natural systems also must address or incorporate several issues. Firstly, sufficient data must be available for rational assessment. Secondly, whereas there may be conflicting demands for use of the natural system by social, government, developmental, educational and research groups, the perceived value judgement of a minority group has to be viewed in perspective. For instance, a scientific community, although a minority, may have information and an understanding about a natural system such as to warrant its conservation even though the public and developers at large are not aware of these values and do not share the same perspective. Alternatively, a minority group in a residential area may also place importance on a natural system in their area of residence that informed professional scientists do not necessarily share. Both value judgements are valid. Thirdly, many of the decisions of today will have impact on generations of the future and, although this is a difficult objective to achieve, decisions taken today should not unduly preempt or predetermine the attitudes and

possibilities of the future. Finally, the significance of any specific natural system in relation to the conservation criteria may have to be assessed giving a weighting to any of the criteria selected in the evaluation process.

Criteria (or guidelines), and assessment schemes, useful for assessing the significance of a given natural system are based on Semeniuk (1988), IWA (1988) and Water Resources Council (1987). The guidelines basically address the issue of the conservation, social or scientific value of a natural system based on criteria of:

- . regional significance of the system is it widespread and common, is it significant to the region, is it restricted to local areas?
- . Does the system contain unique landforms, biota or other natural features that provide it with statewide, national or international status?
- . Does the system offer the potential for scientific/research, educational, social, recreational, and wildlife sanctuary/habitat usage not offered by other areas?

The assessment of a natural system based on regional perspective basically seeks to place a threatened environment into wider scale view. For instance, on one hand a small wetland situated on a freshwater soak may contain a distinct history and a unique serotinity, or may be colonised by vegetation species that are rare or beyond their normal geographic range - this little wetland, though small, may be regionally unique and of international significance. On the other hand, the destruction of several hectares of palusplain wetland, within a system that covers several square kilometres may not be viewed as significant. A regional perspective attempts to balance these views.

## 7 NORTHWEST CORRIDOR

### 7.1 REGIONAL SETTING, AN LANDSCAPE/ECOLOGIC UNITS IN THE CORRIDOR

The area of the Northwest Corridor is situated along the coastal portion of the Swan Coastal Plain between (about) Whitfords Cusp and Two Rocks, with an inland boundary some 4-5 km from the coast. As such it is mainly located in the Quindalup Dunes, with some representative landforms of the Spearwood Dunes and Sassenfean Dunes.

McArthur & Bartle (1980) recognised the Quindalup Dune and Spearwood Dune systems in the Northwest Corridor. They described the Quindalup Dune System as parabolic calcareous sand dunes of different ages with minimal soil profile development; there is some undulating landscapes within the dune terrain.



low in relationship to the water table. The slopes, crests and flats/swales/bowls associated with parabolic dunes and chaots, are all high relief, situated >5m above the water table.

The Spearwood and Bassendean dune systems in the Northwest Corridor are not so well studied. In a recent review of habitats of Banksia woodland and allied plant associations, which colonise the sandy soils of the Spearwood and Bassendean dune systems, Semerik & Glassford (1988) concluded that there has not been a systematic description of the landforms, underlying stratigraphy, soils, age structure and the inter-relationships of these systems, at various scales of reference, with which to delineate vegetation habitats. As such, they considered that the Bassendean and Spearwood dune systems are insufficiently described from the point of view of landscape ecology, and suggested that to adequately address the variability of floristics in Banksia woodlands, phytosociologic studies should be undertaken in conjunction with the determination of physical features of location within dune terrain (e.g., dune type), height above water table, aspect, organic soil development, percentage kaolin (as coatings, and grains), bleached zone, colour (e.g., Fe-mineral content as coatings), moisture content in the vadose zone, and subsurface stratigraphic or pedogenic features.

In earlier studies of the Bassendean and Spearwood dune vegetation systems, Cresswell & Bridgewater (1963) related vegetation associations within the Bassendean and Spearwood Dune systems to location on dune crests (tops), slopes, swales, and which effectively identifies location of habitat within dune terrain, but did not produce any maps showing distribution of these assemblages in relationship to landscape. Consequently their study is not directly applicable at present to this study. Similarly, Huddle et al (1980) also recognized the importance of landform and soil as determinants of vegetation floristics and structure, but did not proceed beyond correlating broad associations to the large scale geomorphic and soil systems as determined by McArthur and Settenay (1960) and Settenay et al (1960).

In regard to wetlands, C.A. Semerik (1989) recognised that there are 3 categories of consanguineous wetland suites in the area of the Northwest Corridor. These are: 1. the Yanchep Suite, encompassing the linear wetland chain of macroscale to microscale lakes and sumplands from Loch Moneas to Lake Goollelal; 2. the Pinjar Suite, encompassing the megascale Lake Pinjar sumpland; and 3. Gngangara Suite, encompassing the macroscale to microscale lake, sumpland and dampland systems around Lake Gngangara.

## 7.2 RESULTS OF ENVIRONMENTAL AUDIT AND RECOMMENDED AREAS FOR CONSERVATION AND/OR MANAGEMENT.

The results of mapping geomorphic units, landform/soil units, vegetation units, remnant vegetation, wetlands and vesting are shown in the accompanying maps. This information forms the

basis of selecting, and recommending for conservation, areas of upland remnant vegetation and landform/soil, and wetlands, that as yet are not adequately secured in reserves in the Northwest Corridor (or even on the Swan Coastal Plain).

The information on the types, extent, vestings and conservation status of vegetation units, landform units, and soil units for the QUINDALUP are presented in Tables III-IV. These tables, and the accompanying maps show that many of the Spearwood and Bassendean landform/soil units and their associated vegetation already are largely represented in existing reserves and National Parks. But there are some obvious omissions of certain systems - for example, most of the variable types of Quindalup Dune landforms and vegetation units are not well represented in reserves. Omissions also occur in the case of the Bassendean complexes within the Northwest Corridor. Well vegetated areas remain in State Forest No. 65, however these areas are not specifically set aside for conservation. Also, not well represented in reserves are the transitions/junctions between various units, e.g., the junction between various vegetation units in the area of Heyburn Heights, and the junction (of patchwork transition) between Quindalup and Spearwood units.

Assessment of priority for recommendations of areas was based on factors of size, complexity of landforms (hence complexity of vegetation), ownership(s), vegetation condition, and linkage to (or gradation into) adjoining large scale geographic units. For a given area, each factor was given a loading of 1-3 (very large size =3, very small =1; complex landform or vegetation =3, weakly complex =1; government owned =3, privately owned =1; vegetation condition very good =3, poor =1; good example of linkage (i.e. strongly complementary) to adjoining units =3 (e.g., Spearwood Dunes, passing west into Quindalup parabolic dunes transgressing over Spearwood terrain, passing west to massive Quindalup dune fields) in contrast to isolated, poorly related and/or linked to adjoining units =1).

The areas of upland recommended for conservation are as follows (areas representing similar landform and vegetation habitats are listed in order of significance, although evaluation determined all sites as high conservation priority areas):

1. Burns Beach - Southern Ridge area; an area of coastal headlands, cliffs, and coastal ridges with heath/shrubland. Junction between Quindalup and Spearwood units.
2. Heyburn Heights: an area with the junction of four vegetation units and landform and soil units.
3. South Mindarie: a coastal zone of dunes in a cusped foreland setting, with its attendant variable/complex development of coastal vegetation habitats and assemblages.
4. Alkimos: a coastal zone of dunes in a cusped foreland setting, with its attendant variable/complex development of coastal vegetation habitats and assemblages.

5. Merraboo Mounds: a coastal nose of rounded dunes - fratted parabolic dunes of moderate to high relief encroaching over Spearwood Dune terrain and associated cracks and blowouts along the seaward edge. Diverse habitats occurring as a result of landscape complexity.
6. Herrington: a coastal nose of rounded dunes - fratted parabolic dunes of moderate to high relief encroaching over Spearwood Dune terrain and associated cracks and blowouts along the seaward edge. Diverse habitats occurring as a result of landscape complexity.
7. Kindalee & Burley: a coastal nose of rounded dunes - fratted parabolic dunes of moderate to high relief encroaching over Spearwood Dune terrain and associated cracks and blowouts along the seaward edge. Diverse habitats occurring as a result of landscape complexity.
8. Merraboo National Park extensions: low hill undulating terrain composed of various dune types, variable soil development resulting from limestone core outcropping on ridge crests to deep sands, variable soil types and variable depth to water table.

These recommended areas thus would secure an example of a cuspage foreland system, a rounded dune system (both recommended by Cederick et al. 1989, as typical but unsecured examples of the Kimberley-Murchison coastal sector), and would secure the transition between the Kimberley and Spearwood systems.

The justification and/or rationale for the selection of the recommended areas is outlined below for each of the areas.

### 7.2.1 Burns Beach - Southern Ridge

1. Occurrence of limestone ridge forming cliffs and headlands at the coast. This medium scale landform is a Spearwood Unit and occurs along the coast at two locations in the Northwest Corridor region i.e. at Mindarie and South of Burns Beach. However the ridge at Mindarie has been modified and cleared for the siting of the marina, and hence only the Burns Beach example of this coastal landform remains intact.

2. The occurrence of a Spearwood geomorphic unit at the coast results in structural and compositional variation of the vegetation assemblages normally associated with this landform. The vegetation is therefore regionally significant and floristically rich.

3. The abrupt junction between the limestone ridge and deeper sands of the swale and ridge system adjoining is indicated by a change in vegetation. This is an important educational resource as well, since it documents the transition between two landform types.

### 3.1.2 South Murchie - Cragate Foreland

1. Cragate forelands are an important representative feature of the Western Murchie-Lancelotti coastal sector. Several well defined cragate forelands are located in the Northwest Coastal region, however the largest and best developed examples of this landform type located at Whitford and Quinne Rock have been largely destroyed and/or eroded. South Murchie now represents the largest well defined cragate foreland and its associated dune system in this coastal sector.

2. The cragate forelands exhibit a range of geomorphic features associated with cragate forelands in this coastal sector. They are the surface expression of dune development.

3. The vegetation is variable and typifies the range of habitats found within a dune setting. It is in good condition. A number of species in the area are regionally significant in terms of rarity and conservation numbers. The vegetation conditions therein are not represented in any of the present reserves.

4. The cragate foreland is a discrete medium scale geomorphic unit which is of scientific interest to students of biology, geomorphology, climatology, sedimentology and oceanography.

5. The alternative site to South Murchie is the cragate foreland at Whitford. Generally the cragate foreland at Whitford is less well developed than South Murchie. Also the climate and geomorphic wave patterns begin to change as one progresses further north and gradually the dune change from the Whitford-Lancelotti type to become the West Cape-Cragate sector dune.

### 3.1.3 South Murchie - Beached Dunes

1. The term beached dunes describes a range of dune types i.e. beached, crescentic, attenuated, parabolic and chaotic, which are common over South Murchie. They are one of two major geomorphic features endemic to and characteristic of the Western Murchie-Lancelotti coastal sector. At present they are not represented in any reserves.

2. The representative range of dune types and associated swales and bowls occur in discrete accretionary areas.

3. The vegetation is heterogeneous and in this small area, nine different assemblages have been identified. Some of the flora is regionally significant in that it occurs at range extremes at South Murchie, and some flora have restricted or uncommon distributions. The vegetation is in good to excellent condition and is not represented in reserves.

4. Comparable sites are located at Jindalee/Butler and at Wellington. Both areas comprise a wide range of geomorphic and vegetation types. However, further study is required to

Occurrence of habitats and species composition at Clifdale/Butler  
streams. The soil and geomorphic units, and vegetation assemblages  
occurring at each location are documented in Table V for  
comparison.

7.2.2 Hedgery Heights

1. The area is an area which is located at the intersection of  
the Hedgery Heights and the... vegetation  
assemblages represented by these two geomorphic units as well  
as the area between them. This is a small but highly  
diverse habitat area.

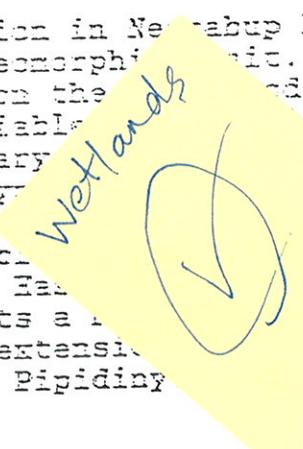
2. Hedgery Heights is situated in the midst of urban development  
and is a natural refuge area for flora and fauna.

3. Hedgery Heights is an occurrence of an unaltered Central South  
Vegetation Complex, which was once widespread in the Northwest  
Coastal region, but has been progressively developed for urban  
and rural purposes. Hedgery Heights is one of the two areas  
where this vegetation complex remains undisturbed.

4. Conservation of Hedgery Heights has the support of a large  
number of residents within the Murrumbidgee Shire, Murrumbidgee City  
Council, C.M.V., M. Heringham and the Liberal Party. It is  
recognized as an important in terms of regional occurrence,  
biological diversity and aesthetic contrast to the surrounding  
landscape.

7.2.3 Meerabup National Park Extensions - Spearwood Dune

1. The area designated for inclusion in Meerabup National Park  
along the Spearwood Dune geomorphic unit. In terms of  
vegetation structure and composition the Spearwood Dune area is  
considered to be a habitat of variable assemblages  
and communities. These habitats vary in changes in  
topography, hydrology, depth and type of soils and  
distance from the coast. It is the...  
this diversity of habitats by...  
both a North/South axis and an...  
National Park at present represents a...  
by including the proposed lateral extension...  
area north of Bulls Beach and... East West  
transition can be represented.



2. The proposed extended areas include important wetlands.  
Their inclusion increases the number of ecosystems represented  
as well as protects the wetlands - provides a buffer and  
interchange between ecosystems.

3. The proposed extensions to the Meerabup National Park link up  
existing reserves. This has many important implications  
including the increased size of the reserve area, the  
facilitation of fauna movement and the facilitation of  
management of the reserve to protect its important ecological  
features.

Wetlands of the ...

Wetlands are an important part of the ...

Wetlands are an important part of the ...

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Wetlands of the ...

Wetlands are an important part of the ...

### 8.0 WATER MANAGEMENT.

To obtain an understanding of the parameters involved in the management of wetlands in relationship to nearby urban areas it was necessary to conduct a literature review and to conduct a series of discussions with personnel from relevant government departments. The information obtained from these sources included firstly, advice on the inter-relationships of wetlands and urbanisation, secondly, current ideas and understanding of the problems associated with managing wetlands, and thirdly, current ideas on how to modify urban areas that are proximal to wetlands, or that may interface with a wetland or that may directly or indirectly alter wetlands. To ensure a consistency in accessing the information from the literature sources and from the discussions with government personnel, a range of objectives were formulated; that is the information was accessed with the explicit objectives to determine:

1. Anticipated impact of urbanisation on wetlands (e.g., groundwater extraction, nutrient loading pollution, drainage, or other unknown factors);
2. Generalised management recommendations to protect wetland (e.g., groundwater extraction, bores in suburbia, control of fertilisers, etc.)
3. Specific recommendations on how to modify urban structures to preserve wetlands;
4. Specific recommendations on how to modify WAWA water extraction or drainage practices to preserve wetlands;
5. Any additional comments.

The most relevant literature in the Perth region (relating to the management of wetlands in urban areas, the management of groundwater resources in urban and near-urban areas, and discussion of current problems associated with wetland - urban area interactions) are those recently produced by and for the Water Authority of Western Australia, as well as some specific publically available ERMP and PER documents. The main literature consulted included:

1. Perth Urban Water Balance Study Vol 1 Findings May 1987 (WAWA);
2. Land Planning & Groundwater Resource Protection and Policy 1988 (WAWA);
3. Gnangara Mound Groundwater Resources: WAWA Report & Recommendations. EPA Bulletin 295 1987;
4. Review of Groundwater Availability Wanneroo 1989 (WAWA);
5. Jandakot Groundwater Scheme Stage PER Vol 1 & 2 Water Resources Directorate Groundwater Branch 1991;
6. Water Sensitive Residential Design: An Investigation Into Its Purpose & Potential in the Perth Metropolitan Region. Water Sensitive Urban Design Research Group 1990;

7. Determination of Buffer Zones for Shallow Lakes & Wetlands  
L. Townley & J. Turner CSIRO Division of Water Resources  
1991
8. A Baseline Biological Monitoring Programme for the Urban  
Wetlands of the Swan Coastal Plain, Western Australia.  
J. A. Davis & S. W. Rolls. EPA Bulletin 265 1987;

The personnel consulted included:

J. Kite, P. Lavery, A. Hill & H. Tan of Water Authority Western Australia; J. Sutton, P. Humphreys & R. McAlpine of Environmental Protection Authority; J. Dixon & R. George of Department of Agriculture; J. Davis, S. Balla, P. Froend & A. McComb of Murdoch University; and L. Townley, J. Turner & R. Gerritse of CSIRO Division of Water Resources.

### 8.1 PREAMBLE ON MANAGEMENT OF URBAN AREAS ADJOINING WETLANDS.

Many of the recommendations in the published literature have been endorsed and implemented by the Water Authority through policy, planning, and careful management. However, it is beneficial to collate the major concerns and recommendations into a brief summary for purposes of future planning. Wetlands located within urban landuse areas are impacted upon in three major ways:

- 1) changes to the volume of water stored in the underground aquifer, and consequently to wetlands maintained directly by this source;
- 2) changes in water quality towards a more eutrophic state;
- 3) changes in the periodicity of wetland inundation and/or waterlogging.

These effects necessitate management of wetlands and groundwater supplies as an integrated system. Recommendations on protection of wetlands from these impacts must arise from a comprehensive data base of individual wetland functioning, and a regional overview of wetland variability. Groundwater extraction and drainage discharge, both of which, considerably effect wetland water levels, should then be managed to keep within the limits deduced from assessment of long term cyclic patterns. Protection of water quality is reliant on three procedures, a) prevention of direct drainage into wetlands of either untreated surface runoff or untreated water from other contaminated wetlands, b) establishment of priority use areas and groundwater protection zones. In the N.W. Corridor these areas have been organised to protect public water supplies in the Gnangara Mound, but a similar system needs to be put in place for groundwater protection in the zone of the Yanchep chain of wetlands. c) the establishment and management of adequate buffer zones to wetlands. Buffer zones are vegetated areas which still maintain both a diversity of structure and a reasonably dense areal cover. Parkland is not considered an adequate buffer zone.

Protection of the natural cycle of inundation of water is crucial to maintaining wetland diversity. Recent studies support this idea by demonstrating the relationship between hydrological variability and wetland flora and fauna.

Recommendations on the protection of wetlands include... to the urban structure and rural landscape... Some of the goals are to prevent urban encroachment and to... In order of priority, the goals are: 1) sanitation of... 2)... 3)... 4)... 5)...

Urban development use particularly those... low-lying areas is particularly... in the surficial sediments... the region of the Ganga-Mat... It is therefore recommended that either broadcast grazing be encouraged in areas of... land... which lie within wetland groundwater catchment areas, or that strict controls be applied on the amount and frequency of application of chemicals, or that, if necessary, these lands be converted to an alternative landscape.

In planning future urban development it is important that water conservation features be included in the design of settlements and that where possible, water sensitive parameters become one of the priorities of the design.

Other areas of concern need to be addressed by the... Authority can be summarized into five categories:

- a) Maintenance of regular monitoring of wetland water levels, wetland water quality, and any other parameters relevant to the function of each wetland and its management.
- b) Reliance on placement of wells with respect to wetlands, and... vegetation, and... areas of... plants.
- c) Treatment of surface water... to its entry into a wetland basin, or into the groundwater aquifer.
- d) The minimization of groundwater recharge where possible, at the same time mitigating against deterioration of these... receiving waters.
- e) The design of contingency plans in cases of unexpected or major contamination to groundwater or to wetlands, such as in cases of road spills.

Following on from this, we present below the results of the literature review and discussions, as related to the management of wetlands. To ensure that those wetlands, in an urban setting or adjoining urban areas, that are selected for conservation and protection are adequately managed, the procedures/recommendations outlined in the literature would need to be largely implemented. This may imply some modification of the urban structure along the urban/wetland interface, or at least management of the urban impact.

## 9.2 RESULTS OF LITERATURE REVIEW & DISCUSSIONS

The information in each of these key literature sources pertaining to management of groundwater resources on the Swan Coastal Plain is presented below within the framework of the following headings:

- A. Anticipated Impacts of Urbanisation on Wetlands
- B. Generalised Management Recommendations to Protect Wetlands & Groundwater
- C. Recommendations on How to Modify Urban Structures to Preserve Wetlands
- D. Recommendations on How to Modify WAWA Procedures

1. REPORT: Perth Urban Water Balance Study Vol 1 Findings  
May 1997 (WAWA)

### Anticipated Impact of Urbanisation on Wetlands

1) Changes in groundwater quality in relationship to changing landuses.

Changes in groundwater quality were noted by Bawden (1997) as groundwater moved along flow lines beneath various types of landuse and through different types of aquifer. This was due to partial evaporation of irrigation water, modification of vegetation, and groundwater pumping causing salt accumulation, and to an increase in both sulphate and nitrate from fertilisers and septic tanks.

2) Changes in water balance as a result of increased groundwater extraction. The transition in landuse, from natural to rural to urban, causes changes in groundwater recharge and discharge processes leading to changes in the volume of water stored in the aquifer and hence to changes in the water table elevation.

Extraction of groundwater also reduces flow to the coast increasing the risk of saltwater intrusion in local areas.

3) Detrimental changes in wetland water quality due to large inputs of eutrophic groundwater and surface runoff, with resulting associated problems, such as increase in the number of decomposers, detritus, and anaerobic microbial processes, first and second order compositors, and primary consumers. These changes result in odours, algal blooms, changes in population and species of fauna, oxygen depletion, high populations of pathogenic bacteria, high concentrations of bacterial and algal toxins, and death of waterbirds.

4) The report outlines predicted impacts upon groundwater elevations of complete development of the North West Corridor in the context of variable climatic regimes, and variable extraction procedures.

Scenario 1.- Below average rainfall with full corridor development. Fig. 70 predicts a fall of 1.0m in wetlands from Loch Mc Ness to Lake Gnangara, a possible salt water incursion at the coast. Wetlands most adversely affected are Lake Carabooda, Mowergup Lake, Meerarup Lake, and North Joondalup. Shallow wetlands would dry out for longer periods and would be under stress.

Scenario 2. - Average rainfall with full corridor development.

Fig. 68 predicts a rise of 0-1.0m over most of the North West Corridor, with rises of 1.0-2.0m in Beenyup-Goollelal area, and falls of up to 1.0m in the Carabooda-Nowergup area. There will be no problems of wetlands drying out, or of salt water intrusion.

Scenario 3. - Above average rainfall with full corridor development. Fig. 69 predicts a rise in water levels over the North West Corridor from 0-0.5m nearest the coast to greater than 3.0m in the Neerabup area and the Lake Goollelal area. Drainage will be required to remove excess water to prevent local inundation.

Management Recommendations to Protect Wetlands & Groundwater.

- 1) Areas should be identified where groundwater resources may be at risk due to overutilisation/degeneration of water quality.
- 2) Groundwater management options should be developed for risk areas.
- 3) Classify and evaluate wetlands in order to decide for which major function they are being conserved.
- 4) Define limits on permissible water levels in wetlands, then manage the water balance of the surrounding areas appropriately.
- 5) Summer drying should be maintained for seasonal wetlands.
- 6) Wetlands and the groundwater system should be managed together.
- 7) Recommendations on horticultural water requirements by Dept. of Agriculture (4mm per day) and C.S.I.R.O. (16mm per week) should be adopted. Present use in Wanneroo is 12.7mm per day during the summer period.

Recommendations on How to Modify Urban Structures to Preserve Wetlands.

- 1) Vary extraction rates eg. reduce domestic rates. This recommendation has no impact on wetlands in the Yanchepp suite, the Gnangara suite, or the Pinjar suite.
- 2) Reduce domestic, local authority, and institutional use of groundwater. This recommendation has no impact on Wanneroo wetlands.
- 3) Clear pine forests. This recommendation results in increased water levels in lakes Neerabup, Nowergup, and Goollelal, sumplands North Joondalup, and Beenyup.
- 4) Direct road drainage to infiltration basins. This proposal will have little effect on Wanneroo wetlands.
- 5) Recharge aquifer with sewage effluent. This proposal will increase water levels in all wetlands in the Yanchepp suite, especially Lake Joondalup, Beenyup, and Walluburnup swamps. Recharge wells should be placed down gradient of wetlands, which precludes any development of public water supply along the coast.

Recommendations on How to Modify WAWA Procedures.

- 1) Control pumping by WAWA.
- 2) Design drainage to remove stormwater and control high groundwater levels.

- 3) Provide local infiltration basins.
- 4) Discharge to ocean

2. REPORT: Land Planning and Groundwater Resource Protection Policy 1988 (WAWA)

Anticipated Impact of Urbanisation on Wetlands.

- 1) Urbanisation provides a potential for pollution of groundwater resources, primarily from industrial areas, waste disposal, and unsewered developments.
- 2) Within or adjacent to Public Water Supply Areas (PWSA), rural irrigation will compete with public water supplies for available groundwater resources.
- 3) Nutrification will occur from intensive animal husbandry, and over application of fertiliser, pesticides, and herbicides, which result in long term increases in soluble salts.
- 4) Increased surface runoff (with pollutants).
- 5) Leakage of petroleum products from underground storage tanks.
- 6) Pollution of groundwater by noxious substances, petroleum and toxic organic substances.

Management Recommendations to Protect Wetlands & Groundwater.

- 1) Implement the Groundwater Resource Protection Policy, - a groundwater control area and a primary source area where there is either State forest or no development, and recharge is sufficient to ensure wetlands and public water supply abstraction are in accord with drinking water and aquatic ecosystem standards.
- 2) Enforce quotas for private use of groundwater - Ratio 1 hectare irrigated land to nine hectares undeveloped land.
- 3) In areas of public water supply, the ratio should be less than 1/10.
- 4) Use more efficient slow release fertilisers.
- 5) Restrict release of horticultural land.

Recommendations on How to Modify Urban Structure to Preserve Wetlands.

- 1) Urban structure should be such that major development is downstream from wetlands.
- 2) Development should be such that landuses within the corridors are managed to protect the priority beneficial uses of underlying groundwater resources.
- 3) In rural areas large lots are preferred.
- 4) Special rural zones should not be permitted if proposed activities are not compatible with water allocations or if septic tanks are at a density greater than 1 tank/ 2ha.
- 5) Industry that processes substances that are mobile in the subsurface, or are any of the following;
  - toxic at low concentrations in water
  - produce organoleptic effects at low concentrations
  - adversely effect water treatment
  - do not readily degrade
  - difficult to clean up after spillage

OR

Moderately toxic substances at medium concentrations, should be prohibited in primary source areas or upstream of wetlands.



3) Regularly monitor groundwater and wetland water levels, and vegetation transects.

4. REPORT: Review of Groundwater Availability. Wanneroo. WAWA. 1989.

Recommendation on How to Modify WAWA Procedures.

- 1) Recommends that Pinjar groundwater extraction stages 1, 2, 3, go ahead.
- 2) Recommends appropriate management of pine forests, consistent with the policy of priority resource areas.
- 3) Recommends increased private abstraction, increased urbanisation, and artificial maintenance of Lake Nowergup, as being in compliance with EPA standards for natural ecosystems, according to the groundwater model used.

5. REPORT: Jandakot Groundwater Scheme Stage 2 PER Vol.1 & 2. Water Resources Directorate Groundwater Branch 1991.

[Although this report deals with wetlands of the Southern Corridors, principles therein are also applicable to the N.W. Corridor]

Management Recommendations to Protect Wetlands & Groundwater.

- 1) It is necessary to establish the relationship between groundwater and wetlands.
- 2) It is necessary to establish the functions of wetlands.
- 3) It is necessary to set up baseline monitoring of native vegetation trends.
- 4) Groundwater levels should be sufficient to flush nutrients.
- 5) Fringe concentration of nutrients should only occur where it does naturally, otherwise sediments may pick up nutrients and hold them in the system eg. Lake Joondalup.
- 6) Adhere to criteria set by CALM for A class reserves.
- 7) Maintain habitat diversity.
- 8) Wetland water levels must reflect natural seasonal patterns.
- 9) The link between wetland water levels and rainfall must be maintained.

Recommendations on How to Modify WAWA Procedures.

- 1) Changes in wetland water levels should be gradual to allow vegetation to adapt.
- 2) Artificial recharge of sensitive areas may be necessary.
- 3) Wells should not be placed closer than 300m to natural non-degraded swamplands - preferably 500m.
- 4) Wells should not be placed closer than 200m to System 6 areas - preferably 400m.
- 5) Any well whose drawdown cone is greater than 1.5m deep in sensitive areas, will be phased in over three years.
- 6) Drawdowns must not exceed 1.0m in areas of phreatophytic vegetation i.e. where the water table is less than 5.0m below the surface.
- 7) In areas where rare species occur, drawdown should be less than 0.5m.

6. REPORT: Water Sensitive Residential Design: An Investigation Into Its Purpose & Potential in the Perth Metropolitan Region. Water Sensitive Urban Design Research Group 1990.

Anticipated Impact of Urbanisation on Wetlands.

- 1) Urbanisation has modified the water balance to the detriment of aquifer recharge and wetland ecology.
- 2) Water quality has been prejudiced via the input of a range of nutrients and pollutants.
- 3) The present form of urban development has encouraged wasteful watering practices.
- 4) Changes have occurred in peak flow characteristics of surface runoff, such that they occur sooner, and in larger quantities.

Management Recommendations to Protect Wetlands & Groundwater.

- 1) Identify potential water quality contamination sources.
- 2) Stormwater systems should be designed to minimise pollution to surface and groundwater.
- 3) There should be no direct discharge into wetlands.
- 4) Identify acceptable levels of groundwater extraction.

Recommendations on How to Modify Urban Structures to Preserve Wetlands.

- 1) Increase urban density.
- 2) Develop landscape to incorporate water conservation features.
- 3) Use water harvesting techniques.
- 4) Maximize dispersion of stormwater infiltration.

7. REPORT: Determination of Buffer Zones for Shallow Lakes and Wetlands

L Townley & J Turner. CSIRO Division of Water Resources 1990.

Unpublished.

Management Recommendations to Protect Wetlands & Groundwater.

- 1) Identify capture zones, within which all groundwater will eventually flow into lakes or wetlands.
- 2) Identify buffer zones corresponding to different "times of protection."
- 3) Protect wetlands from contaminated groundwater.
- 4) Identify locations adjacent to wetlands where recharge of mildly contaminated water might never resurface into a down gradient wetland.

8. REPORT: 1. A Baseline Biological Monitoring Programme for the Urban Wetlands of the Swan Coastal Plain, Western Australia. J A Davis & S W Polls. EPA Bulletin 265. 1987.

2. Wetland classification using aquatic invertebrate communities and environmental variables. J E Grows, J A Davis, L Schmidt, R Rosich, & S J Bradley. (In prep.)

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 J Royal Society WA 69:
- 1988 Conterminous wetlands and their distribution  
 in the Darling Stater, Western Australia. J Royal Society WA 70:
- 1989 Wetlands of the Darling Stater, Western Australia: a  
 classification using vegetation pattern and form. J Royal  
 Society WA 73:
- 1985 Development of mangrove habitats along the  
 coasts in north and northwestern Australia. Vegetatio 69: 3-23.
- 1988 Threats to, and exploitation and destruction  
 of, mangrove systems in Western Australia in C D Field & A J  
 Darnall (eds), Mangrove Ecosystems of Asia and the Pacific;  
 status, exploitation and management. Proc Research for  
 Development Seminar, Townsville, 228-240. Aust Inst Mar Sci.
- 1985 Holocene climate history using calcareate as an  
 indicator. Paleo-3 53: 289-308

Semeniuk V, Crosswell ID & Wurm PAS 1989 The Quindalup Dunes: the regional system, physical framework and vegetation. J. R. Soc. WA 71: 23-47.

Semeniuk V & Crosswell ID 1989 Significance of aeolian dunes in coastal erosion: an historical perspective. Sedimentary Geology 67: 1-10.

Semeniuk V & Crosswell ID 1989 Sedimentary and structural dunes: a regional study, with special reference to the Quindalup Dunes. J. R. Soc. WA 71: 23-47.

Semeniuk V & Crosswell ID 1985 Stratification of dunes in Holocene coastal dune systems. J. R. Soc. WA 67: 1-10.

Semeniuk V & Crosswell ID 1988 Variability of Holocene coastal dunes on the south-western coast of Western Australia: implications for coastal erosion. Mar. Geol. 72: 47-60.

Semeniuk V & Crosswell ID 1987 The Whitford dunes - their origin, age and structure. J. R. Soc. WA 69: 1-10.

Semeniuk V, Crosswell ID & Wurm PAS 1989 Sedimentary and structural dunes: a regional study. J. R. Soc. WA 71: 23-47.

Water Resources Council 1987 Environmental significance of water in the south to Sydney region. A Water Resources Council Report No. 10 of the Water Authority of NSW, Sydney.

TABLE 1 - REVIEW OF LITERATURE PERTAINING TO THE ENVIRONMENT IN THE NORTHWEST CORRIDOR

NAME	CONTRIBUTION	NEW INFORMATION	RECOMMENDATIONS AND COMMENTS BY AUTHOR	RELEVANCE TO CONSERVATION	COMMENTS
Guinna Rock North and Jindalee, City of Wanneroo Coastal Development and Management Study, P. J. Woods 1990	Foreshore crown land parcels nos. 5, 10, 10, 9 (Guinna North to Aikimos)	Divides Wanneroo coast-line between Aikimos and Guinna beach into sectors based on medium scale geomorphology.	1. Natural rather than cadastral boundaries should be used for reserves. 2. Management of potential erosion should be sensitive.	Coastal heath C & D should be retained in part. Natural landforms near D.	Report focuses largely on management of potential erosion.  Areas C & D recommended for conservation correspond to area of dune-dunes shown on map as 'Jindalee'.
Proposed Refuse Disposal Facility at Mindarie, EEMF, Mitchell Stearna 1983	Mindarie Lot 17 - Cities of Wanneroo, Stirling and Perth	Hydrology - W.T. levels - Infiltration % Soils - uniform CO3 conc. Fauna - lists of reptiles, avifauna and amphibians Flora - two transects - species list - assemblages - map	1. Supports System 6 recommendation for regional park for recreation and some conservation DCE 1981b:10. 2. Rejects System 6 recommendation for a transect of natural vegetation of botanical significance.	Supports the idea of removing sand and limestone from the area and infilling with rubbish.  Supports an East/West corridor linking coastal Blowout area to Neerabup National Park. DCE 1981b.  Supports Parks and Recreation corridor between Guinna and Yanchoe and north of Two Rocks.	Groundwater contamination potential in the case of use of groundwater is not addressed.  Documented potential impacts on wildlife: 1. destruction of vegetation 2. introduction of new food source 3. introduction of Salmonella 4. increased burning 5. dissection of areas 6. human pressure
Results of the Wanneroo Coastal Study, P. J. Woods 1984	Coast between Sorrento and Ocean Reef.  Foreshore from Mandion to Burns Beach and Ocean Reef.	Division of the coast into geomorphic sectors: - stable rocky coast - eroding or stable sandy coast - sandy coast around beach ridge plains  Erosional areas: - Guinna Burns Beach, Sorrento.  Accretionary areas: - Pinnaroo Point. Aikimos (Beach ridge pl.)  Aboriginal Sites: none  Historic Sites: - Geneff Park Lime Kilns - Eglinton Water Mole - Burns Spring  (see map of resources)	Endorses Landscape Enhancement Policy 1980 (Shire of Wanneroo) 'Any development shall enhance & not degrade the environment.' Need to conserve: a) typical landforms b) habitats c) vegetation d) scientific sites e) unspoiled landscapes  Coastal Regional Open Space should include erosion prone land.  Variable width of coastal reserve  No North-south roads.  North-west Corridor Plan - incl. 3 transverse reserves: a) Burns/Mindarie, b) Aikimos, c) Two Rocks. P. J. Woods suggests multiple use of these areas except in the case of scientific conservation areas.	Wanneroo Town Planning Scheme No. 1, Section 5-17: 'Preserve and protect against development which may or could destroy the existing physical characteristics of flora adjacent to the coast.'  'No still conservation areas have been designated.'	Commentary on Mindarie Refuse Site which says rubbish is incompatible with System 6 and the North West Corridor Plan.

Landforms & Soils Map of areas occur- 12 mapping units based on Management recommendations for Q4 areas occur at Mullaloo. Mullaloo Q4 area has been  
 as an Aid to Urban ring in Spearwood geology, landform & soils erosion control. Mandarie South & North Yanchap reshaped and developed  
 Planning in the and Quindalup Wetlands and areas with exposed limestone pinnacles are recomm- Q4 areas coincided with foreshore into a residential area,  
 Perth Metropolitan Geomorphic Units ended for conservation. reserve in the NW Corridor plan  
 Northwest Corridor  
 W.A.  
 W. M. McArthur &  
 G. A. Bartle  
 1980

Response by the Wanneroo Shire  
 Wanneroo Shire to  
 System 6 Report  
 Shire of Wanneroo  
 Town Planning Dept  
 1981  
 There should be a regional park including linear lakes and national park.  
 Endorses Landscape Enhancement Policy 1980.  
 Endorses a continuous coastal strip.  
 Recommends that circular lakes should be in a management zone.  
 Areas considered for reserves:  
 1) Coastal strip - min. 500m  
 2) Lakes and wetlands - min. 500m  
 3) Quarries developed as parklands  
 4) areas containing caves  
 5) Two Rocks Reserve defined on the east by the Freeway  
 6) Burns Beach Recreation not to be appended to Neerabup N.P.  
 Wanneroo Shire suggests areas 5) & 6) should be strictly conservation areas and Alkimos & Robertson Rd be fully developed recreational areas.

Draft Management Trigg Island to  
 Plan - proposed Ocean Reef Boat  
 M10 Marine Park: Harbour  
 Trigg Island to  
 Burns Beach inc.  
 Manmion Reef  
 Report and  
 Recommendations  
 by the M10 Marine  
 Park Committee  
 DCE Buil. 220  
 1985  
 Conserve representative examples of coastal habitats in sufficiently large areas to ensure viability of their fauna & flora - there are several areas within this study area large enough to warrant conservation:  
 1. coastal heath at Burns  
 2. pinnacles at Ocean Reef  
 3. coastal dunes on Whitford Plain  
 4. rocky coastline - Trigg to Sorrento, Ocean Reef to Burns Sch

Burns Beach Lot M1722 Vegetation map  
 (South) 655 hectares  
 Feilman Planning  
 Consultants Pty Ltd  
 G.B. Hill &  
 Partners  
 EKDmin Pty Ltd  
 GHD-Parsons Brinck-  
 hoff  
 1978  
 Two areas are recommended as reserves:  
 1. eroded pinnacles south of active limestone pit  
 2. east margin of land around quarry 1.5km inland, east of Manmion Ave and south of road east-west.

<p>Protection of the Groundwater, Wetlands and Associated Ecosystems of the Swan Coastal Plain</p>	<p>Swan Coastal Plain</p>	<p>There is a need to protect groundwater resources in the SCP. There is a need to protect the remaining wetlands that exist on the SCP. There is a need to ensure that the ecosystems that are sustained and supported by the groundwater, including the wetland related ecosystems of the region, are protected and managed properly. Maintenance of essential ecological processes and life support systems. Preservation of genetic diversity. Ensuring the sustainable use of natural resources and ecosystems. Management of wetlands, groundwater, lakes, rivers and estuaries to ensure a clean and healthy condition. Development should 1) not exceed the environment's capacity to assimilate related adverse impacts; and 2) not jeopardise the well being of future generations.</p>	<p>The report presents an indication of probable compatibility of various landuse activities with the idea of beneficial uses of groundwater.</p>	<p>Landuses with significant adverse environmental impact on a) groundwater, b) wetlands, c) ecosystems, include: 1. domestic waste landfill 2. septic tanks 3. drainage 4. commercial underground storage 5. active recreation 6. industrial effluent 7. special residential urban development 8. urban residential 9. tree plantations 10. extensive grazing 11. intensive animal agriculture 12. irrigated agriculture</p>
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<p>The Quindalup Dunes: the regional system, physical framework and vegetation habitats.</p>	<p>Quindalup Dune Geomorphic Unit</p>	<p>Division of Quindalup Dune Geomorphic Unit into Large, Medium and Small Scale geomorphology and habitats.</p>	<p>Recommends the conservation of a) berched dunes and b) accretionary cusps composed of (fretted, crescentic, attenuated) parabolic dunes and chaots as examples of natural features within this sector.  Recommends further investigation of many areas.</p>	<p>Classifies the coastal section of the NW Corridor as 'Whitfords-Lancelin Sector' and shows four detailed maps within the sector. Illustrates the range of habitats in a cusp in this sector, using Mindarie as an example.</p>	<p>Conservation recommendations are based on: 1) landform type 2) scientific interest 3) representativeness 4) vegetation types 5) relative lack of disturbance</p>
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V. Semeniuk,  
I. D. C. Cresswell  
& P. A. S. Wurm  
1989

<p>Assessment of Water Table Drawdown on Lake Carrabooba Wetland</p>	<p>Lake Carrabooba</p>	<p>Water level data Vegetation assemblages</p>	<p><u>Meibomia raphiochylla</u> &amp; <u>Eucalyptus rudis</u> woodland give refuge to non-aquatic species unadapted to farmland. The wetland can be managed towards rehabilitation.</p>	<p>Wetland rated as having few remaining natural attributes and limited human use attributes by EPA (evaluation system).</p>
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LeProvost, Semeniuk  
& Chalmers  
1987

Consanguineous Wetlands and their distribution in the Darling System, South-western Australia	Wetlands in Yanchep Suite Wetlands in Gnangana Suite Wetlands in Pinjar Suite	1. Interrelationship of wetlands 2. Classification of wetlands on the basis of: Water longevity Shallow stratigraphy	Yanchep and Pinjar Suites are regionally unique. Gnangana Suite occurs in domains throughout the Darling System.	Significant for representativeness of wetland type  Additional occurrence of Wetlands of Gnangana St, North of Beermulrah Rd are in good condition South of Beermulrah Rd, north of Gingsin Brook, & west of Culcaederra Lake the wetlands are situated partially in cleared agricultural areas.
C. A. Semeniuk 1987				
Local Coastal Management Plan: 2 & 3 (Sorrento to Burns Beach)	Modern Beachridges		Re-route West Coast Highway to preserve area of heath south of Burns Beach as recommended by System 6 (M2).	Highlights the fact that no significant reserves exist in Wanneroo Coastal area and suggests that this be considered because: 1) relative variety of heath ridges 2) variety of coastal landforms 3) lack of reserved heath
P. J. Woods 1984				
Floristics of System 6 Reserves & Bushland IV - Vegetation & Flora of Hebburn Heights.	Hebburn Heights Area 43ha	4 vegetation assemblages 244 species listed	This area compares favourably in terms of status & diversity with other urban remnants.	Habitat diversity Low number of alien species Large number of flowering native plants. Record of priority species <u>Cartomena philynoides</u> and <u>Caroobrotus</u> sp.
G. J. Keighery 1990				This area has a very high public profile and an active local conservation group. Wanneroo City Council has endorsed the reservation of the area. The State Liberal Party have also supported its conservation.
Eglinton Resort Development Pty Ltd. FER LeProvost Environmental Consultants 1990	Area bounded by Piddinny Rd to the north Beonaddy Rd to the east; covering an area of 245 ha	3 vegetation assemblages are recognised within the Quindalup unit of vegetation mapped by Heddlie, Loneragan & Havel (1975). 6 Fauna habitats are recognised: 1. Shoreline - <u>Spinifex</u> sp. 2. Primary Dune Blowout - <u>Acacia roselifera</u> 3. Secondary Dune Blowout - <u>Calothamnus quadrifidus</u> , <u>Dryandra sessilis</u> 4. Deeper valleys - <u>Banksia</u> sp. 5. Tall open forest - <u>Eucalyptus gomphocephala</u> 6. Pasture	Recommends ongoing monitoring of groundwater, dune stability and vegetation, nutrient contamination, and coastal processes.	Quindalup blowout system is estimated to cover an area of 750 ha and to extend 3km inland. The existing coastal reserve and area covered in system 6 recommendation M2 at Eglinton totals approximately 100 ha with a maximum width of 1200 m.
				Fauna usage: Banksia woodlands and Tuart forest account for the majority of fauna species - 117 and 104 species. Heathlands account for 100 and 82 species. Pasture accounts for 55 species. Shoreline accounts for species Note: effects of clearing on numbers of fauna species Rare species: Peregrine falcon - schedule 2 Aust. Sea-lion - schedule 2 Black-striped snake - schedule 1

Shire of Wanneroo  
- a study of land  
resources and  
planning  
considerations.

all rural and  
undeveloped  
coastal land in  
the Wanneroo Shire

Uses McArthur & Bartle  
landform framework to map  
small scale soil units

1. Land developments within the Shire should aim to be sympathetic to the natural landform and soil conditions.
2. Protect and maintain sensitive wetland areas and coastal lakes.
3. Retain as far as practical the natural vegetative cover of coastal dune areas.
4. Buffer zones should separate conflicting landuses from waterbodies and their recharge areas.
5. Land resource mapping at a more detailed scale than 1:25,000 is used as a basis for environmental impact assessment.
6. Q4 and Q9 areas are capable of supporting subdivision with buffer zones and considerable management if they are to be used.

Authors relate resource to planning considerations.  
Karrakatta sands have greatest horticultural potential.  
Residential areas should be sewered  
Q units - residential or conservation  
S3 units - quarrying  
Ky, Kg, Sd, Sw - agriculture  
Swamps - do not compete with irrigated areas  
Equestrian landuse needs summer pastures

West. Aust. Dept.  
Agriculture  
Technical Report 47  
- Division of  
Resource  
Management.

M. R. Wells &  
A. J. Clarke  
1966

Dune Vegetation of  
the Swan Coastal  
Plain, Western  
Australia

Variability of  
vegetation  
assemblages  
/communities on  
Bessendeau,  
Spearwood and  
Quindalup Dunes.

Species lists  
New vegetation units  
There are 8 upland  
vegetation complexes and  
7 wetland vegetation  
complexes  
There are 14 upland  
communities and 16  
wetland communities.

Floristically based methods  
appear the most appropriate to  
describe the full vegetation  
variation - an essential  
prerequisite to the development  
of adequate conservation plans.  
It is important that adequate  
and representative samples of the  
coastal plain vegetation be  
conserved.

Bessendeau soil association  
exhibits the greatest species  
richness.  
Complexity of vegetation  
patterns is greatest in  
Karrakatta and Cottesloe soil  
associations, because of the  
diverse landform types.  
Variability of vegetation  
assemblages/communities to a  
level never before subdivided.

May need further  
investigation at specific  
sites.

I. D. Cresswell &  
P. B. Bridgewater  
1985

Environmental  
significance of  
wetlands in the  
Perth to Bunbury  
region.

Wetlands included  
in survey:  
Jandabup Lake,  
Lake Adams,  
#8, #13 Sydney Rd.  
Marginiup Lake  
Lake Pinjar  
Lake Goolieal  
Lake Joondalup  
Nearabup Lake  
Nowergup Lake  
Carabooda Lake  
Yonderup Lake  
Pippidiny Lake  
Loch McNess

Wetland Classification  
and Evaluation systems

Loch McNess, Yonderup, Lake  
Joondalup, Lake Goolieal, Lake  
Pinjar, Lake Gnargara, Jandabup  
Lake, Lake Marginiup, #8, #13  
are considered by a number of  
wetland experts, on the basis  
of current available  
information in 1987, to be of  
regional to international  
significance.

W.A. Water  
Resources Council  
1987

Draft: Wetlands and  
Environmental Groundwater  
Protection Policy  
for Groundwater,  
Wetlands and  
Associated  
Ecosystems of the  
Swan Coastal Plain

Swan Coastal Plain  
Environmental  
Protection Advisory  
Committee  
1990

Maintenance and management of the wetlands of the SCP such that a) current or proposed landuse activities protect and do not adversely affect the number and quality of the wetlands; and b) management of wetlands and landuse activities in adjacent areas are undertaken to protect the attributes of the wetlands.

Protection and management of ecosystems that are dependent on the groundwater or wetlands of the SCP such that: a) vegetation dependent on the groundwater is retained, b) landuse activities provide for the protection and management of these ecosystems, c) groundwater levels are maintained at levels such that the dependent ecosystems are protected, d) quality of the groundwater is protected from adverse effects resulting from current and proposed landuse activities; and e) ensures that adequate natural vegetation buffer zones surrounding wetlands are retained. Existing landuse activity within groundwater protection zones be permitted provided that: a) does not cause pollution of the groundwater, b) does not cause loss or degradation of existing wetlands, c) does not cause additional removal or degradation of areas of remnant native vegetation.

Policy put forward to protect groundwater, wetlands and associated ecosystems.

The Whitfords Cusp: Whitfords Cusp  
its geomorphology,  
stratigraphy and  
age structure.

V. Saemniuk  
& D. J. Searle  
1976

Stratigraphy  
Sea level history  
Sedimentary facies  
Geomorphology

Baseline study for similar  
cusps at Mindarra and Alkinds.  
(comparative data)

Evidence of shoreline erosion.  
Significance of variable  
sealevel history.

Illustrates importance of  
cusate forelands in the  
studies of shoreline erosion,  
sediment movement and sealevel  
history.

State Woodlands  
Commission

Society of

Areas of remaining  
Banksia Woodland  
in the Spearwood  
and Bassendean  
Dunes

Gnangara Water  
Reserve between  
Gnangara Rd. and  
Singing Brook

Beard & Sprenger 1911  
Geographical Data from  
the Vegetation Survey of  
W. Aust. (Veg Surv WA Gov  
Paper 11- 61% of Banksia  
Woodland is now cleared.  
(C.S. Beard)

Geomorphologically, the  
Bassendean & Spearwood  
dunes can be subdivided  
into drylands & wetlands.  
Drylands include dunes &  
interdunes. Dunes are  
further subdivided into  
relief, dune crests,  
flanks, different aspects  
& geometry. Interdunes  
are subdivided further  
into thick & thin sand-  
sheets, & width wrt. WT  
Depth. (V. Semeniuk &  
D.K. Glassford)

Quenda - Isodon theaeus  
occurs in Banksia  
woodlands where these  
surround ephemeral swamps  
Skinks: Egernia nankivillei  
& Emblembia branchialis  
only occur in woodlands  
adjacent to denser &  
moister vegetation  
types. (R.A. How & J. Bell)

There is a positive  
correlation between  
urbanisation,  
horticultural activities  
& nitrate levels in  
groundwater in  
superficial aquifers on  
SCF (Cangeeg et al 1987)

To adequately address the  
variability of floristics in the  
Banksia Woodlands of the  
Bassendean and Spearwood dunes,  
phyto-sociologic studies should  
be undertaken in conjunction  
with a determination of physical  
features such as dune or  
interdune type; depth to WT;  
aspect; organic soil  
development; kaolin content etc.  
(Semeniuk & Glassford)

Because of extensive clearing  
and disturbance of the Banksia  
Woodlands of the SCF, these  
woodlands are now at a point  
where effective conservation and  
management is critical.  
....these woodlands have been  
neglected scientifically.  
The fire-wood interaction is  
probably the most important  
issue to be taken into account  
in terms of management (A. J. M.  
Hopkins & E. A. Griffin)

Management of remnants to  
prevent demise of species and  
their dependent fauna (E. Lamont)

Management of groundwater  
resources so that no degradation  
of resources occurs

Management of land use in areas  
surrounding groundwater  
resources

Management of quantities of  
groundwater pumped by domestic &  
agricultural borea (J. Kite  
& K. Webster)

The degree of floristic  
variation found in Banksia  
Woodlands has significant  
implications for conservation,  
since adequate conservation  
requires that the range of  
variation should be represented  
in reserves.

Endemic and rare species have  
not been assessed fully for  
Banksia Woodlands (J. Dodd &  
E. A. Griffin)

Conservation of a few hectares  
in size of remnant woodland  
areas, if managed to maintain  
environmental quality, can be  
adequate to preserve almost all  
invertebrate species of the  
community (Key 1987 in:  
J. D. Majer)

No vertebrate species is unique  
to Banksia Woodlands.

Banksia Woodlands attract  
migratory bird species from end  
of spring onwards.

Banksia Woodlands should be  
contiguous with  
wetlands!! especially for  
amphibians and skinks mentioned  
in column 3)

Storr & Johnstone 1988

A Report on the Flora & Vegetation of the Aikimos area and Conservation issues affecting it. 1070ha known as the Aikimos area -approximately 3.2km x 4.2km in widest areas

Report to Landcorp.

M. Trudgen  
& B. Kieghery  
1990

-Information on the structure and floral composition of the vegetation.  
-223 flowering plants were recorded (-36 introduced species).  
-Assessment of the condition of the vegetation.  
-Documentation of species of particular interest.  
-Vegetation complexes of Heddlé et al. 1978 are used;  
Quindalup Complex has 7 assemblages  
Cottesloe-Central/South has 10 assemblages  
Conservation value of the study area is documented.

Vegetation: The Aikimos area contains vegetation types which comprise the Quindalup Complex. These are not as yet adequately reserved.  
The area contains vegetation variant to the Cottesloe-Central/South Complex in structure and association because of the near coastal location. At Aikimos is the most western occurrence of the Cottesloe Complex. These vegetation types are not adequately reserved.  
The vegetation within the Cottesloe-Central/South Complex is diverse, therefore larger areas are required to be reserved. NE section of study area is recommended.  
Landform: The occurrence of dune type G1 (McArthur & Bartle 1978) abutting the coastline is unusual and worthy of conservation. The occurrence of G2 dune within the area is a fine example of the parabolic dune.  
Research & Education: The Aikimos area is valuable for future research and education. Several examples of future research in field of plant ecology, with which the author is most familiar are cited.

Most of the vegetation in the Quindalup Complex is in very good condition and has high species diversity.  
The Quindalup Complex is reserved in moderate areas in Waigorup Nat. Park, Nambung Nat. Park and associated Managarah Nature Reserve. These areas comprise the southern and northern extremes of the vegetation complex. There are no reserves in this specific climatic and geomorphic region - apart from a few hectares in Yanchoep Nat. Park.  
Some plant species occur at the limits to their ranges [*Stylidium* aff. *repens*, *Veronica* aff. *calycina* and *Laxmannia sessiliflora* ssp. *australis*]. Other plant species which are widespread but uncommon occur in this area [*Conostylis pauciflora* ssp. *eurhipis*, *Stylidium* sp. ('*maritima*'), *Leporhynchus scabrus*, *Veronica* aff. *calycina* and *Conostylis tetradiflora* ssp. *planescens*].

A Report on the Flora & Vegetation of the Ningara area and Conservation issues affecting it. 540ha known as Ningara area, south of Yanchoep -approximately 1.4km x 3.8km in the widest areas

Report to Landcorp

M. Trudgen  
& B. Kieghery  
1990

-Information on the structure and floral composition of the vegetation.  
-183 flowering plants were recorded (-36 introduced species).  
-Assessment of the condition of the vegetation.  
-Documentation of species of particular interest.  
-Vegetation complexes of Heddlé et al. 1978 are used;  
Quindalup Complex has 9 assemblages  
Cottesloe-Central/South has 7 assemblages  
Conservation value of the study area is documented.

The Ningara area contains vegetation types restricted to coastal and near coastal areas. These are vegetation types of the Quindalup dune system and the near coastal variants of the Spearwood dune system (McArthur & Bettenay 1959). These vegetation types are not adequately reserved. As a consequence the Ningara area, Aikimos area, uncleared areas between them and to the north of Ningara have very significant conservation value.

Some plant species occur at the limits of their range [*Stylidium* sp. ('*maritima*')]. Other plant species which are widespread but uncommon also occur in this area [*Conostylis pauciflora* ssp. *eurhipis*, *Stylidium* sp. ('*maritima*'), *Leporhynchus scabrus*, *Alysicarpus hughesii*? var. *glabrescens* and *Tetragonia tetragonioides*].

Wetlands of the  
Darling System,  
south-western  
Australia: a  
descriptive  
classification  
using vegetation  
pattern and form.

Classification of  
vegetation  
patterns and  
assemblages for  
the following  
wetlands:

Lake Pinjar  
Lake Joondalup  
Lake Jandabup  
Lake Grangara  
Lake Canabooda

C.A. Semeniuk,  
V. Semeniuk,  
I.D. Chesswell &  
H.G. Marchant  
1990

Wetland classification  
using vegetation pattern  
and form.

Representativeness of wetland  
vegetation assemblages within  
each consanguineous suite.

Pinjar Suite:  
Maculiform: Lake Pinjar  
Yanchep Suite:  
Latiform: Lake Wilganup  
Carraman Swamp  
Zoniform: Lake Joondalup  
Lake Koungup  
Heteriform: Loch McNess  
Concentri.: Lake Beenyp  
Maculiform: Canabooda Lake  
Lake Neerabup, Walluburnup  
Grangara Suite:  
Zoniform: Lake Grangara  
Lake Manginup  
Concentri.: #8, #13, #15, #21  
Bacata.: Lake Jandabup  
Maculiform: Lake Adams, #27  
#23, Little Badgerup Lake  
Badgerup Lake

TABLE II - DISTRIBUTION AND RESERVE STATUS OF REGIONAL VEGETATION COMPLEXES  
IN THE NORTHWEST CORRIDOR

Vegetation Type	Distribution within Swan Coastal Plain	Conservation in System 6 reserves or National Parks	Recommended for conservation in the structure plan
<u>Quindalup</u>			
B-unvegetated	Restricted	No areas conserved	Foreshore reserve
D-heathland	Widespread	Foreshore Reserve Minor area - Yanchep Nat. Park	Minor area -Whitfords Cusp Minor area -Alkimos Minor area -Yanchep Nat. Park South Yanchep
<u>Cottesloe-Central &amp; South</u>			
heathland	Widespread	Neerabup Nat. Park	Neerabup Nat. Park
woodland	Widespread	Neerabup Nat. Park Yanchep Nat. Park	Neerabup Nat. Park Minor area -Yanchep Nat. Park Lake Joondalup border
variant heath	Restricted	Burns Beach Reserve	Burns Beach Reserve
<u>Cottesloe-North</u>			
heathland	Widespread	Yanchep Nat. Park	Yanchep Nat. Park
woodland	Widespread	Yanchep Nat. Park	Yanchep Nat. Park
<u>Karrakatta-Central &amp; South</u>			
woodland	Restricted	State Forest No.65 (but no areas specifically set aside for conservation)	-
<u>Bassendean-North transition</u>			
woodland	Restricted	State Forest No.65 (but no areas specifically set aside for conservation)	-
<u>Bassendean-Central &amp; South</u>			
woodland	Restricted	State Forest No.65 (but no areas specifically set aside for conservation)	-
<u>Pinjar</u>			
woodland	Restricted	No areas conserved	No areas conserved

TABLE III - DISTRIBUTION AND RESERVE STATUS OF MEDIUM SCALE SOIL UNITS  
IN THE NORTHWEST CORRIDOR

Soil Type	Distribution within Swan Coastal Plain	Conservation in System 6 reserves or National Parks	Recommended for conservation in the structure plan
<u>Quindalup</u>			
Q1	Restricted	No areas conserved	Yanchep Nat. Park Minor area -South Yanchep
Q2	Restricted	No areas conserved	Minor area -South Yanchep
Q3	Restricted	No areas conserved	No areas conserved
Q4	Restricted	Foreshore reserve	Foreshore Reserve
Qu	Restricted	No areas conserved	Foreshore Reserve at Mindarie and at South Yanchep - very small areas
Qp	Restricted	No areas conserved	Yanchep Nat. Park Minor area -South Yanchep
Qs	Widespread	No areas conserved	Minor area -South Yanchep
<u>Spearwood</u>			
Kls	Widespread	Neerabup Nat. Park Yanchep Nat. Park	Neerabup Nat. Park Yanchep Nat. Park South Yanchep
Ky	Widespread	Neerabup Nat. Park Yanchep Nat. Park	Neerabup Nat. Park Yanchep Nat. Park Yellagonga Reg. Park
Kg	Restricted	No areas conserved	No areas conserved
Sp	Widespread	Neerabup Nat. Park Yanchep Nat. Park	Neerabup Nat. Park Yanchep Nat. Park Yellagonga Reg. Park
B	Restricted	Yanchep Nat. Park	Yanchep Nat. Park Neerabup Nat. Park Yellagonga Reg. Park
<u>Bassendean</u>			
Bd	Widespread	No areas conserved	No areas conserved
Bw	Widespread	No areas conserved	No areas conserved
Sw	Restricted	System Six M8	No areas conserved
L	Restricted	Lake Jandabup Fauna Reserve	Lake Jandabup Fauna Reserve

TABLE IV - DISTRIBUTION AND RESERVE STATUS OF MEDIUM & LARGE SCALE  
GEOMORPHIC FEATURES IN THE NORTHWEST CORRIDOR

Geomorphology Type	Distribution within Swan Coastal Plain	Conservation in System 6 reserves or National Parks	Recommended for conservation in the structure plan
Foreshore =foredunes parallel dunes swales	Widespread	Foreshore reserve	Foreshore reserve
Coastal headlands Cliffs & Coastal limestone ridges	Restricted	Foreshore reserve	Foreshore reserve
Cuspate foreland (inc. Parabolic dunes & Chaots)	Restricted	No areas conserved	No areas conserved
Perched dunes	Restricted	No areas conserved	Minor area -South Yanchep
Mobile parabolic Dunes & Blowouts	Very Restricted	Minor area: Burns Beach Reserve	Minor area: Burns Beach Reserve
Low hilly- undulat. terrain with sandy lime- stone core, outcropping on ridge crests	Widespread	Yanchep Nat. Park	Yanchep Nat. Park Minor area -South Yanchep
Low hilly- undulat. terrain of sand	Widespread	Neerabup Nat. Park Yanchep Nat. Park	Neerabup Nat. Park Yanchep Nat. Park
Very gently undulat. to flat terrain	Widespread	No areas conserved	No areas conserved
Steep-sided linear basin wetlands within karst topography	Widespread	Yanchep Nat. Park	Yanchep Nat. Park Neerabup Nat. Park Lake Nowergup Yellagonga Regional Park
Shallow rounded basin wetlands	Widespread	Part of Jandabup Lk.	Lake Adams Lake Marginiup Jandabup Lake Gnangara Lake
Large scale hummocked and lowland basin wetlands	Restricted	No areas conserved	No areas conserved

TABLE V - UPLAND AREAS IN THE NORTHWEST CORRIDOR RECOMMENDED FOR CONSERVATION

Area Recommended for Conservation	Soil Units	Vegetation Complex	Geomorph. Unit	Rare & Endangered Flora	Endangered Fauna	Competing Landuses	Present Landuse	Testing	Justification	Comments
Burns Beach-Southern Ridge	El5	Cottesloe-Cent/Sth Assemblages: 1) low heath <u>Scaevola crassifolia</u> 2) heath <u>Scaevola thaeoides</u> 3) low heath <u>Acacia pulchella</u> 4) shrubland <u>Acacia rostellifera</u> , <u>Acacia cyclops</u> 5) shrubland, <u>Leather-rosea preissii</u> 6) woodland <u>Banksia attenuata</u>	- Limestone headlands - Coastal ridge - Cliffs	Unknown	Unknown		Parks & Open Space  Resident.  Roman Cath. Archbishop of Perth  Edelaide Steamship Company	EPCC. Crown Res. Roman Cath. Archbishop of Perth  Edelaide Steamship Company	1. Occurrence of limestone ridge at the coast. 2. Vegetation is important regionally and is floristically rich.	Extend boundary eastwards to incl. small scale zone of Ey landform & other veg. assemblages found in Cottesloe Cent/Sth line. Banksia Woodland mosaic showing gradation and change with landform type.
South Minderic Qc	Q1 Q2 Q3 Q4	Cottesloe-Cent/Sth Quindalup Complex Assemblages: 1) low shrubland of <u>Acacia</u> spp 2) closed heath with <u>Cheeria acillaris</u> 3) low shrubland disturbed by blowouts 4) low open woodland <u>Banksia attenuata</u> <u>Banksia neeblei</u> 5) heath, dominated by <u>Bryandra sessilis</u> 6) grassland 7) woodland <u>Baccharis caribaeoides</u>	Large Scale: None Acrot. Cusp  Medium Scale: Parabolic Dunes Shore parallel ridge systems  Low hilly to undulating terrain with limestone outcropping.	None Recorded	Leafless Lizards: <u>Gelg</u> <u>cravii</u> <u>pygmaea</u> <u>lepidocentrus</u> Goats: <u>Macropus rufus</u> <u>maculosa</u> Reptiles are locally rare. Birds: Peregrine falcon Browne cuckoo Rufous Skyhawk	Parks & Open Space Active Rec. Residential Pub. Util.	Pub. Util. Private  Landcorp  Circles of Perth Swirling Bannerco	1. Best developed Recreational Cusp now remaining in the Northwest Corridor (Coastal Sector IV- Whitfords to Lancelin) 2. Representative geomorphology & geological features 3. Typical range of habitats within cusp setting 4. Relative lack of disturbance. Vegetation is in good condition 5. Link to Neerabup National Park 6. Scientific interest 7. Vegetation is variable, representative of cusp setting & shows gradational habitat change.		
Jindalee & Butler	Q2 Q3 Q4 Qp Qs El5 Ky	Quindalup Complex: 2 habitats	Perched Dunes	Unknown	Unknown	Residential	Undeveloped	Private	1. Occurrence of Perched Dunes (Coastal Sector IV- Whitfords to Lancelin) Preservation of: a) clacts b) parabolic dunes	Requires further study

Mihingo	Q1 Q2 Q3 Q4 Q5 Q6	Quindalup Complex Assemblages: 1. open hummock grass -land 2. hummock grassland 3. low open heath <u>Scoroparia crassifolia</u> <u>Acacia truncata</u> 4. shrubland <u>Myoporum insulare</u> <u>Sporobolus clobulosus</u> 5. low open heath <u>Acacia rostellifera</u> <u>Melaleuca acerosa</u> 6. shrubland <u>Melaleuca acerosa</u> 7. open shrubland <u>Cleistanthus argentea</u> <u>Scoroparia nitida</u>	Large Scale: Accretionary cusp  Medium Scale: Parabolic dunes Blowout Shore parallel ridge system Low hilly to undulating terrain with limestone outcroppings. Low undulating terrain with deep sands	Flora at extremes of their ranges and is wide- spread but unknown	Unknown	Parks & Open Space Residential Pub. Util.	Undeveloped Private	Landcorp	1. Occurrence of Accretionary Cusp of South Minderie it is a lower class example 2. Representative geomorphology -dune types Q1-Q4 3. Parabolic Dune of good quality 4. Diversity of Vegetation 5. Vegetation in good to excellent condition 6. Some Vegetation of regional significance 7. Representative vegetation
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South Vetchep	Q2 Q3 Q4 Q5 M's	Quindalup Complex Assemblages: 1. open-closed heath <u>Scoroparia crassifolia</u> <u>Cleistanthus argentea</u> 2. low open shrubland <u>Acacia truncata</u> <u>Acrotriche cordata</u> <u>Melaleuca acerosa</u> <u>Ptilothrix ferruginea</u> 3. low open heath <u>Leptocarpus preissii</u> <u>Heulandria hirsuta</u> 4. herbland <u>Leptocarpus argentea</u> 5. low open shrubland to open heath <u>Melaleuca acerosa</u> 6. low open heath <u>Trypaleia albicans</u> <u>Acacia lasiocarpa</u> <u>Corylobium reticulatum</u> <u>Melaleuca acerosa</u> 7. low open heath <u>Acacia rostellifera</u> <u>Melaleuca acerosa</u> 8. closed shrubland <u>Acacia rostellifera</u> 9. closed heath <u>Acacia rostellifera</u>	Perched Dunes Flora at extremes of their ranges and flora that is wide- spread but unknown	Flora at extremes of their ranges and is wide- spread but unknown	Unknown	Parks & Open Space	Undeveloped	Landcorp	1. Perched Dunes -good example Preservation of: a) dunes b) parabolic dunes 2. Representative geomorphology -dune types Q2-Q4 3. Diversity of Vegetation 4. Vegetation in good to excellent condition 5. Some Vegetation of regional significance 6. Representative Vegetation
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Eglington	Q1 Q4 Q8	Q1 Q2 Q3	Quindalup Complex	Perched Dunes	Peregrine falcon (sched. 1) Australian Sea-lion (sched. 1) Black striped snake (sched. 1)	Parks & Open Space Future Urban	Undeveloped	Private	<ol style="list-style-type: none"> <li>1. Perched Dunes</li> <li>2. fauna habitats:</li> <li>3. Shoreline <u>Colinvaux</u> spp.</li> <li>4. Primary dune blowout <u>Acacia rostellifera</u></li> <li>5. Secondary dune blowout <u>Callitriche</u> <u>quadrifida</u>, <u>Dracopis sessilis</u></li> <li>6. Deeper valleys <u>Banksia</u> spp.</li> <li>7. Tall open forest <u>E. concolorata</u></li> <li>8. Pasture</li> </ol>	Requires further study
Epburn Heights	Q1 K1s K1y	Q1 Q2	Corrlesloe-Cent/Stb Karrakatta-Cent/Stb Quindalup Complex Assemblages: 1) Woodland <u>Eucalyptus</u> <u>gambocensis</u> 2) Low open woodland <u>Phacelium marginata</u> 3) Low woodland <u>Banksia</u> sp. 4) Limestone heath	Low hilly undulating terrain with sandy lime- stone core outcropping on ridge crests. Low hilly undulating terrain of sand.	<u>Cartotena</u> <u>philoides</u> -priority species	Residential Pub. Util. Parks & Open Space	Undeveloped	<ol style="list-style-type: none"> <li>1. Junction of 4 landform/soil units and hence 6 habitats exist:</li> <li>2) Jarrah Woodland</li> <li>3) <u>Banksia</u> low Wood.</li> <li>4) <u>Acacia rostellifera</u> scrubland</li> <li>5) <u>Acacia truncata</u> closed heath</li> <li>6) <u>Dracopis sessilis</u> heath</li> <li>7) Quartz woodland</li> <li>8) Regional open space between Quindalup and Carine.</li> </ol>	Support of local residents Ganneroo City Council, CALM & WA Herbarium	
Meerup National Park Extension	K1s Sp	K1s Sp	Corrlesloe-Cent/Stb 1) heath 2) Woodland	Low hilly to undulating terrain of	Unknown Unknown	Parks & Open Space Pub. Util.	Agriculture Undeveloped	CALM DPUD Private	<ol style="list-style-type: none"> <li>1. Link with Venchep National Park</li> <li>2. Area includes wetlands</li> <li>3. Chain of reserves</li> <li>4. Management facilitated</li> <li>5. Advantages to fauna</li> <li>6. Includes both heath and woodlands of Corrlesloe-Cent/Stb vegetation unit</li> <li>7. Represents K1s. Ey and Spearwood soil units</li> <li>8. Represents low hilly undulat. terrain of Spearwood geomorphic unit</li> </ol>	

Buffer zones to  
wetlands  
-all remaining  
areas of upland  
vegetation abut-  
ting wetlands.

1. Protects wetlands from accessibility
2. Protects wetland from nutrient runoff, from surface drainage, groundwater drainage & incompatible landuses
3. Aesthetic value
4. Provides important wetland fringe for nesting/breeding waterfowl
5. Transition zone for terrestrial species utilizing wetland
6. Buffer to edges in urban areas
7. Buffer to water level rise
8. Transition from wetland to upland vegetation assemblages

## PRELIMINARY

TABLE VI : CRITERIA FOR CONSERVATION OF NATURAL SYSTEMS  
INCLUDING WETLANDS

1. Is the system regionally widespread, or is it restricted in distribution? Is it typical and representative, or distinct and unique?
2. Is it important as a productive area upon which depend such commercial endeavours as fisheries?
3. Is it important to maintain the quality of human or animal and plant life?
4. Does it function in shore stabilisation or is it important to the local problems of sedimentation/erosion?
5. Does it have important ecological or geological features of national or international significance?
6. Is it important in providing natural environments or habitats (or system of these units) which are a research resource?
7. Could it function as an important natural or relatively undisturbed, or even altered environment for use by primary, secondary or tertiary educationalists because of scientific features and accessibility?
8. Does it function as a habitat of rare and endangered species?
9. Does it function as an important regional wildlife sanctuary, even if the flora/fauna are not rare or endangered?
10. Is it important as either a seasonal or temporary habitat or breeding ground of large numbers of migratory or nomadic animals, particularly waterbirds?
11. Can it function as a relatively undisturbed or natural area or wilderness for use by naturalists, bushwalkers, etc.?
12. Does it have importance from the point of view of aesthetics and function as a wilderness?
13. Does it have importance as an historic or actively utilised Aboriginal heritage site?
14. Does it have value for active waterbased recreation (e.g. fishing)?
15. Does it (regardless of whether it is natural or degraded) constitute part of a linked natural system, either physical or biological, such that its destruction or alternate use would result in disturbance/alteration to adjoining areas?
16. Does it have social values evidenced by community concern for its conservation, regardless of scientific values?

TABLE VII - Status of Vegetation of Wetlands.

Five categories of vegetation cover were recognized:

1) natural vegetation present in wetland and natural vegetation present in surrounding upland areas;

2) natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared;

3) wetland vegetation partly modified or cleared, or with introduced species;

4) natural vegetation present in wetland but surrounding upland vegetation totally modified or cleared;

5) wetland vegetation totally cleared or destroyed.

**DRAFT CONSERVATION ASSESSMENT of  
PART LOT 52 ON PLAN 16832  
(CERTIFICATE OF TITLE VOLUME 2112 FOLIO 88)  
BASED ON INFORMATION AVAILABLE PRIOR TO 5<sup>TH</sup> MAY 1998**

**Department of Environmental Protection**  
June 2000

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## **Wetland Values**

Lot 52 presently contains two protected wetlands. These have been protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP) since 18 December 1992.

This policy applies to the Swan Coastal Plain in the State of Western Australia and provides a mechanism to preserve, enhance and protect the beneficial uses of lakes of the Swan Coastal Plain.

The inclusion of these lake within the EPP protects the values and uses of the wetland from degradation through activities such as draining, mining, filling or excavation. Under the EPP these activities are prohibited and penalty provisions apply to any such breach. (Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.)

It is highly likely that the Environmental Protection Authority would require a formal assessment for any activity proposed on this property due to the presence of these protected wetlands.

To include Lot 52 as part of the Neerabup National Park would secure the buffer area of the smaller wetland and part of the larger wetland.

It is well documented that wetlands require adequate well structured and diverse buffer zones to withstand any environmental changes associated with encroaching development. (Environmental & Landscape Audit of the Southwest, Northwest & Northeast corridors, Perth Metropolitan Area).

- The required width of buffer zones vary from site to site but should not be less than 500 m.
- Buffer zones provide a barrier to midges in urban areas.
- Buffer zones are important which considering hydrological changes associated with unpredictable climatic regimes or changes in landuse.

Urbanisation would threaten the integrity of the wetland through increased groundwater extraction, nutrient loading, drainage etc.

## 2.2 Fauna Values

The faunal communities of Neerabup National Park have not been described in detail. Of the five principal plant communities present in the Park (Map 5 and listing in Section 2.1, above) the vertebrate fauna of only one plant community has been listed. A list of the birds, reptiles and amphibians present in the Tuart (*Eucalyptus gomphocephala*) Woodland on deeper sands with limestone at depth) was presented in Dell *et al.* 1998. The bird data in Dell *et al.* (1998) was compiled from unpublished notes from J. Dell, A.H. Burbidge and members of Birds Australia over several seasons and the herpetofauna was compiled from unpublished surveys over several seasons by J. Dell, B. Maryan and D. Robinson. Both the bird and herpetofauna listings are incomplete and the total species present would be greater than those listed. However, the current list indicates species-rich bird and reptile assemblages.

### *Birds*

The bird listing for Tuart woodland in Neerabup National Park (Dell *et al.* 1998) includes 21 Non-passerines and 33 Passerine species giving a total of 54 species. This is considerably more than the 37 bird species known from Tuart woodlands in Yanchep National Park (Dell *et al.* 1998) or the 26 bird species known from Tuart woodlands in the Hepburn Heights part of Bushplan Site 303 (Howe *et al.* 1996, Dell *et al.* 1998). Accordingly, the Tuart woodland in Neerabup National Park has a regionally rich avifauna.

Other plant communities in Neerabup National Park have not been assessed for their bird communities and the number of bird species is not known. However, considering that the Park has five regional floristic types present it is likely to have a rich avifauna comparable to that recorded in other areas with similar plant communities. The nearest National Park with a comprehensively recorded avifauna is Yanchep National Park with 134 species of birds of which 92 species are land birds (CALM 1989). Additional to those already listed by Dell *et al.* (1988) the majority of these land birds are also likely to occur in Neerabup National Park.

Significantly the Tuart woodlands of Neerabup National Park contain at least 19 species (Dell *et al.* 1998) of those birds listed by Government of Western Australia (1998a) as having special conservation significance on the Swan Coastal Plain as they are either habitat specialists with a reduced distribution on the Swan Coastal Plain or they are wide-ranging species with reduced populations on the Swan Coastal Plain. Based on known distribution (Storr and Johnstone 1988) it is likely that at least another nine of these significant bird species are also likely to occur in other habitats within Neerabup National Park.

The overall conservation significance of Tuart woodlands is highlighted by Dell *et al.* (1998). Although none of these species are restricted to them, Tuart woodlands have considerable conservation significance. Specialist woodland insectivorous bird species have declined in both Tuart as well as other woodlands on the Coastal Plain and some species such as Weebill and White-naped Honeyeater are now infrequently recorded in other vegetation associations on the Coastal Plain. Tuart trees also provide essential hollows for obligate tree hollow breeders as well as tall trees for other species such as diurnal birds of prey.

### *Reptiles*

The reptile listing for Tuart woodland in Neerabup National Park (Dell *et al.* 1998) totals 20 species. This is higher than that known for Tuart woodlands in Yanchep National Park with 12 species or that known from Tuart woodlands in the Hepburn Heights part of Bushplan Site 303 with 17 species (Howe *et al.* 1996, Dell *et al.* 1998). Of seven Tuart woodland sites on the Swan Coastal Plain where the reptile fauna has been assessed only Tuart woodlands in Bold Park are known to have more reptile species (23 species) when compared to Neerabup National Park (Dell *et al.* 1998).

The regional significance of the herpetofaunal assemblage in Neerabup National Park is highlighted by the presence there of reptile species that have either disappeared from or declined over most of the Swan Coastal Plain. These include the Clawless Gecko (*Crenadactylus ocellatus*) which has only been recorded on one other reserve (Yanchep National Park), and the

Barking Gecko (*Underwoodisaurus milii*) and Gray's Legless Lizard (*Delma grayii*) which have not been recorded on any other reserve (Dell *et al.* 1998).

Surveys of Tuart forest over the last 20 years have revealed a relatively diverse herpetofaunal community with 42 species of reptiles. This means that more than half of the 71 reptile species that either currently or previously occurred on the Swan Coastal Plain (How and Dell 1993, 1994) have been recorded recently in Tuart woodlands (Dell *et al.* 1998). Although no reptile species is unique to Tuart woodlands, some species reach their maximum population level in them. Included here are arboreal as well as litter inhabiting species.

#### *Amphibians*

Dell *et al.* (1998) recorded no species of amphibians in Tuart woodlands of Neerabup National Park. However Burbidge, *et al.* (1993) recorded two species, the Moaning Frog, *Heleioporus eyrei* and the Banjo Frog, *Limnodynastes dorsalis*. Both these species disperse widely from their breeding areas and aestivate underground during summer. The absence of lakes or swamps in Neerabup National Park explains the low frog diversity.

#### *Mammals*

The mammal fauna of Neerabup National Park has not been assessed in detail. Limited trapping surveys by Burbidge *et al.* (1993) recorded four species of native mammals, Western Grey Kangaroo, *Macropus fuliginosus*, Western Brush Wallaby, *Macropus irma*, Honey Possum, *Tarsipes rostratus* and White-striped Freetail-bat *Tadarida australis*. The presence of the Honey Possum is highly significant as this species is now absent from most reserves on the Coastal Plain (How and Dell 1993). Many of the nine bat species recorded on the Coastal Plain (How and Dell 1993) are dependent on tree hollows as daytime roosts and Tuart woodlands are an important roosting and breeding resource (Dell *et al.* 1998).

#### *Invertebrates*

The invertebrate fauna of Neerabup National Park has not been assessed. Surveys on other sites on the Coastal Plain indicate that larger bushland remnants have a higher species richness and abundance (Harvey *et al.* 1997) compared to smaller areas. The results of Harvey *et al.* (1997) also indicate significant differences between the invertebrate fauna on different landform units. Both these results indicate the need for large reserves on each landform to adequately conserve the invertebrate fauna.

### **2.3**

- a diverse vertebrate fauna typical of the Spearwood Dunes and including a high number of conservation significant species that have declined severely elsewhere in reserves on the Swan Coastal Plain

### **3.2 Fauna Values**

As Lot 52 is contiguous with the southern boundary of Neerabup National Park and has areas of Woodlands to Low Woodlands dominated by Tuart, *Eucalyptus gomphocephala* and Jarrah, *E. marginata* over several species of *Banksia* it is likely to have many of the species of vertebrates that occur in similar habitat in the National Park. Many of these species have been recognized as having high conservation status as they have declined from most reserves further south on the Coastal Plain. These include at least 19 species of birds listed by Government of Western Australia (1998a) as having special conservation significance on the Swan Coastal Plain as they are either habitat specialists with a reduced distribution on the Swan Coastal Plain or they are wide-ranging species with reduced populations on the Swan Coastal Plain.

A vegetation type present in Lot 52 that is not represented in the National Park is the Woodland to low Woodland dominated by the Flooded Gum *Eucalyptus rudis* and with its associated Sedgelands. This habitat is likely to support an assemblage of vertebrate species not well represented in the National Park. Apart from the isolated Lake Nowergup to the east of Wanneroo Road the National Park has no wetlands suitable for frog breeding. Being

contiguous with the boundary of the National Park, Lot 52 allows seasonal movement of frogs from breeding areas to summer aestivating areas in different habitats in the National Park. These swampy habitats may also provide habitat for species of reptiles not currently recorded in the National Park.

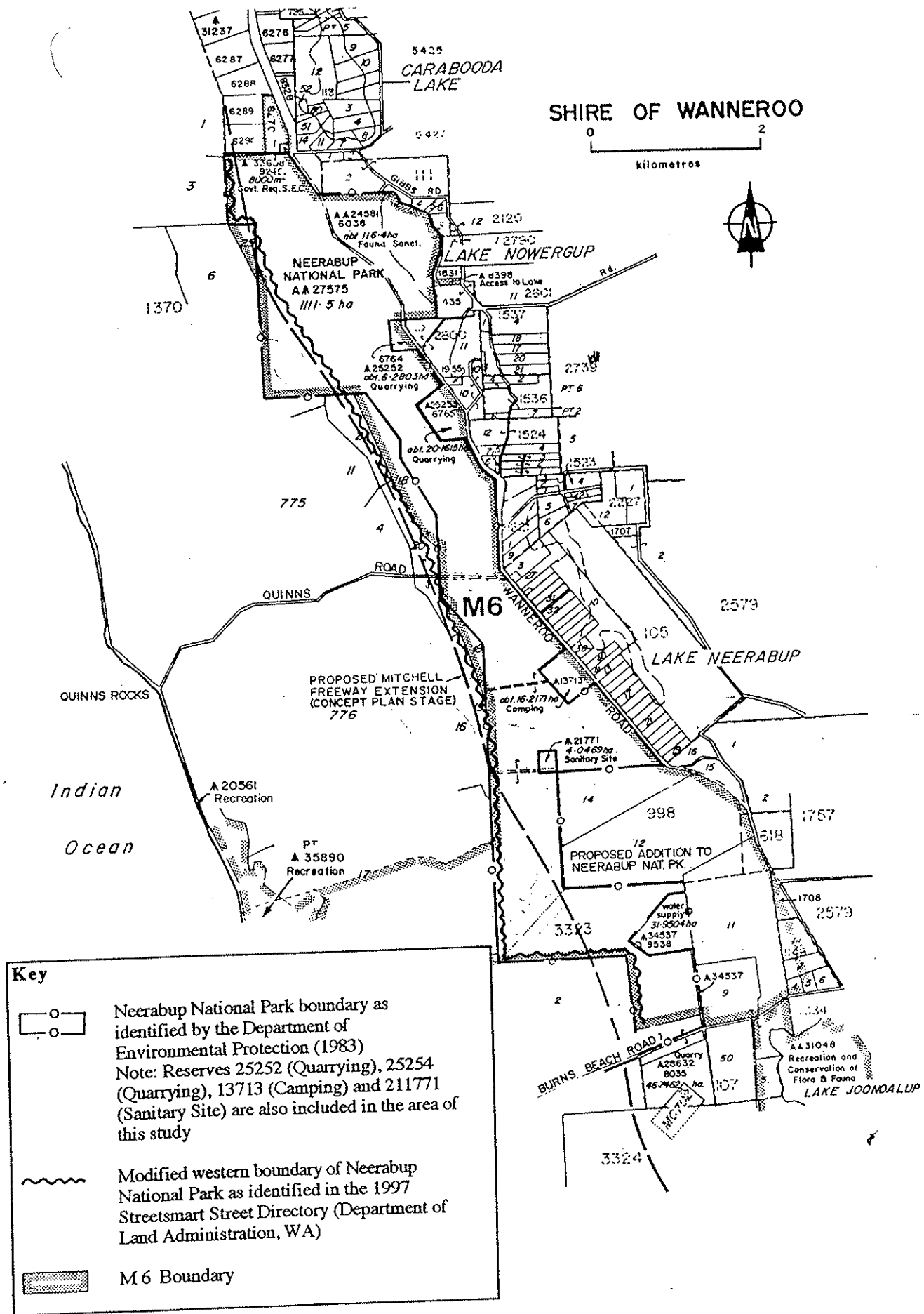
Another significant faunal value of Lot 52 is in facilitating the seasonal migration of small Passerine birds as it provides a corridor link between the Joondalup Regional Park to the south and Neerabup National Park to the north. This corridor would also have long term value in maintaining genetic movement between these two large regional parks and thus having a role in the conservation of Australia's biological diversity.

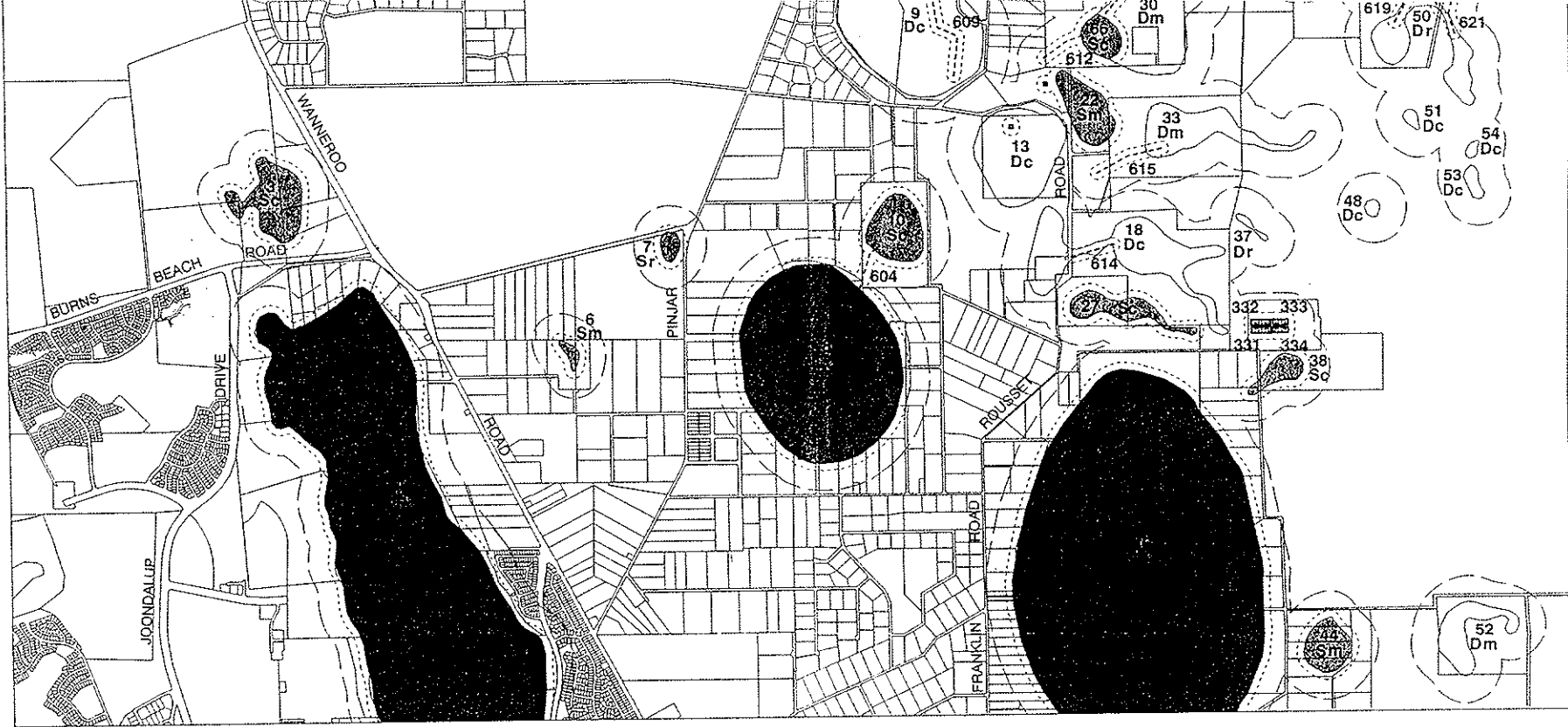
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

# Map 1: Neerabup National Park Location.

(Map modified from Fig 78, Department of Environmental Protection 1983)









**BASIN AND FLAT WETLANDS**

-  lake (permanently inundated), estuary (permanently inundated)
-  sumpland, floodplain (seasonally inundated), estuary (peripheral)
-  vegetated section of extensive wetland
-  dampland, palusplain (seasonally waterlogged)
-  vegetated section of extensive wetland
-  other basin wetlands

**CHANNEL WETLANDS**

-  River (permanently inundated)
-  Creek (seasonally inundated)
-  Artificial channel
-  Gravity or Pressure Drainage Pipes (metro area)

**WETLAND TYPE**



- L Lake
- CR Creek
- S Sumpland
- D Dampland
- AL Artificial Lake
- F Floodplain
- P Palusplain
- R River
- EW Estuary (Waterbody)
- E Estuary (Peripheral)
- PS Paluslope

**PRELIMINARY WETLAND MANAGEMENT CATEGORY**

- c Conservation
- r Resource Enhancement
- m Multiple Use
- na Not Assessed

Note: All vegetated sections of extensive wetlands are assigned a Management Category of Conservation.

**ZONES OF INFLUENCE**

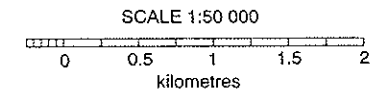
-  Zone of Critical Influence 50 metre boundary
-  Zone of Secondary Influence 200 metre boundary

-  Road Boundary
-  Property Boundary

**WETLAND MAP IDENTIFICATION NOS. EG. 12, 12-V1**

Map Identification Numbers have been assigned to each wetland according to their type and method of classification. Map Identification Numbers less than 300 represent wetlands mapped by the V & C Semeniuk Research Group for the Water Authority. 'V' denotes a vegetated selection of a wetland. eg. 12-V2

Map Identification Numbers ranging from 301 to 600 have been assigned to basin wetlands (mostly rock pools and dams) and numbers 601 and greater to channel wetlands (rivers, creeks, and artificial channels). Wetlands numbered 301 and greater have been described from complimentary DOLA digital hydrographic mapping.



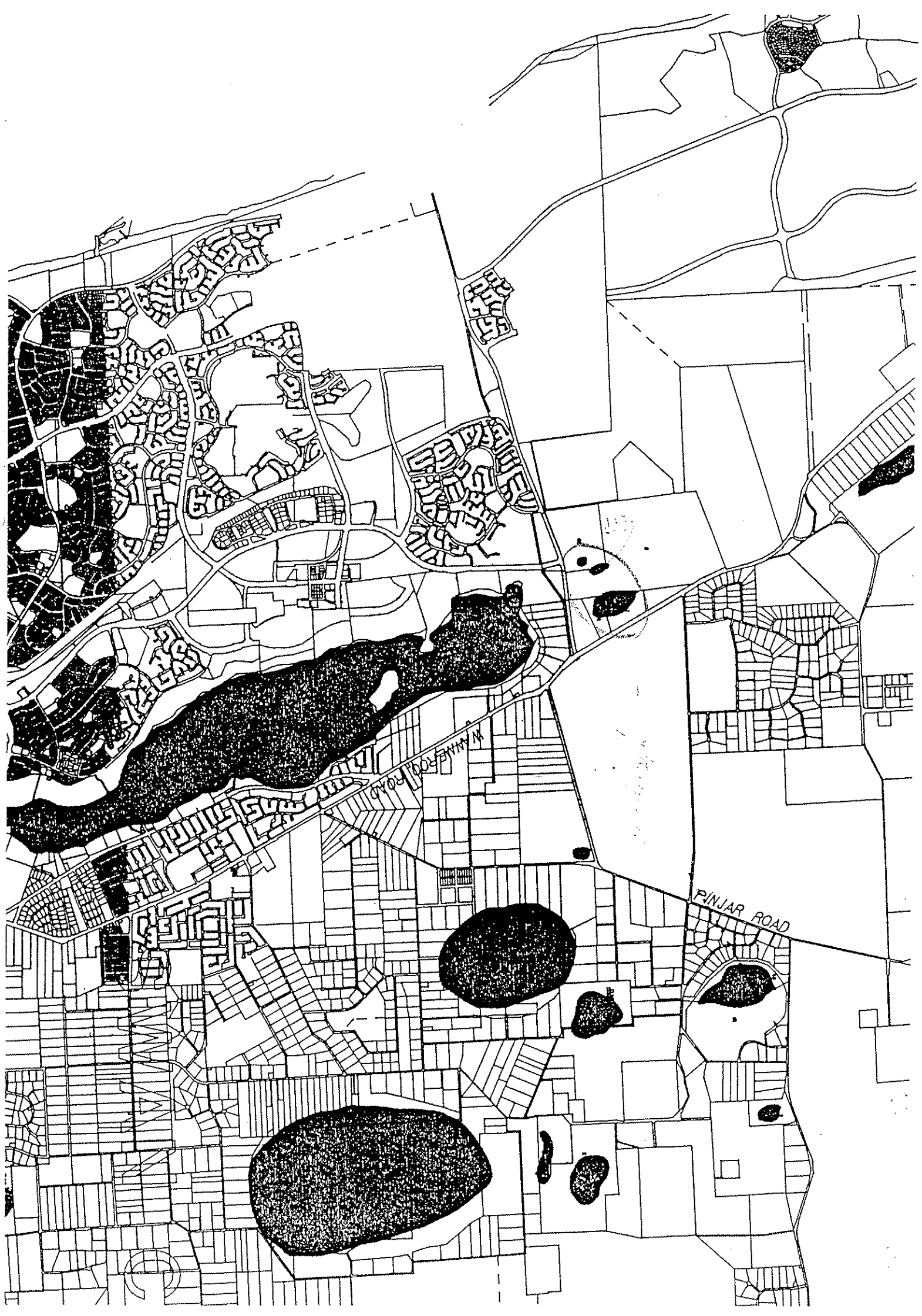
Basin and Flat Wetlands of Map 2034 I SW

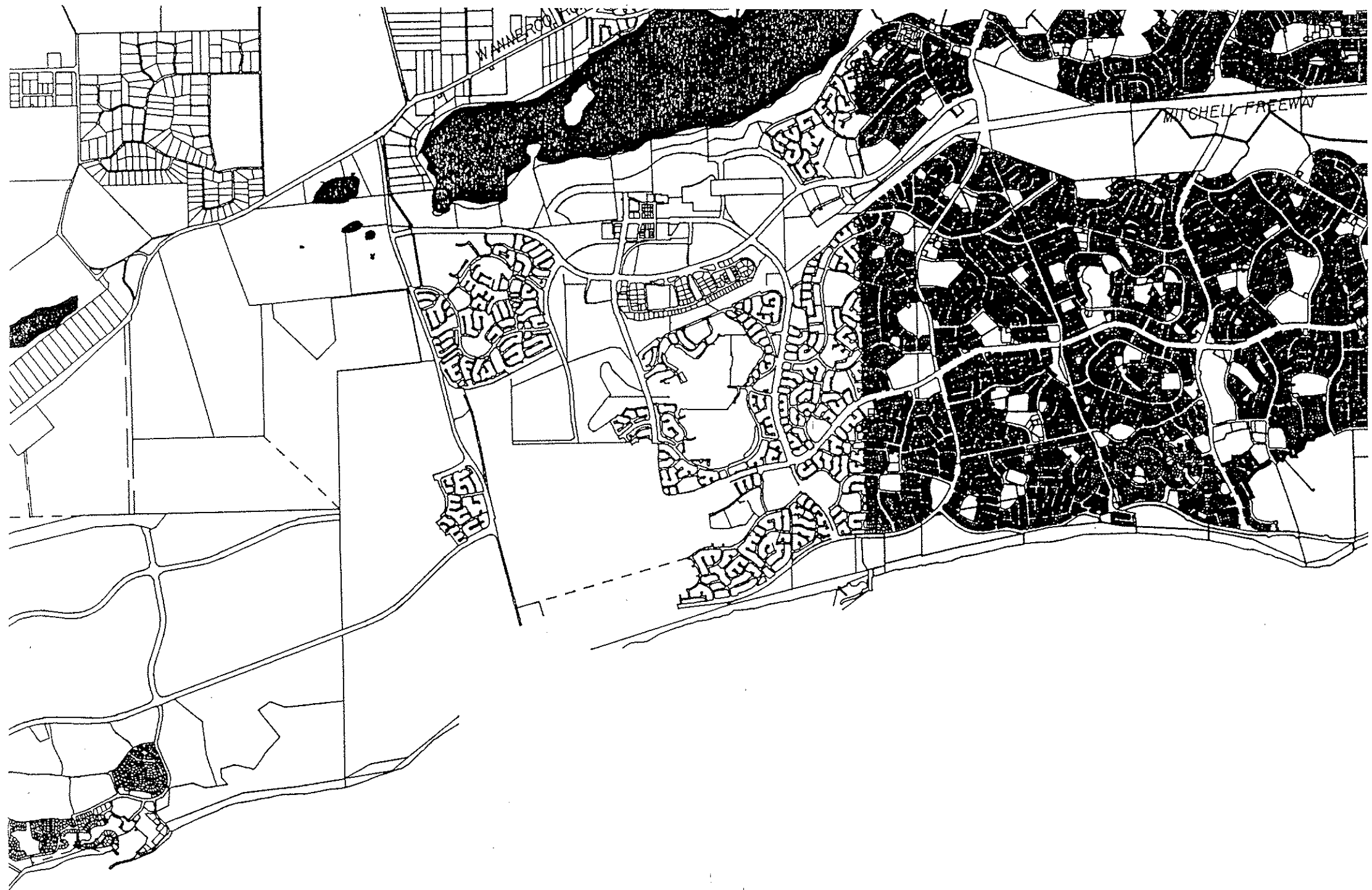
Identification and Classification							Evaluation and Management																Protection	
No (MIN)	NAME	WETLAND IDENTIFICATION NUMBER (WIN)	AREA (ha)	SUITE	WETLAND TYPE	VEG FORM	n	SUIT/TYPE (area)	%RNK n	%RNK area	1st TIER RECOGN	OLD MAN CAT	NAT SCR	%RNK SCR	%VEG	%RNK VEG	CAT EXPLN	NEW MAN CAT	ZONE 50m %VEG	ZONE 200m %VEG	LOCAL GOVERNMENT AUTHORITY	CALM	LAKES EPP	
1	NEERABUP LAKE	38205649442	94.7	S.1	SUMLAND	HETERO	17	418.9	41	29		R	24	50	40	63	R	R	NA	NA	WANNEROO		L	
2	CAMEL SWAMP	38345649888	61	B.2	DAMPLAND	MACULI	56	483.9	48	53		R	15.5	74	80	64	R	R	NA	NA	WANNEROO	C	L	
3		38348649057	20.8	S.1	SUMLAND	PANI	17	418.9	82	88	S O	C	37.5	88	88	88	C	C	NA	NA	WANNEROO	C	L	
4	LAKE JOONDALUP	38429648852	342.3	S.1	LAKE	HETERO	7	985.1	86	79	NASWO	H	41	71	88	43	H	C	NA	NA	WANNEROO	C	L	
5	LAKE PINJAR	38766649788	1409.6	B.1	SUMLAND	MACULI	2	2227.9	100	100	SWO	M	21	100	40	100	C 1*	C	NA	NA	WANNEROO		4	
6	JIMBUB SWAMP	38562648940	1.8	S.1	SUMLAND		17	418.9	18	5		M	20	25	0	19	M	M	NA	NA	WANNEROO		L	
7	CLARKSON/PINJAR	38657649022	2.8	B.2	SUMLAND	LATI	131	1055.4	31	31		R	27	55	12	16	R	R	NA	NA	WANNEROO		L	
8	MARGINIUP LAKE	38773648936	145.1	B.2	LAKE	BACATA	36	775.7	94	33	SW	R	22	22	75	25	C 1*	C	NA	NA	WANNEROO		L	
9	LAKE ADAMS	38844649190	89.9	B.2	DAMPLAND	HETERO	56	483.9	93	98	S	R	22	91	20	34	C 1*	C	NA	NA	WANNEROO		L	
10	LITTLE MARGINIUP	38830649035	17.4	B.2	SUMLAND		131	1055.4	79	72	SW	M	7	3	0	14	C 1*	C	NA	NA	WANNEROO		L	
11	LITTLE COOGEE FLAT	38861649340	5.4	B.2	DAMPLAND	MACULI	56	483.9	70	56		C	17	80	90	68	C	C	NA	NA	WANNEROO			
12	LITTLE COOGEE SWAMP	38886649394	5.1	B.2	DAMPLAND		56	483.9	23	32		R	10	35	0	27	R	R	NA	NA	WANNEROO			
13		38924649097	38.3	B.2	DAMPLAND		56	483.9	91	80	S	R	10.5	39	0	27	C 1*	C	NA	NA	WANNEROO			
14		38903649750	0.6	B.1	DAMPLAND	MACULI	1	0.6	100	100		C	19	100	100	100	C	C	NA	NA	WANNEROO			
15		38922649369	1.9	B.2	DAMPLAND		56	483.9	43	38		R	15	67	0	27	R	R	NA	NA	WANNEROO	CP	L	
16	JANDABUP LAKE	39024648812	405.1	B.2	LAKE	BACATA	36	775.7	100	100	ASW	O	25	50	66	19	C 1*	C	NA	NA	WANNEROO	C	L	
17		38939649528	2.8	B.3	DAMPLAND	MACULI	987	8497.5	45	65		C	20	63	100	100	C	C	NA	NA	WANNEROO		L	
18		39012649008	42.5	B.2	DAMPLAND	MACULI	56	483.9	75	66		C	19.5	85	30	41	C	C	NA	NA	WANNEROO	C	L	
19		38950649415	1.8	B.2	DAMPLAND	BACATA	56	483.9	50	53		R	16	76	90	68	R	R	NA	NA	WANNEROO		L	
20	LITTLE ADAMS SWAMP	38955649226	4.4	B.2	SUMLAND	MACULI	131	1055.4	76	67	S	M	22.5	39	60	31	C 1*	C	NA	NA	WANNEROO		L	
21		38959649551	1.3	B.3	DAMPLAND	MACULI	987	8497.5	39	59		R	17	53	100	100	C 2*	C	NA	NA	WANNEROO			
22	LAVINA ROAD	38973649126	14.4	B.2	SUMLAND		131	1055.4	9	5		M	24	46	0	14	M	M	NA	NA	WANNEROO	C		
23		38962649389	1.6	B.2	DAMPLAND	MACULI	56	483.9	45	39		C	20	63	96	26	C	C	NA	NA	WANNEROO			
24		38961649571	0.9	B.3	DAMPLAND	MACULI	987	8497.5	45	65		R	NA	NA	0	5	R	R	NA	NA	WANNEROO	C		
25		38866649823	2.2	B.3	DAMPLAND		987	8497.5	14	32		R	13	35	86	18	R	R	NA	NA	WANNEROO	C		
26		39005649516	11.4	B.3	DAMPLAND	MACULI	987	8497.5	18	40		R	13	35	86	18	R	R	NA	NA	WANNEROO		L	
27	ROUSSET TOWNSEND RD	39009648971	11.4	B.2	SUMLAND		131	1055.4	72	63	W	R	21	32	0	14	C 1*	C	NA	NA	WANNEROO	C	L	
28		38971649266	1.2	B.2	DAMPLAND	LATI	56	483.9	64	55		R	14	59	98	75	C 2*	C	NA	NA	WANNEROO	C		
29		38988649826	4.7	B.3	SUMLAND	MACULI	329	3078	38	51		R	NA	NA	98	53	C 2*	C	NA	NA	WANNEROO	C		
30	PINESEND FARM SWAMP	39025649201	47.5	B.2	DAMPLAND		56	483.9	5	18		M	5.5	9	0	27	M	M	NA	NA	WANNEROO	C		
31		38987649361	2.4	B.3	SUMLAND	MACULI	329	3078	57	58		R	31	66	95	48	C 2*	C	NA	NA	WANNEROO	C		
32		38993649777	2.5	B.3	DAMPLAND		987	8497.5	18	40		R	13	35	0	5	R	R	NA	NA	WANNEROO	CP		
33	LAVINA PLACE EAST	39081649109	22.4	B.2	DAMPLAND		56	483.9	4	8		M	3.5	2	0	27	M	M	NA	NA	WANNEROO	C		
34		39064649355	4.4	B.2	DAMPLAND	MACULI	56	483.9	29	34		R	10	35	80	64	R	R	NA	NA	WANNEROO	C		
35		39073649499	1.2	B.3	DAMPLAND	MACULI	987	8497.5	49	66		C	21	84	98	31	C	C	NA	NA	WANNEROO	C		
36		39097649639	5.5	B.3	DAMPLAND	MACULI	987	8497.5	49	66		C	21	84	98	31	C	C	NA	NA	WANNEROO	C		
37	ROUSSET ROAD EAST	39101649037	1.1	B.2	DAMPLAND	MACULI	56	483.9	18	28		M	8.5	22	80	64	R 1*	R	NA	NA	WANNEROO	C		
38	HAWKINS ROAD SWAMP	39120648926	6.2	B.2	SUMLAND	BACATA	131	1055.4	80	73	SW	R	23	42	85	48	C 1*	C	NA	NA	WANNEROO	CP		
39		39107648345	1.1	B.2	DAMPLAND	MACULI	56	483.9	79	66		C	21	89	100	100	C	C	NA	NA	WANNEROO	C		
40		39194649469	27.3	B.3	DAMPLAND	MACULI	987	8497.5	51	67		C	25	91	96	26	C	C	NA	NA	WANNEROO	C		
41		39118649592	1.8	B.3	DAMPLAND	MACULI	987	8497.5	49	66		C	21	84	100	100	C	C	NA	NA	WANNEROO	C		
42		39183649754	70.1	B.3	DAMPLAND	MACULI	987	8497.5	54	72	O	R	7	3	98	31	H*	C	NA	NA	WANNEROO			
43	RUIN SWAMP	39139649240	6.4	B.2	DAMPLAND		56	483.9	46	40		R	15.5	74	0	27	R	R	NA	NA	WANNEROO			
44	LITTLE DUNDABAR SWP	39157648721	11.2	B.2	SUMLAND		131	1055.4	5	3		M	15.5	11	0	14	M	M	NA	NA	WANNEROO	C		
45		39151649497	0.2	B.3	DAMPLAND	MACULI	987	8497.5	44	64		C	18	58	100	100	C	C	NA	NA	WANNEROO	C		
46		39155649550	1.9	B.3	DAMPLAND		987	8497.5	3	5		M	NA	NA	0	5	M	M	NA	NA	WANNEROO	C		
47		39246649550	33	B.3	DAMPLAND	MACULI	987	8497.5	15	33		R	10	16	12	6	R	R	NA	NA	WANNEROO	C		
48	BUSTARD SWAMP STH	39182649052	1.2	B.2	DAMPLAND	MACULI	56	483.9	63	55		R	11.5	41	98	75	C 2*	C	NA	NA	WANNEROO			
49	NEEVES RD SOUTH	39195649221	2.9	B.3	DAMPLAND		987	8497.5	3	11		M	8.5	5	0	5	M	M	NA	NA	WANNEROO	CP		
50	NEEVES-SILVER RD	39229649204	27	B.3	DAMPLAND	MACULI	987	8497.5	10	23		M	5.5	1	50	11	R 2*	R	NA	NA	WANNEROO	CP		
51	BUSTARD NTH	39221649119	1.3	B.3	DAMPLAND	MACULI	987	8497.5	37	58		R	11.5	24	98	31	C 2*	C	NA	NA	WANNEROO	C		
52	SNAKE SWAMP	39267648740	14.4	B.3	DAMPLAND		987	8497.5	3	11		M	4.5	1	0	5	M	M	NA	NA	WANNEROO			
53	BUSTARD SWAMP	39269649073	2.4	B.3	DAMPLAND	MACULI	987	8497.5	38	59		R	13.5	39	98	31	C 2*	C	NA	NA	WANNEROO	C		
54	BUSTARD LANDING	39267649096	1	B.3	DAMPLAND	MACULI	987	8497.5	36	58		R	10.5	19	95	24	C 2*	C	NA	NA	WANNEROO	C		

See back page foldout for expansion of codes and abbreviations.

Map 2034 I SW







SMALL LAKE NORTH OF BURNS BEACH ROAD

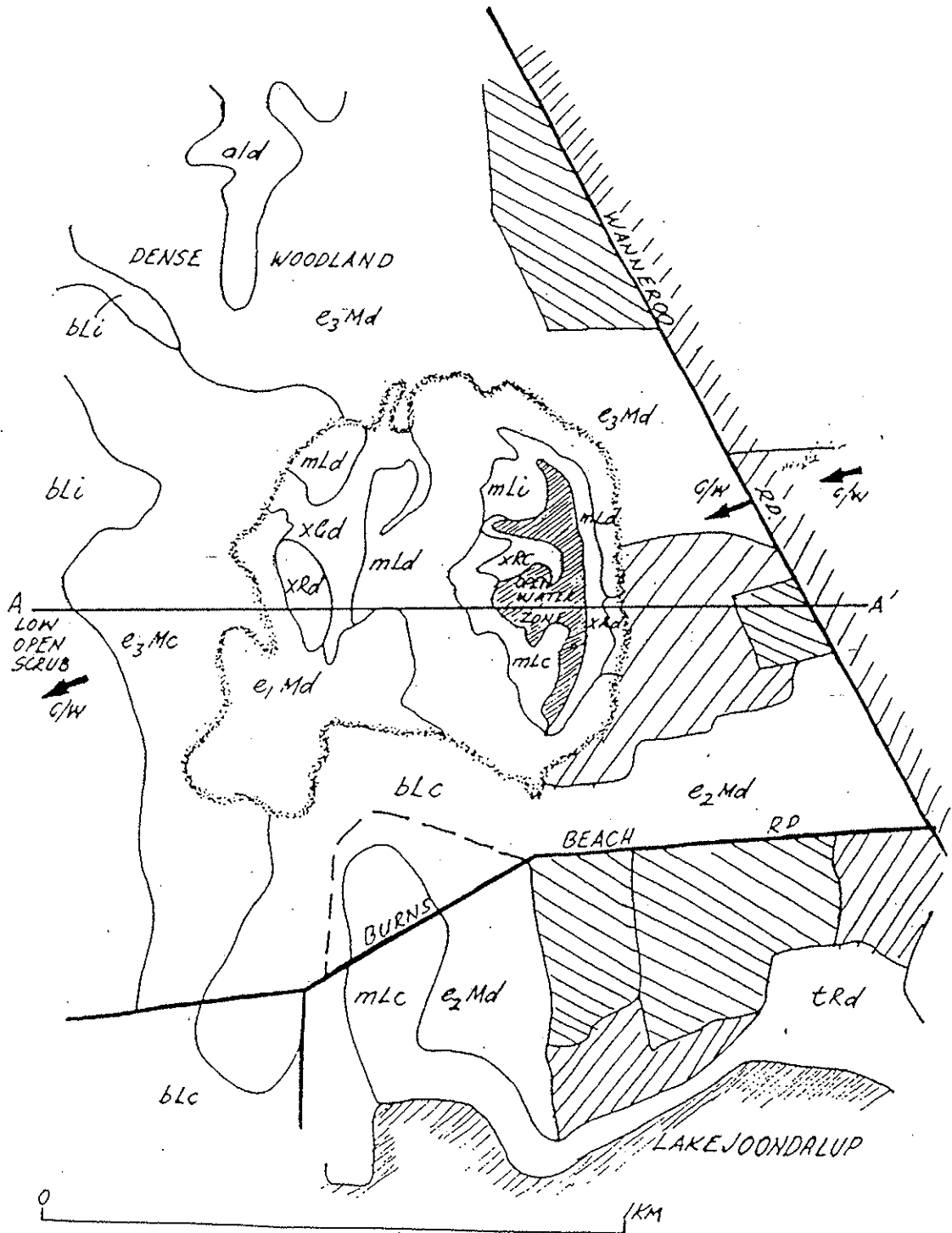


Figure 7.7 Unnamed wetland north of Lake Joondalup: wetland plant communities and surrounding land use.

# BUSHPLAN SITE 383 LOT 52

-  Wetlands Management - Conservation
-  Wetlands Management - Multiple Use
-  EPP Lakes Policy (Boundaries)
-  System 6 Boundaries in Bushplan
-  Bushplan Sites (boundaries)
-  Cadastre with Lot Numbers





*Map 4*



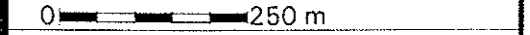
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Prepared By: Andrea Zappacosta  
Prepared For: DEP  
Date: 28 Jun 2000  
Scale 1:10000  
0 250 m  
MFP INTERNAL USE ONLY






**BUSHPLAN SITE 383**  
**LOT 52**  
**(1998 AERIAL IMAGE)**

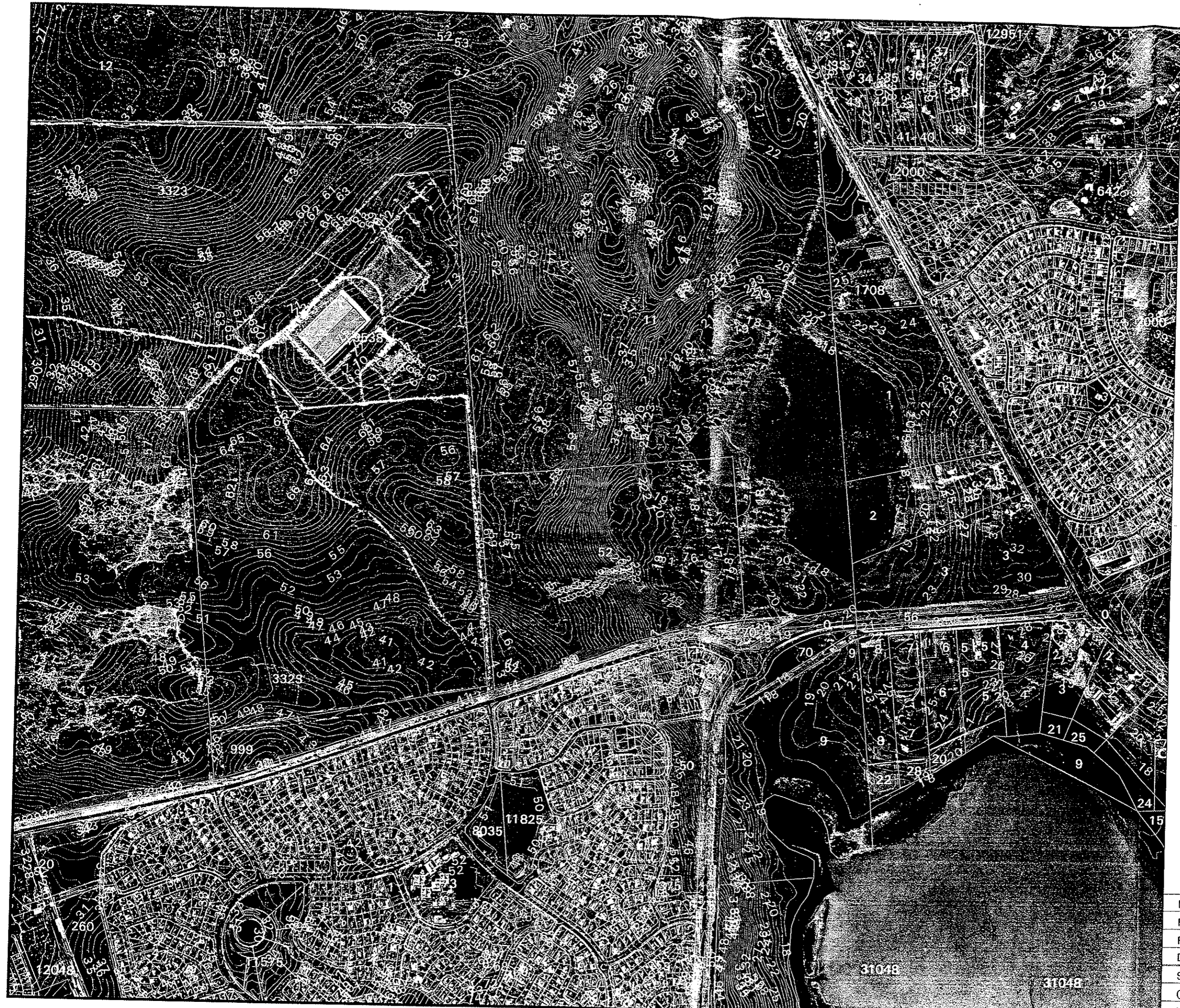
-  System 6 Boundaries in Bushplan
-  Contours - 1m & 2m (DOLA)
-  Cadastre with Lot Numbers
-  Bushplan Sites (boundaries)



Map Ident: plot000630_1
Prepared By: Andrea Zappacosta
Prepared For: DEP
Date: 30 Jun 2000
Scale 1:10000

MFP INTERNAL USE ONLY

# BUSHPLAN SITE 383 LOT 52

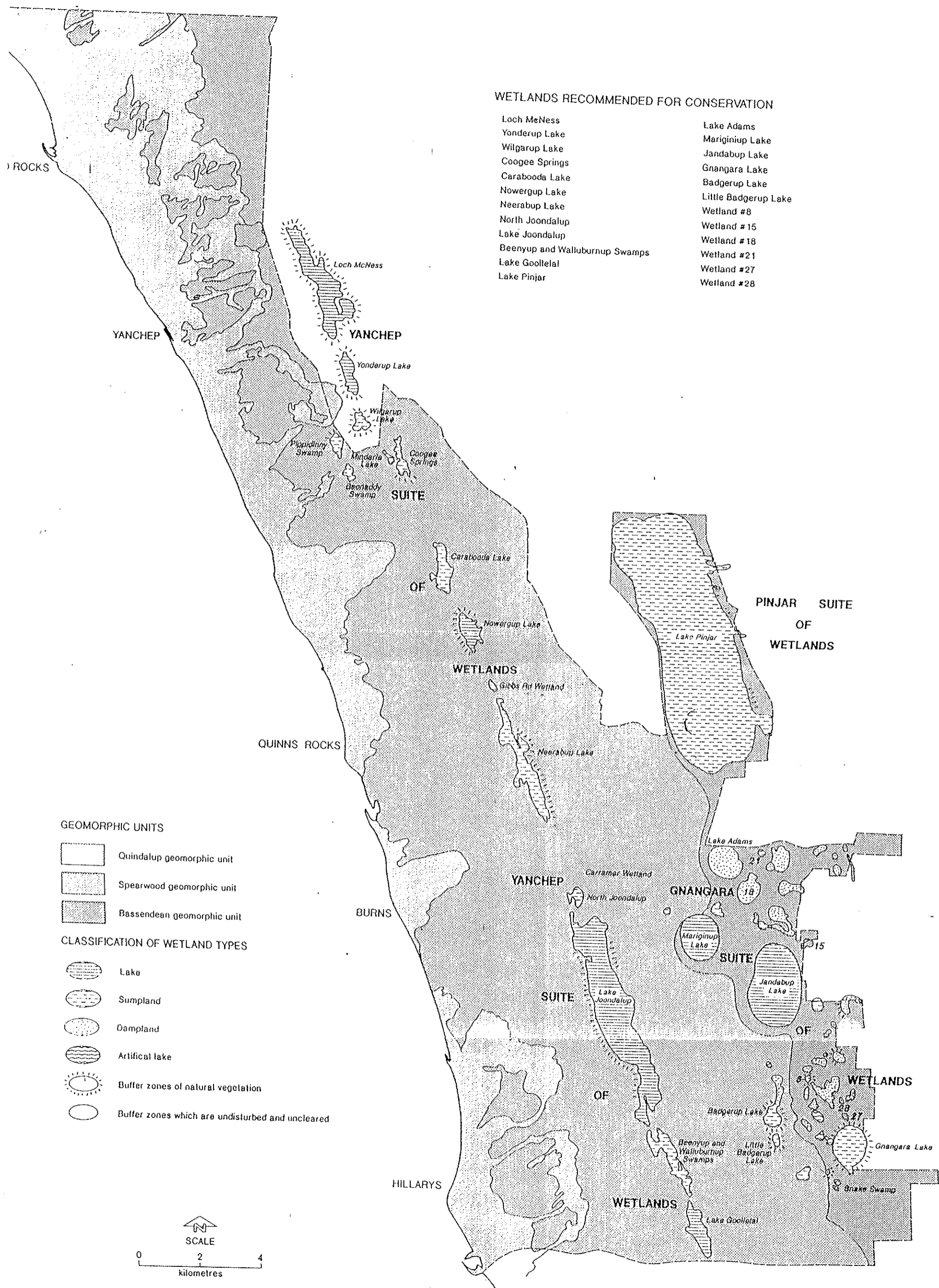
-  Bushplan Sites (boundaries)
-  Contours - 1m & 2m (DOLA)
-  Cadastre with Lot Numbers



Map Ident: plot000628\_1  
Prepared By: Andrea Zappacosta  
Prepared For: DEP  
Date: 28 Jun 2000  
Scale 1:10000  
0 250 m  
MFP INTERNAL USE ONLY

Wetland Name	Suite	Type	Vegetation Classif.	Status	Water Quality	Fauna Usage	Management Categ.	System & Reco- mend.	Incorporated in a reserve	Vesting	Comments
Loch Mc Ness	Yanchep	Lake	Heteroform	A	oligotrophic	Drought Refuge/ Migratory birds	H	M3	National Park	CALM	Fauna Reserve
Yonderup Lake	Yanchep	Lake	Maculiform	C	oligotrophic	Drought Refuge	H	M3	National Park	CALM	Linked wetland
Wilgarup Lake	Yanchep	Sumpland	Latiform	A	oligotrophic	Unknown	C	M3	National Park	CALM	Linked wetland
Coogee Spring	Yanchep	Lake	Cleared	C	eutrophic	Drought Refuge	R	M3	NO	Private	Historic site/Geology Linked wetland
Sarabooda Lake	Yanchep	Sumpland	Maculiform	D	mesotrophic	Minor	R	-	NO	Private	Veg. interspersed
Nowergup Lake	Yanchep	Lake	Zoniform	C	eutrophic	Drought Refuge	R	M6	NO	WCC/CALM	Fauna/Rarst Features
Neerabup Lake	Yanchep	Sumpland	Maculiform	C/D	eutrophic	Minor	R	-	NO	Private	
North Joondalup	Yanchep	Sumpland	Latiform	B/C	oligotrophic	Unknown	C	M6	NO	WCC/Priv.	Historic/Geology-caves
Joondalup	Yanchep	Lake	Zoniform	B/D	eutrophic	Drought Refuge/ Migratory birds	C	M7	proposed Yellagonga Pk	Private	Linked wetland
Beenyup/ Walluburnup	Yanchep	Sumpland	Concentrifm. Maculiform	D	eutrophic	Unknown	R	M6	Yellagonga Pk	Crown Res	Linked wetland
Lake Goollelal	Yanchep	Lake	Gradiform	D	mesotrophic (phosphorus)	Minor	C	M7	Yellagonga Pk	Crown Res	Linked wetland
Lake Pinjar	Pinjar	Sumpland	Maculiform	D	Unknown	Unknown	K	M8	NO	Private	Largest area of Bassendean wetlands in a single complex
Lake Adams	Gnangara	Dampland	Maculiform	D	oligotrophic	None	R	M8	NO	Private	
Lake Jandabup	Gnangara	Lake	Baccataform	D	eutrophic	Minor	C	M8	NO	WCC/CALM	Fauna Reserve
Lake Mariginiup	Gnangara	Lake	Zoniform	D	eutrophic (M)	Minor	R	M8	NO	Private	
Lake Gnangara	Gnangara	Sumpland	Zoniform	B	eutrophic (M)	None	C	M8	NO	Private	
Badgerup Lake	Gnangara	Sumpland	Maculiform	B	Unknown	Unknown	R	M8	NO	WCC	Recreation
Little Badgerup	Gnangara	Sumpland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #8	Gnangara	Sumpland	Concentrifm.	B	oligotrophic	Unknown	R	M8	NO	Private	Small scale circular basin typical of Bassendean wetlands
Wetland #13	Gnangara	Dampland	Concentrifm.	C	oligotrophic	None	R	M8	NO	Private	
Wetland #15	Gnangara	Dampland	Concentrifm.	D	Unknown	Unknown	R	M8	NO	CALM	
Wetland #21	Gnangara	Sumpland	Concentrifm.	D	Unknown	Unknown	M	M8	NO	Private	
Wetland #27	Gnangara	Dampland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	Small scale basins included in protection Zone area around Lake Gnangara
Wetland #28	Gnangara	Dampland	Maculiform	A	Unknown	Unknown	C	M8	NO	Private	
Wetland #18	Gnangara	Dampland	Maculiform	D	Unknown	Unknown	R	M8	NO	Private	

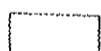


Wetland Name	State	Type	Vegetation Classif.	Status	Water Quality	Fauna Usage	Management Categ.	System & Recommendation	Incorporated in a reserve	Vesting	Comments
Loch McNess	Yanchep	Lake	Heteroform	A	oligotrophic	Drought Refuge/ Migratory birds	H	M3	National Park	CALM	Fauna Reserve
Yonderup Lake	Yanchep	Lake	Maculiform	C	oligotrophic	Drought Refuge	H	M3	National Park	CALM	Linked wetland
Wilgarup Lake	Yanchep	Swamp	Latiform	A	oligotrophic	Unknown	C	M3	National Park	CALM	Linked wetland
Coogee Spring	Yanchep	Lake	Cleared	C	eutrophic	Drought Refuge	R	M3	NO	Private	Historic site/Geology
Saraboda Lake	Yanchep	Swamp	Maculiform	D	mesotrophic	Minor	R	-	NO	Private	Linked wetland
Kowergup Lake	Yanchep	Lake	Zoniform	C	eutrophic	Drought Refuge	R	M6	NO	WCC/CALM	Veg. interspersed Fauna/Karst Features
Neerabup Lake	Yanchep	Swamp	Maculiform	C/D	eutrophic	Minor	R	-	NO	Private	Historic/Geology-caves
North Joondalup	Yanchep	Swamp	Latiform	B/C	oligotrophic	Unknown	C	M6	NO	WCC/Priv.	Linked wetland
Joondalup	Yanchep	Lake	Zoniform	B/D	eutrophic	Drought Refuge/ Migratory birds	C	M7	proposed	Private	Linked wetland
Beenyup/ Walluburnup	Yanchep	Swamp	Concentrifm. Maculiform	D	eutrophic	Unknown	R	M6	Yellagonga Pk	WCC/CALM	Fauna/Caves
Lake Goollelal	Yanchep	Lake	Gradiform	D	mesotrophic (phosphorus)	Minor	C	M7	Yellagonga Pk	Crown Res	Linked wetland
Lake Pinjar	Pinjar	Swamp	Maculiform	D	Unknown	Unknown	M	M8	NO	Private	Largest area of Bassendean wetlands in a single complex
Lake Adams	Gnangara	Danpland	Maculiform	D	oligotrophic	None	R	M8	NO	Private	
Lake Jandabup	Gnangara	Lake	Baccataform	D	eutrophic	Minor	C	M8	NO	WCC/CALM	Fauna Reserve
Lake Mariginiup	Gnangara	Lake	Zoniform	D	eutrophic (H)	Minor	R	M8	NO	Private	
Lake Gnangara	Gnangara	Swamp	Zoniform	B	eutrophic (H)	None	C	M8	NO	Private	
Badgerup Lake	Gnangara	Swamp	Maculiform	B	Unknown	Unknown	R	M8	NO	WCC	Recreation
Little Badgerup	Gnangara	Swamp	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #8	Gnangara	Swamp	Concentrifm.	B	oligotrophic	Unknown	R	M8	NO	Private	Small scale circular basin typical of Bassendean wetlands
Wetland #11	Gnangara	Danpland	Concentrifm.	C	oligotrophic	None	R	M8	NO	Private	
Wetland #15	Gnangara	Danpland	Concentrifm.	D	Unknown	Unknown	R	M8	NO	Private	
Wetland #21	Gnangara	Swamp	Concentrifm.	D	Unknown	Unknown	M	M8	NO	CALM	
Wetland #27	Gnangara	Danpland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #28	Gnangara	Danpland	Maculiform	A	Unknown	Unknown	C	M8	NO	Private	Small scale basins included in protection Zone area around Lake Gnangara
Wetland #18	Gnangara	Danpland	Maculiform	D	Unknown	Unknown	R	M8	NO	Private	



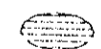





**WETLANDS RECOMMENDED FOR CONSERVATION**

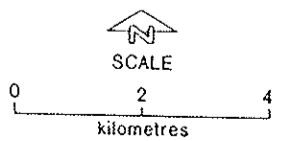
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|--------------------------------|----------------------|
| Loch McNess                    | Lake Adams           |
| Yonderup Lake                  | Mariginup Lake       |
| Wilgarup Lake                  | Jandabup Lake        |
| Coogee Springs                 | Gnangara Lake        |
| Carabooda Lake                 | Badgerup Lake        |
| Nowergup Lake                  | Little Badgerup Lake |
| Neerabup Lake                  | Wetland #8           |
| North Joondalup                | Wetland #15          |
| Lake Joondalup                 | Wetland #18          |
| Beenyup and Walluburnup Swamps | Wetland #21          |
| Lake Goollelal                 | Wetland #27          |
| Lake Pinjar                    | Wetland #28          |

**GEOMORPHIC UNITS**

-  Quindalup geomorphic unit
-  Spearwood geomorphic unit
-  Bassendean geomorphic unit

**CLASSIFICATION OF WETLAND TYPES**

-  Lake
-  Sumpland
-  Dampland
-  Artificial lake
-  Buffer zones of natural vegetation
-  Buffer zones which are undisturbed and uncleared

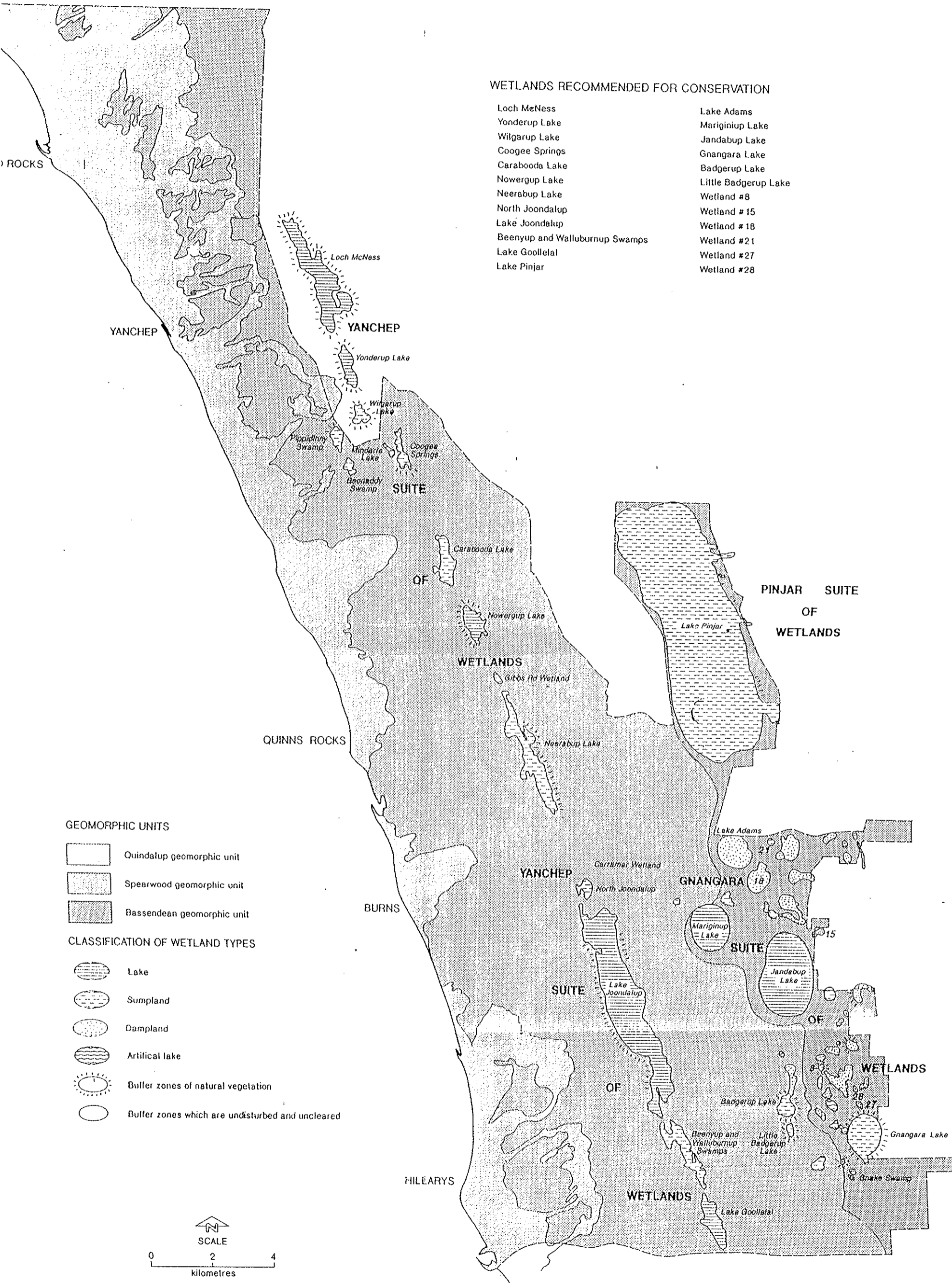


Wetland Name	Shire	Type	Vegetation Classif.	Status	Water Quality	Fauna Usage	Management Categ.	System 6 Recor- mend.	Incorporated in a reserve	Vesting	Comments
Loch McMess	Yanchep	Lake	Heteroforma	A	oligotrophic	Drought Refuge/ Migratory birds	H	M3	National Park	CALM	Fauna Reserve
Yonderup Lake	Yanchep	Lake	Maculiform	C	oligotrophic	Drought Refuge	H	M3	National Park	CALM	Linked wetland
Wilgarup Lake	Yanchep	Swampland	Latiform	A	oligotrophic	Unknown	C	M3	National Park	CALM	Linked wetland
Coojee Spring	Yanchep	Lake	Cleared	C	eutrophic	Drought Refuge	R	M3	NO	Private	Historic site/Geology Linked wetland
Carabooda Lake	Yanchep	Swampland	Maculiform	D	mesotrophic	Minor	R	-	NO	Private	Veg. interspersed
Nowergup Lake	Yanchep	Lake	Zoniform	C	eutrophic	Drought Refuge	R	M6	NO	WCC/CALM	Fauna/Karst Features
Naerabup Lake	Yanchep	Swampland	Maculiform	C/D	eutrophic	Minor	R	-	NO	Private	
North Joondalup	Yanchep	Swampland	Latiform	B/C	oligotrophic	Unknown	C	M6	NO	WCC/Priv.	Historic/Geology-caves
Joondalup	Yanchep	Lake	Zoniform	B/D	eutrophic	Drought Refuge/ Migratory birds	C	M7	proposed Yellagonga Pk	Private	Linked wetland
Beenyup/ Walluburnup	Yanchep	Swampland	Concentrifm. Maculiform	D	eutrophic	Unknown	R	M6	Yellagonga Pk	Crown Res	Linked wetland
Lake Goollelal	Yanchep	Lake	Gradiform	D	mesotrophic (phosphorus)	Minor	C	M7	Yellagonga Pk	Crown Res	Linked wetland
Lake Pinjar	Pinjar	Swampland	Maculiform	D	Unknown	Unknown	M	M8	NO	Private	Largest area of Bassendean wetlands. in a single complex
Lake Adams	Gnangara	Swampland	Maculiform	D	oligotrophic	None	R	M8	NO	Private	
Lake Jandabup	Gnangara	Lake	Bacostiform	D	eutrophic	Minor	C	M8	NO	WCC/CALM	Fauna Reserve
Lake Mariginiup	Gnangara	Lake	Zoniform	D	eutrophic (M)	Minor	R	M8	NO	Private	
Lake Gnangara	Gnangara	Swampland	Zoniform	B	eutrophic (M)	None	C	M8	NO	Private	
Badgerup Lake	Gnangara	Swampland	Maculiform	B	Unknown	Unknown	R	M8	NO	WCC	Recreation
Little Badgerup	Gnangara	Swampland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #8	Gnangara	Swampland	Concentrifm.	B	oligotrophic	Unknown	R	M8	NO	Private	Small scale circular basin typical of Bassendean wetlands
Wetland #13	Gnangara	Swampland	Concentrifm.	C	oligotrophic	None	R	M8	NO	Private	
Wetland #15	Gnangara	Swampland	Concentrifm.	D	Unknown	Unknown	R	M8	NO	Private	
Wetland #21	Gnangara	Swampland	Concentrifm.	D	Unknown	Unknown	M	M8	NO	CALM	
Wetland #27	Gnangara	Swampland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #28	Gnangara	Swampland	Maculiform	A	Unknown	Unknown	C	M8	NO	Private	Small scale basins included in protection Zone area around Lake Gnangara
Wetland #18	Gnangara	Swampland	Maculiform	D	Unknown	Unknown	R	M8	NO	Private	

Wetland Name	Shire	Type	Vegetation Classif.	Status	Water Quality	Fauna Usage	Management Categ.	System 6 Amend.	Incorporated in a reserve	Vesting	Comments
Loch McNess	Yanchep	Lake	Heteroform	A	oligotrophic	Drought Refuge/ Migratory birds	H	M3	National Park	CALM	Fauna Reserve
Yonderup Lake	Yanchep	Lake	Maculiform	C	oligotrophic	Drought Refuge	H	M3	National Park	CALM	Linked wetland
Wilgarup Lake	Yanchep	Sumpland	Latiform	A	oligotrophic	Unknown	C	M3	National Park	CALM	Linked wetland
Coogee Spring	Yanchep	Lake	Cleared	C	eutrophic	Drought Refuge	R	M3	NO	Private	Historic site/Geology Linked wetland
Carabooda Lake	Yanchep	Sumpland	Maculiform	D	mesotrophic	Minor	R	-	NO	Private	Linked wetland
Nowergup Lake	Yanchep	Lake	Zoniform	C	eutrophic	Drought Refuge	R	M6	NO	WCC/CALM	Veg. interspersed Fauna/Karst features
Heerabup Lake	Yanchep	Sumpland	Maculiform	C/D	eutrophic	Minor	R	-	NO	Private	Historic/Geology-caves
North Joondalup	Yanchep	Sumpland	Latiform	B/C	oligotrophic	Unknown	C	M6	NO	WCC/Priv.	Linked wetland
Joondalup	Yanchep	Lake	Zoniform	B/D	eutrophic	Drought Refuge/ Migratory birds	C	M7	proposed Yellagonga Pk	Private	WCC/CALM Fauna/Caves
Beenyup/ Walluburnup	Yanchep	Sumpland	Concentrifm. Maculiform	D	eutrophic	Unknown	R	M6	Yellagonga Pk	Crown Res	Linked wetland
Lake Coollalal	Yanchep	Lake	Gradiform	D	mesotrophic (phosphorus)	Minor	C	M7	Yellagonga Pk	Crown Res	Linked wetland
Lake Pinjar	Pinjar	Sumpland	Maculiform	D	Unknown	Unknown	M	M8	NO	Private	Largest area of Bassendean wetlands in a single complex
Lake Adams	Gnangara	Dampland	Maculiform	D	oligotrophic	None	R	M8	NO	Private	
Lake Jandabup	Gnangara	Lake	Baccataform	D	eutrophic	Minor	C	M8	NO	WCC/CALM	Fauna Reserve
Lake Mariginiup	Gnangara	Lake	Zoniform	D	eutrophic (H)	Minor	R	M8	NO	Private	
Lake Gnangara	Gnangara	Sumpland	Zoniform	B	eutrophic (H)	None	C	M8	NO	Private	
Badgerup Lake	Gnangara	Sumpland	Maculiform	B	Unknown	Unknown	R	M8	NO	WCC	Recreation
Little Badgerup	Gnangara	Sumpland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #8	Gnangara	Sumpland	Concentrifm.	9	oligotrophic	Unknown	R	M8	NO	Private	Small scale circular basin typical of Bassendean wetlands
Wetland #13	Gnangara	Dampland	Concentrifm.	C	oligotrophic	None	R	M8	NO	Private	
Wetland #15	Gnangara	Dampland	Concentrifm.	D	Unknown	Unknown	R	M8	NO	CALM	
Wetland #21	Gnangara	Sumpland	Concentrifm.	D	Unknown	Unknown	M	M8	NO	Private	
Wetland #27	Gnangara	Dampland	Maculiform	B	Unknown	Unknown	R	M8	NO	Private	
Wetland #28	Gnangara	Dampland	Maculiform	A	Unknown	Unknown	C	M8	NO	Private	Small scale basins included in protection Zone area around Lake Gnangara
Wetland #18	Gnangara	Dampland	Maculiform	D	Unknown	Unknown	R	M8	NO	Private	








WETLANDS RECOMMENDED FOR CONSERVATION

- |                                |                      |
|--------------------------------|----------------------|
| Loch McNess                    | Lake Adams           |
| Yonderup Lake                  | Mariginup Lake       |
| Wilgarup Lake                  | Jandabup Lake        |
| Coogee Springs                 | Gnangara Lake        |
| Carabooda Lake                 | Badgerup Lake        |
| Nowergup Lake                  | Little Badgerup Lake |
| Neerabup Lake                  | Wetland #8           |
| North Joondalup                | Wetland #15          |
| Lake Joondalup                 | Wetland #18          |
| Beenyup and Walluburnup Swamps | Wetland #21          |
| Lake Goollelal                 | Wetland #27          |
| Lake Pinjar                    | Wetland #28          |







LEGEND for Diagram A on Figures 2-9.

QUINDALUP DUNE SYSTEM

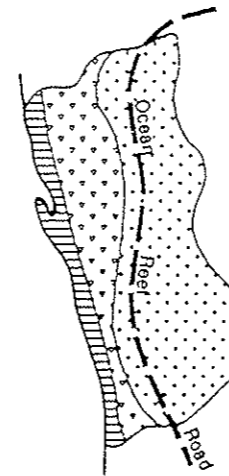
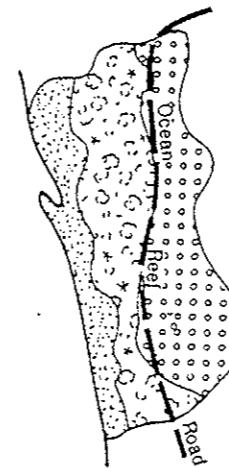
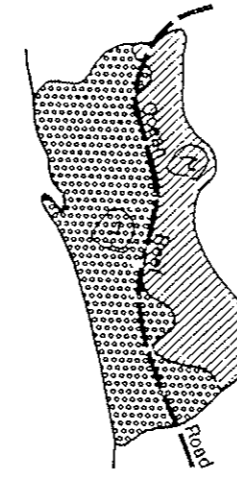
-  Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Q3 Third Phase - Steep irregular dunes with high relief. Sandy soils.
-  Q4 Youngest Phase - Steep irregular dunes of loose sand.
-  Qu Presently unstable sand.
-  Qp Undulating landscapes with deep calcareous sands.
-  Qs Undulating landscapes with shallow calcareous sand over limestone.

SPEARWOOD DUNE SYSTEM

-  Kls Bare limestone
-  Ky Karrakatta sand
-  Sp Spearwood sand - Banks of depressions. Sand and limestone.
-  B Beonaddy sand - Flat topography often surrounding lakes and swamps in floors of depressions.

NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.

For location and comparative size of this area, refer to Figure 1.



LANDFORM AND SOIL UNITS



-  Bare limestone
-  Karrakatta sand

Diagram B VEGETATION ASSEMBLAGES







-  Low heath - *Melaleuca cardiophylla*
-  Low heath - *Acacia rostellifera*  
*Dryandra sessilis*
-  Low open woodland - *Banksia menziesii*

Diagram C VESTINGS

-  Privately owned
-  Crown land
-  Department of Planning and Urban Development

SCALE 1:25 000  
0 500 metres

NC Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

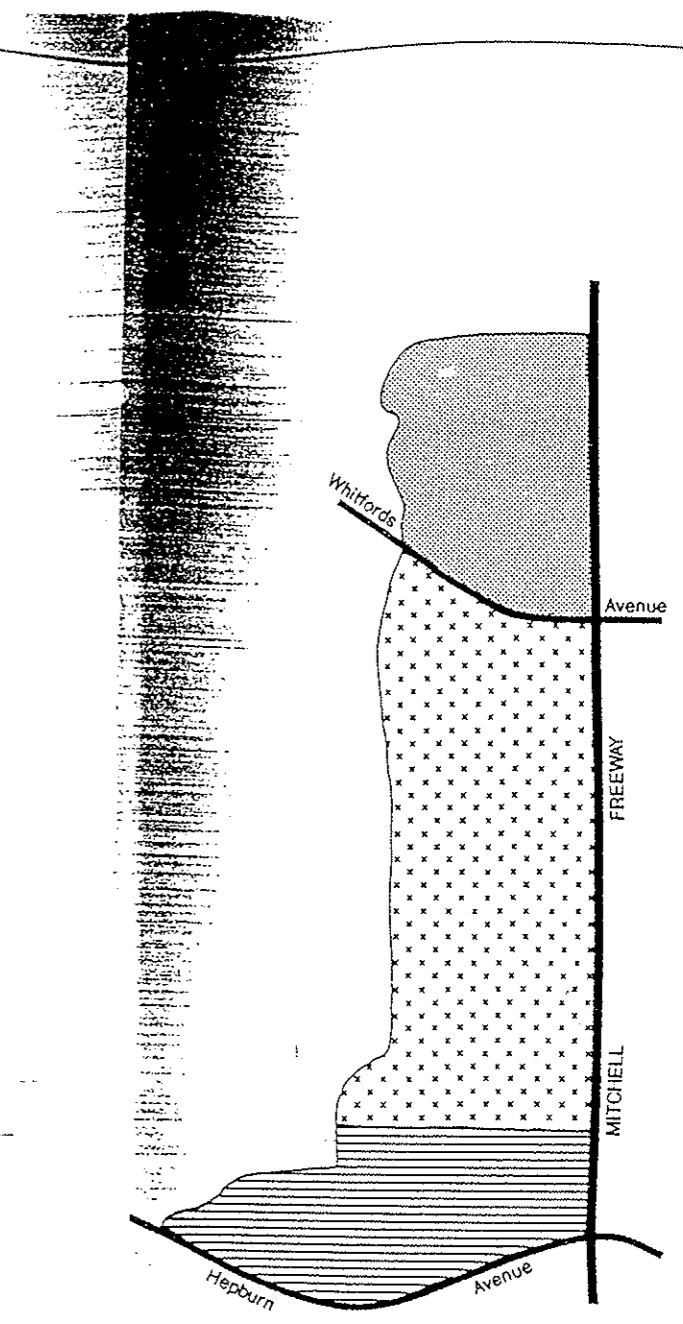
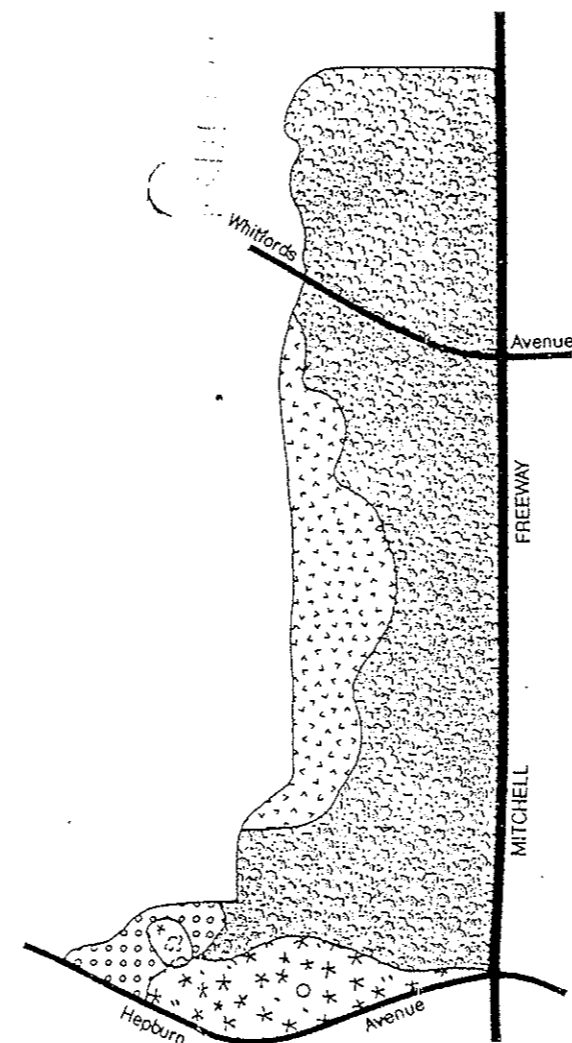
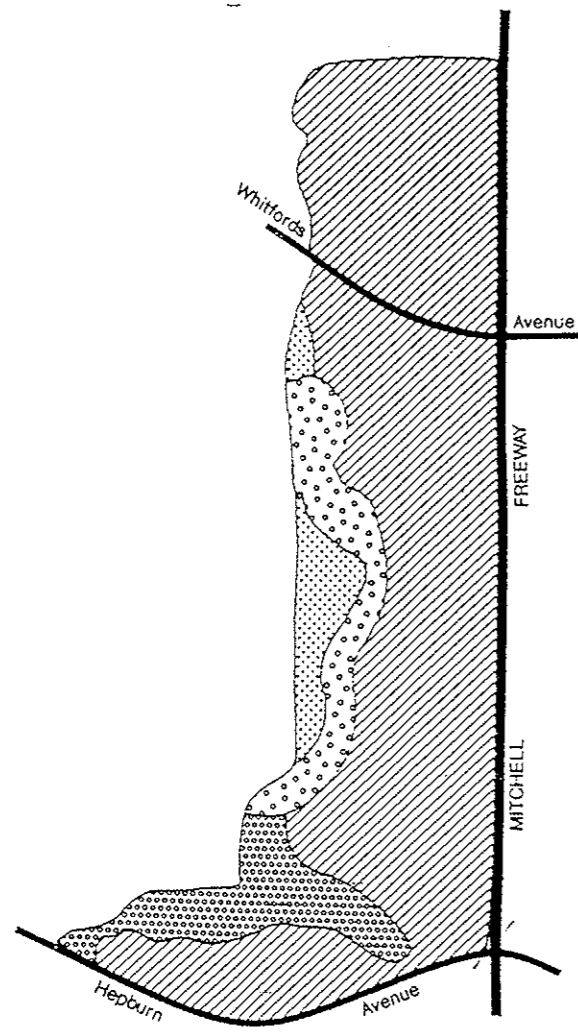


Diagram A LANDFORM AND SOIL UNITS





-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Qp Undulating landscapes with deep calcareous sands
-  Kl<sub>s</sub> Bare limestone
-  Ky Karrakatta sand

Diagram B VEGETATION ASSEMBLAGES









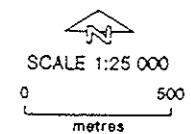
-  Low open woodland - *Banksia menziesii*  
*Banksia priorotes*
-  Low woodland - *Eucalyptus marginata*
-  Heath - *Dryandra Sessilis*
-  Heath - *Olearia axillaris*
-  Woodland - *Eucalyptus gomphocephala*  
*Banksia attenuata*  
*Banksia menziesii*

Diagram C VESTINGS

-  City of Wanneroo
-  Pinnaroo Cemetery
-  Crown Land



NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

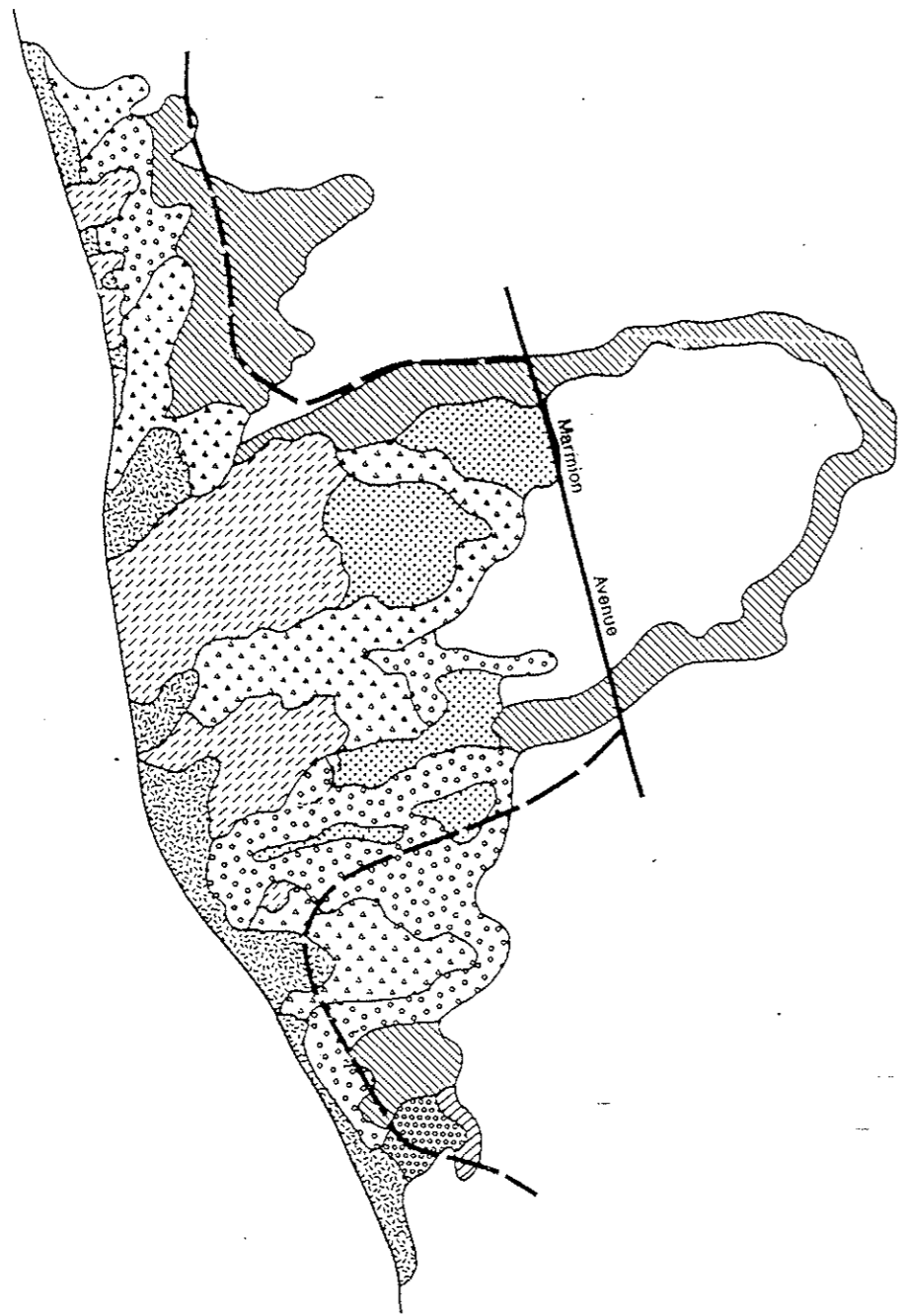










Diagram A LANDFORM AND SOIL UNITS  
Cuspate Foreland with parabolic dunes and chaots

-  Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Q3 Third Phase - Steep irregular dunes with high relief. Sandy soils.
-  Q4 Youngest Phase - Steep irregular dunes of loose sand.
-  Qu Presently unstable sand
-  Qp Undulating landscapes with deep calcareous sands
-  Kl Bare limestone
-  Ky Karrakatta sand

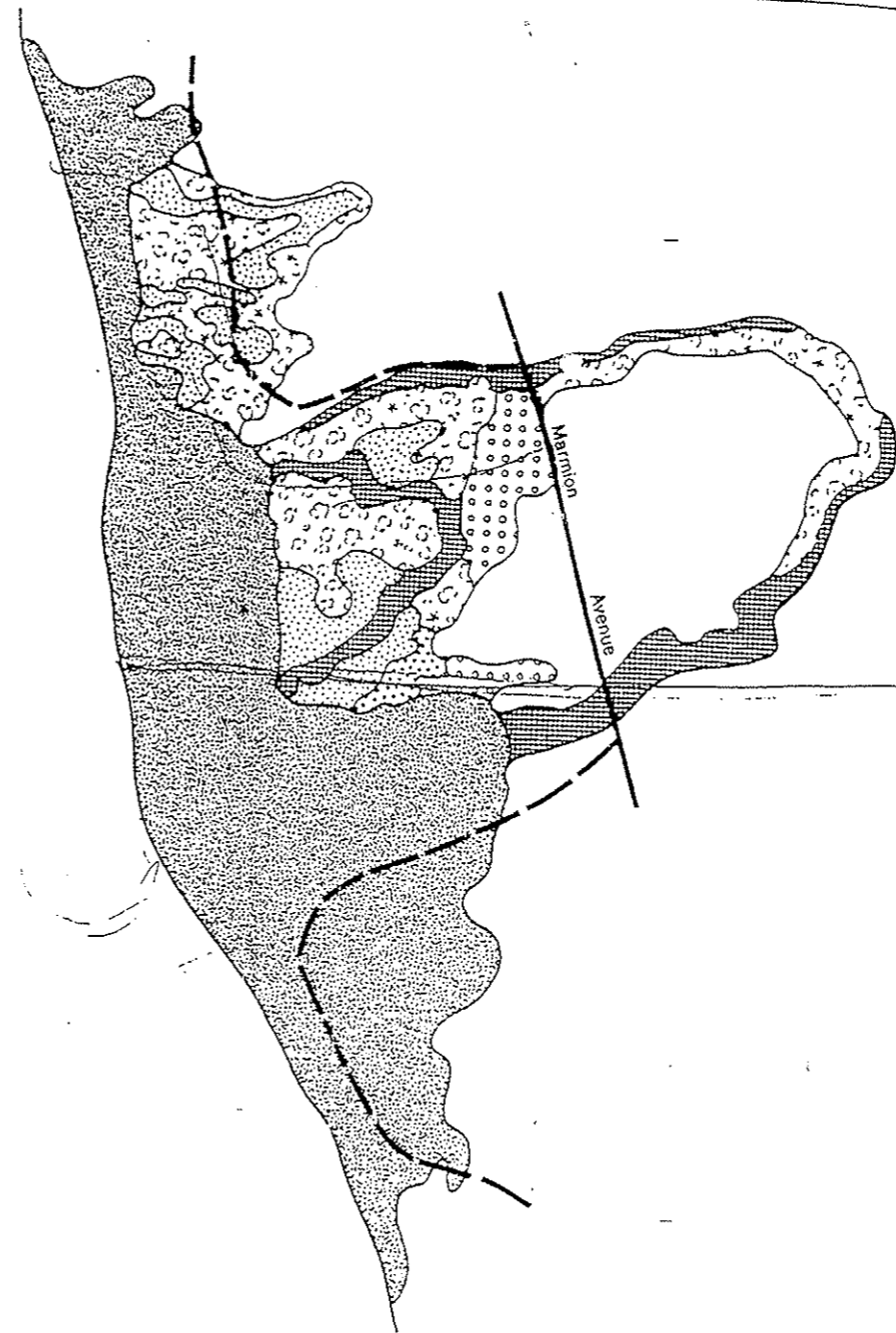








Diagram B VEGETATION ASSEMBLAGES

-  Low shrubland - *Acacia rostellifera*
-  Coastal complex - *Oleria axillaris*
-  Low shrubland and unvegetated blowout areas
-  Low open woodland - *Banksia attenuata*  
*Banksia menziesii*
-  Limestone heath - *Dryandra sessilis*
-  Undifferentiated Quindalup Dune Complex

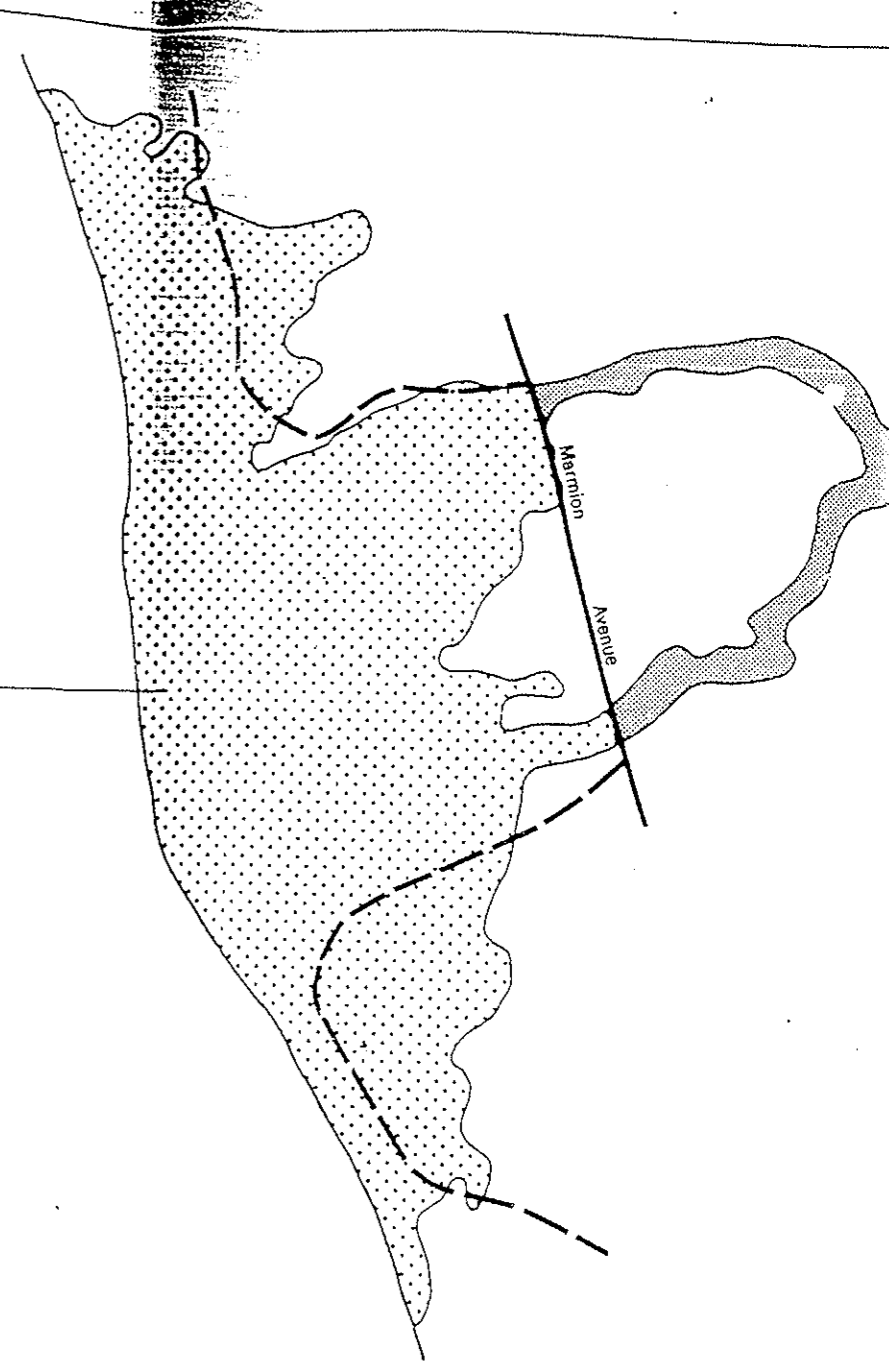


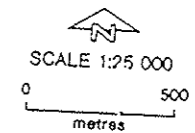


Diagram C VESTINGS

-  Privately owned
-  City of Perth, City of Stirling, City of Wanneroo



NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

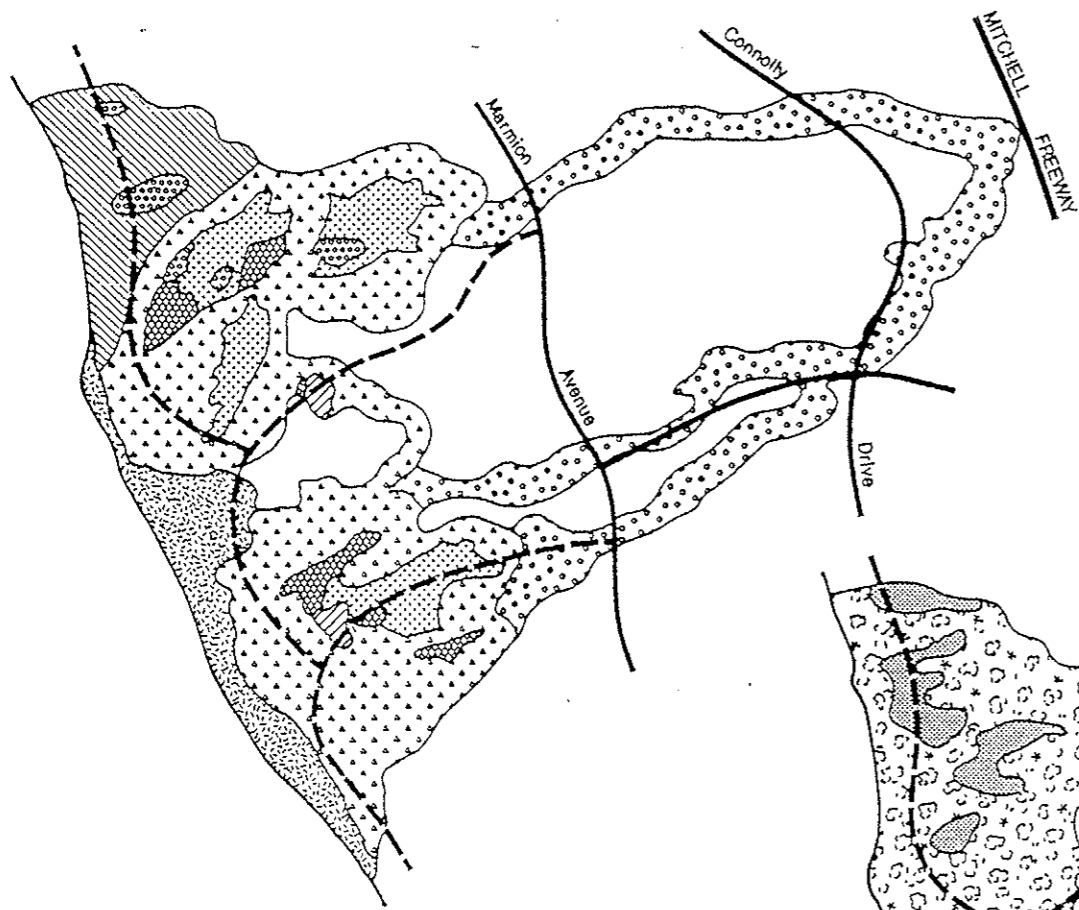


Diagram A

**LANDFORM AND SOIL UNITS**

Cuspate Foreland with parabolic dunes and chaots

- Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
- Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
- Q3 Third Phase - Steep irregular dunes with high relief. Sandy soils.
- Q4 Youngest Phase - Steep irregular dunes of loose sand.
- Op Undulating landscapes with deep calcareous sands.
- Os Undulating landscapes with shallow calcareous sand over limestone.
- Kls Bare limestone
- Ky Karrakatta sand



Diagram B

**VEGETATION ASSEMBLAGES**

- Low open heath - *Scaevola crassifolia*  
*Acacia truncata*
- Shrubland - *Myoporum insulare*  
*Spyridium globulosum*
- Low open heath - *Acacia rostrilifera*
- Low shrubland to shrubland - *Melaleuca acerosa*
- Open shrubland - *Olearia axillaris*  
*Scaevola nitida*
- Cleared of natural vegetation
- Remnant woodland - *Eucalyptus gomphocephala*

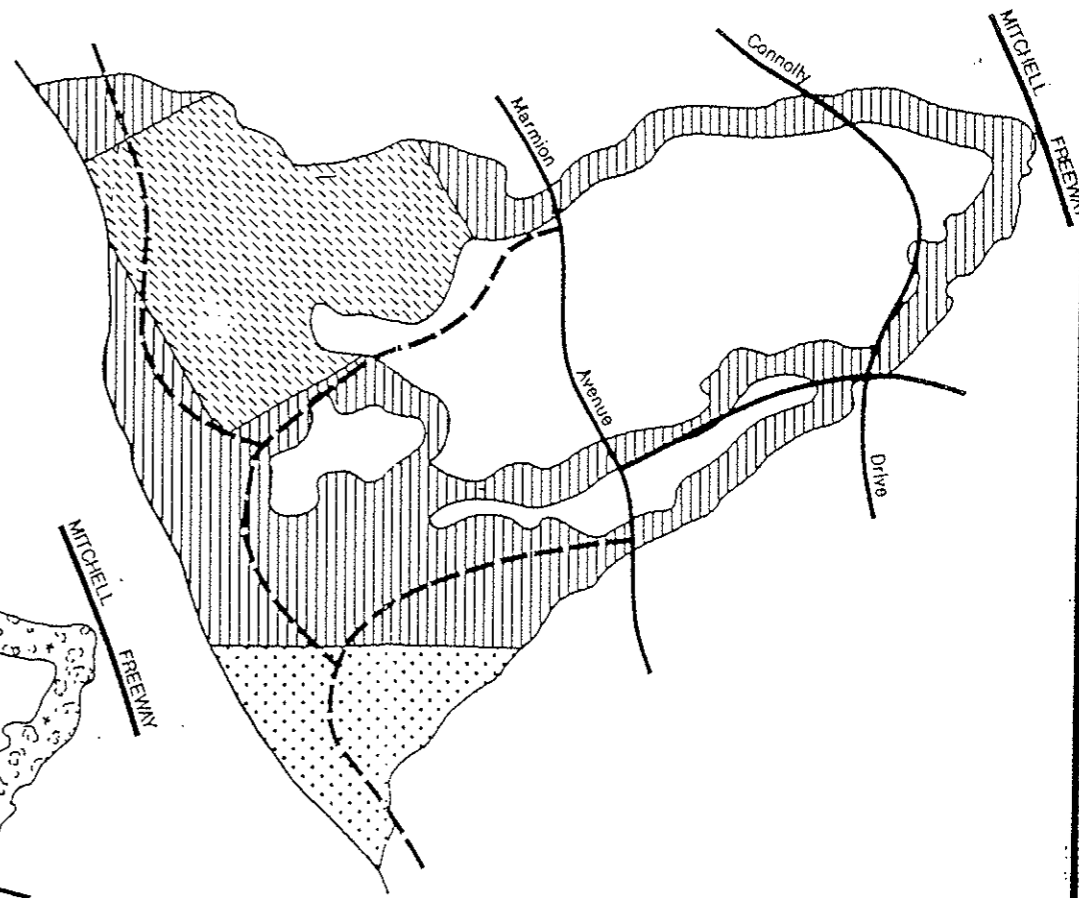
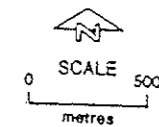


Diagram C

**VESTINGS**

- Privately owned
- Water Authority of Western Australia
- Landcorp



NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

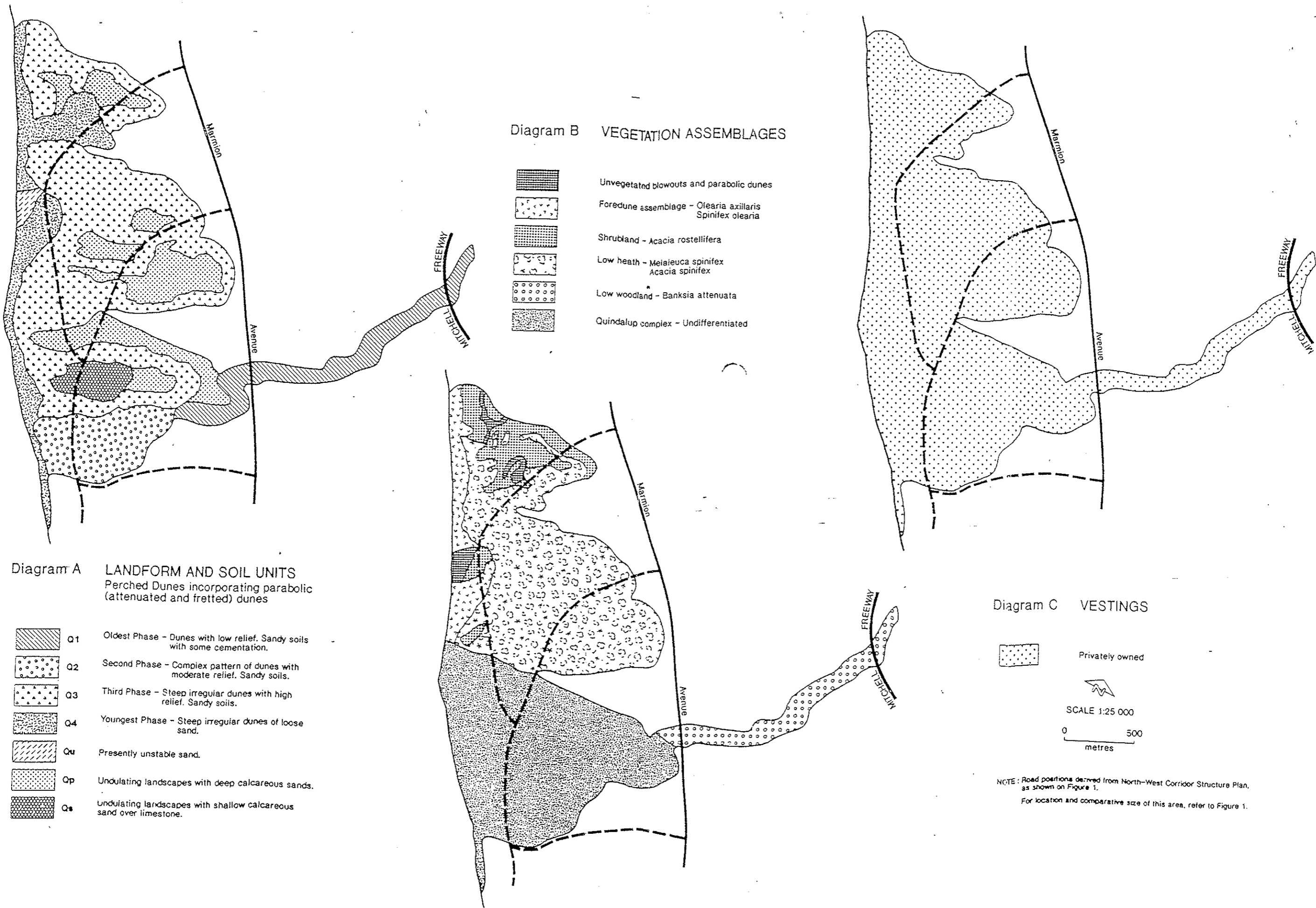


Diagram A LANDFORM AND SOIL UNITS  
Perched Dunes incorporating parabolic (attenuated and fretted) dunes

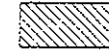






-  Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Q3 Third Phase - Steep irregular dunes with high relief. Sandy soils.
-  Q4 Youngest Phase - Steep irregular dunes of loose sand.
-  Qu Presently unstable sand.
-  Qp Undulating landscapes with deep calcareous sands.
-  Qs Undulating landscapes with shallow calcareous sand over limestone.

Diagram B VEGETATION ASSEMBLAGES


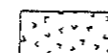

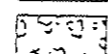
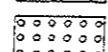

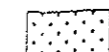
-  Unvegetated blowouts and parabolic dunes
-  Fore-dune assemblage - *Olearia axillaris*  
*Spinifex olearia*
-  Shrubland - *Acacia rostellifera*
-  Low heath - *Melaleuca spinifex*  
*Acacia spinifex*
-  Low woodland - *Banksia attenuata*
-  Quindalup complex - Undifferentiated

Diagram C VESTINGS

-  Privately owned
- SCALE 1:25 000
- 0 500 metres

NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

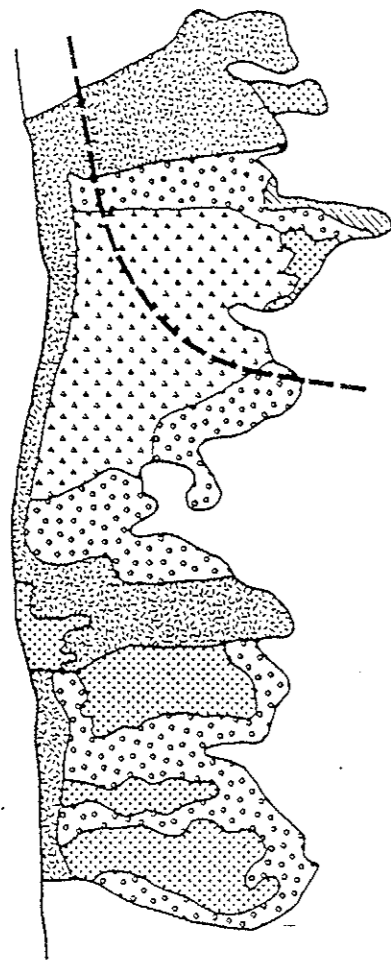







Diagram A LANDFORM AND SOIL UNITS

-  Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Q3 Third Phase - Steep irregular dunes with high relief. Sandy soils.
-  Q4 Youngest Phase - Steep irregular dunes of loose sand.
-  Qp Undulating landscapes with deep calcareous sands.

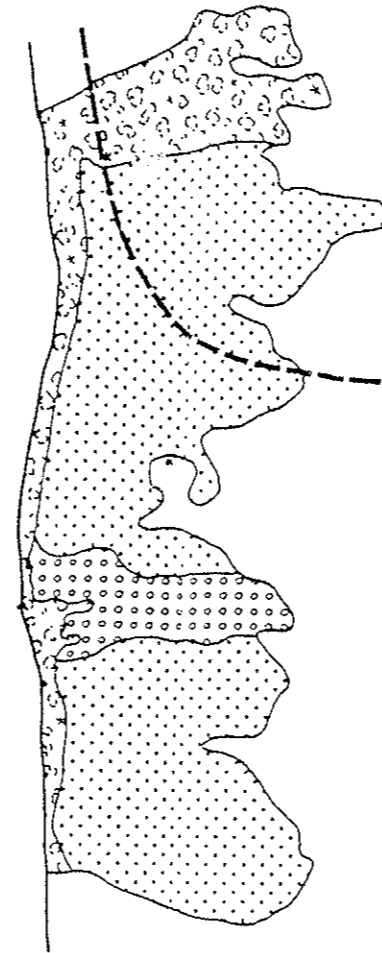










Diagram B VEGETATION ASSEMBLAGES

-  Open to closed heath - *Scaevola crassifolia*  
*Olearia axillaris*
-  Low open shrubland to low shrubland - *Acacia truncata*  
*Melaleuca acerosa*  
*Pimelia ferruginea*
-  Low open heath - *Acanthocarpus preissii*/*Hemiandra pungens*
-  Herbland - *Lomandra maritima*
-  Low open shrubland to Low open heath - *Melaleuca acerosa*
-  Low open heath - *Trymalium albicans*/*Acacia lasiocarpa*/  
*Oxylobium reticulatum*/*Melaleuca acerosa*
-  Low open heath - *Acacia rostellifera*/*Melaleuca acerosa*
-  Closed scrub - *Acacia rostellifera*

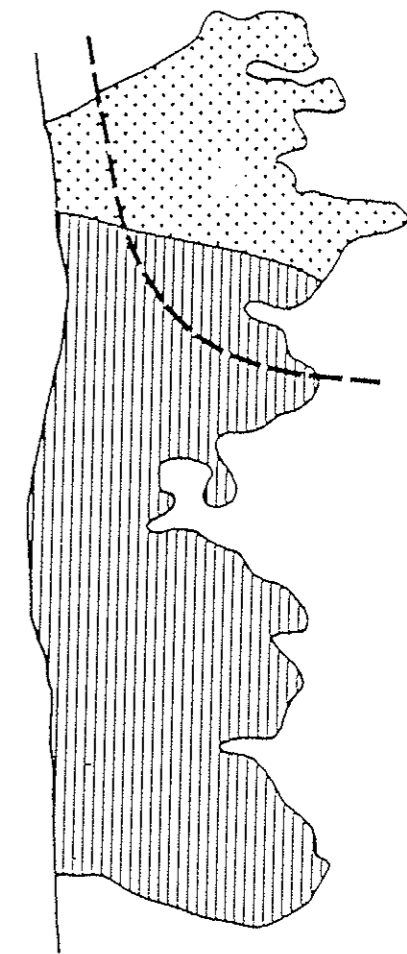





Diagram C VESTINGS

-  Privately owned
-  Landcorp

  
SCALE 1:25 000  
0 500  
metres

NOTE: Road locations derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.

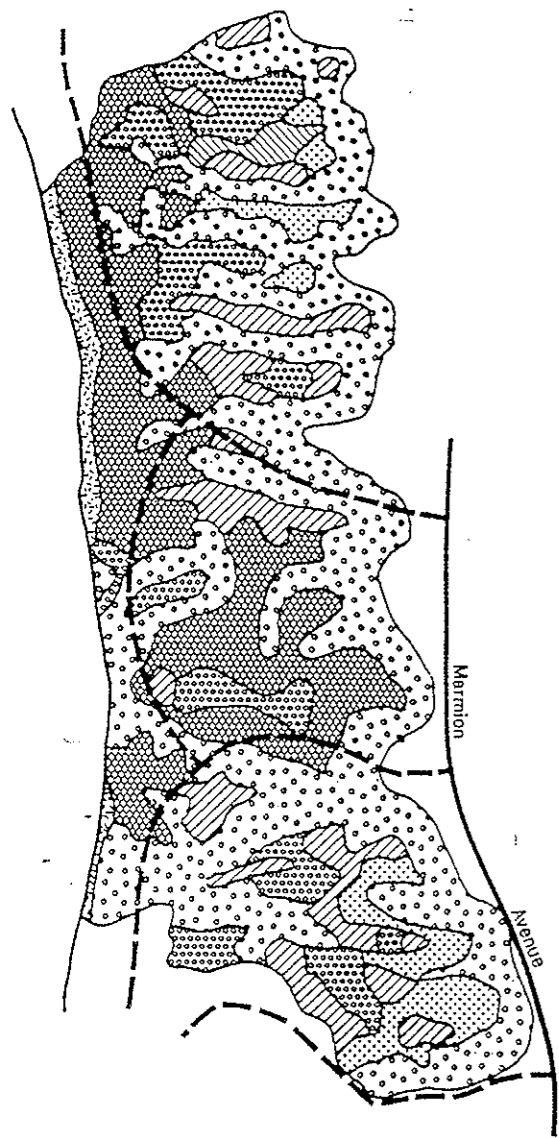








Diagram A LANDFORM AND SOIL UNITS

-  Q1 Oldest Phase - Dunes with low relief. Sandy soils with some cementation.
-  Q2 Second Phase - Complex pattern of dunes with moderate relief. Sandy soils.
-  Q4 Youngest Phase - Steep irregular dunes of loose sand.
-  Qp Undulating landscapes with deep calcareous sands.
-  Qs Undulating landscapes with shallow calcareous sand over limestone.
-  Kls Bare limestone

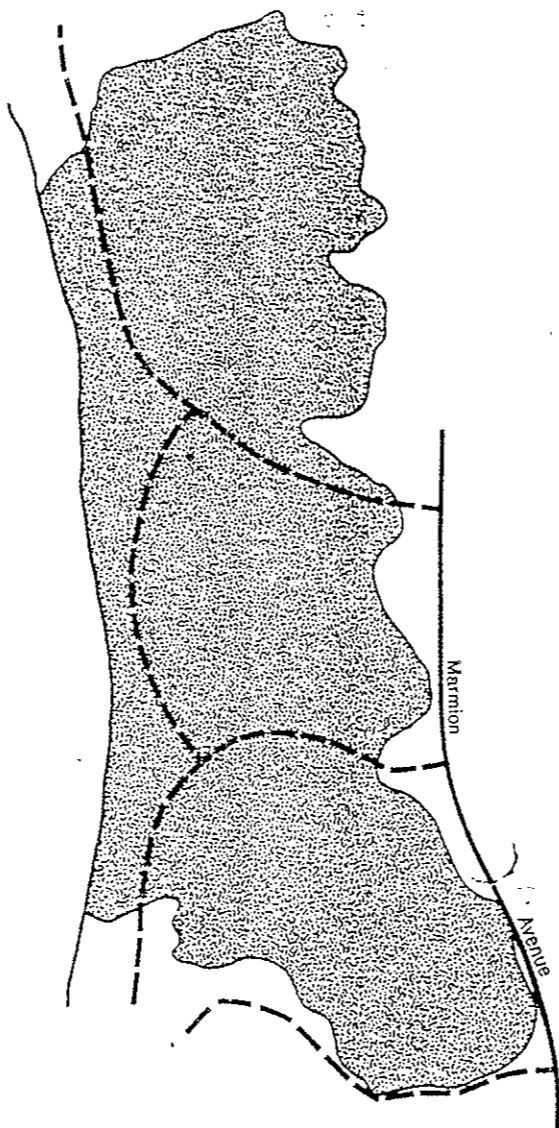



Diagram B VEGETATION ASSEMBLAGES

-  Quindalup complex - Undifferentiated

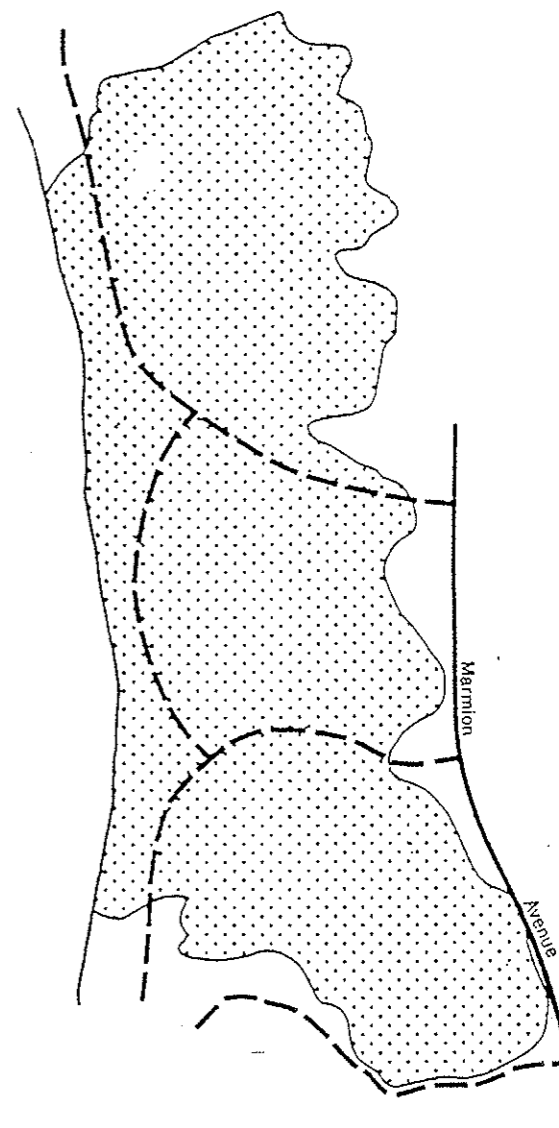


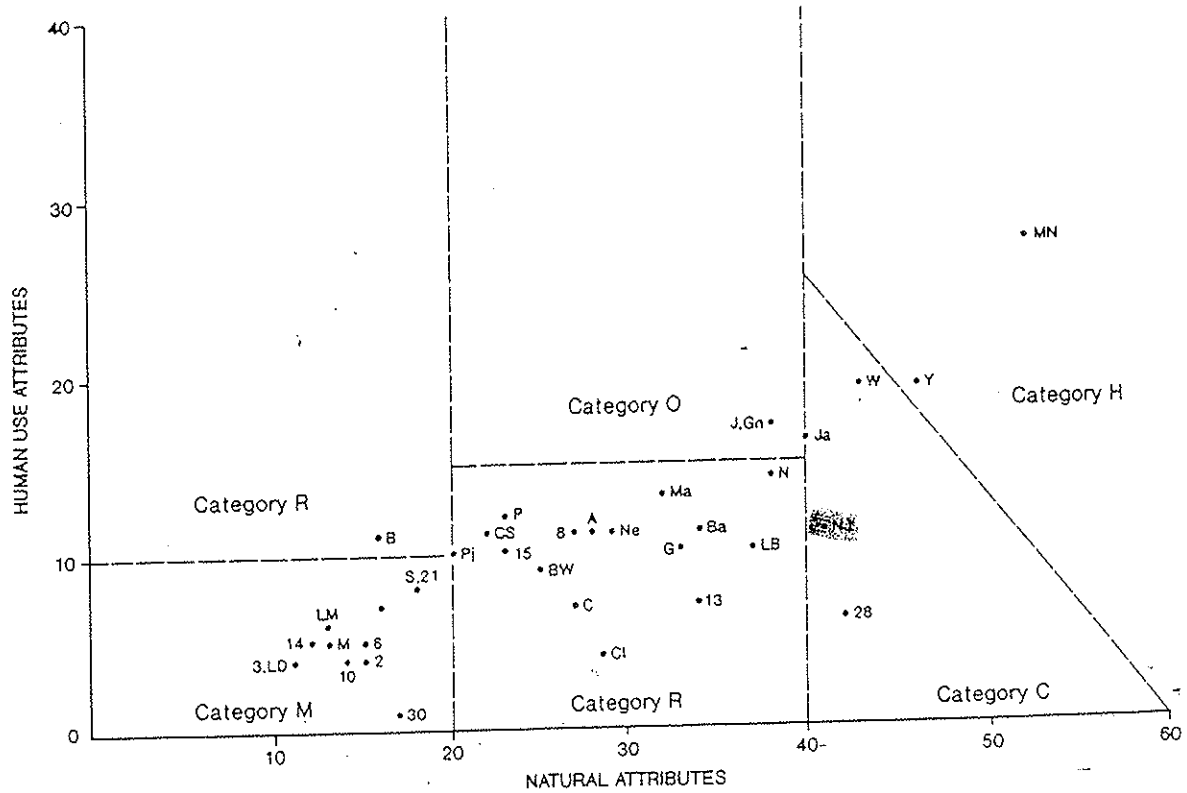


Diagram C VESTINGS

-  Privately owned
- 
- SCALE 1:25 000
- 0 500 metres

NOTE: Road positions derived from North-West Corridor Structure Plan as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.



**YANCHEP SUITE**

- MN - Loch McNess
- Y - Yonderup
- W - Wilgarup
- P - Pippidinny
- B - Beonaddy
- M - Mindarie
- CS - Coogee Spring
- C - Carabooda
- N - Nowergup
- Ne - Neerabup
- NJ - North Joondalup
- J - Joondalup
- BW - Beenyup and Walluburnup
- G - Goollelal

**PINJAR SUITE**

- P - Pinjar

**GNANGARA SUITE**

- A - Adams
- Ma - Mariginup
- LM - Little Mariginup
- Ja - Jandabup
- Ba - Badgerup
- LB - Little Badgerup
- Gn - Gnangara
- S - Snake
- LD - Little Dunderbar
- Cl - Clarkson

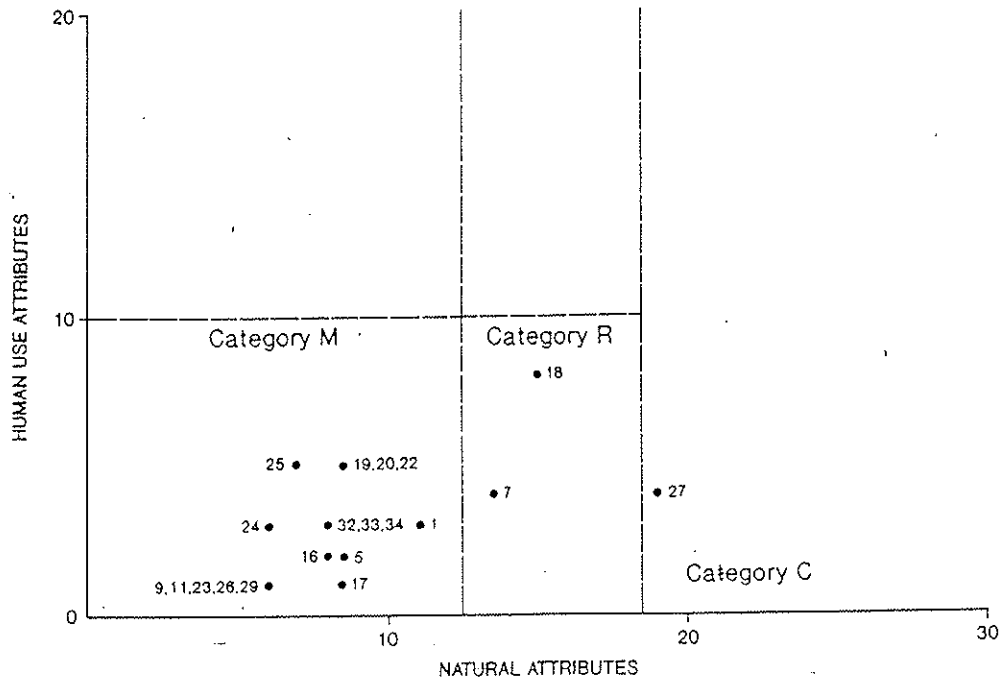
- Category H - High Conservation
- Category C - Conservation
- Category O - Conservation and Recreation
- Category R - Resource enhancement
- Category M - Multiple Use

**WETLANDS EVALUATION**

Well defined boundaries  
using EPA Bulletin 374

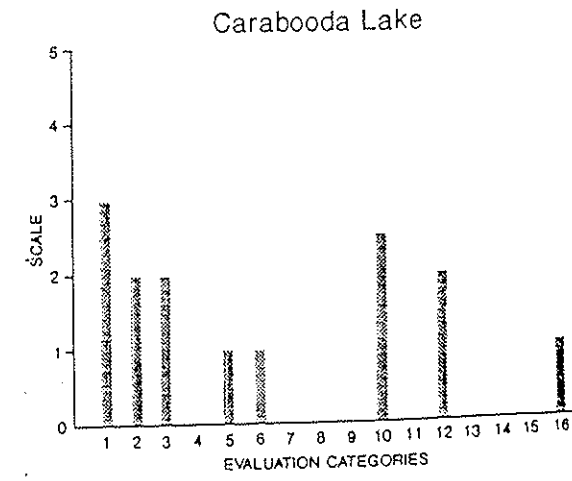
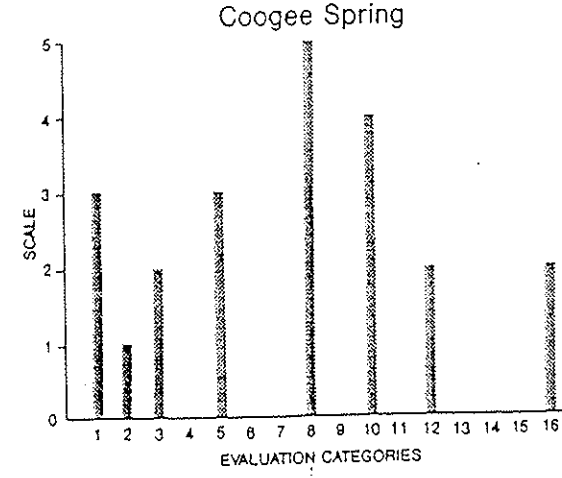
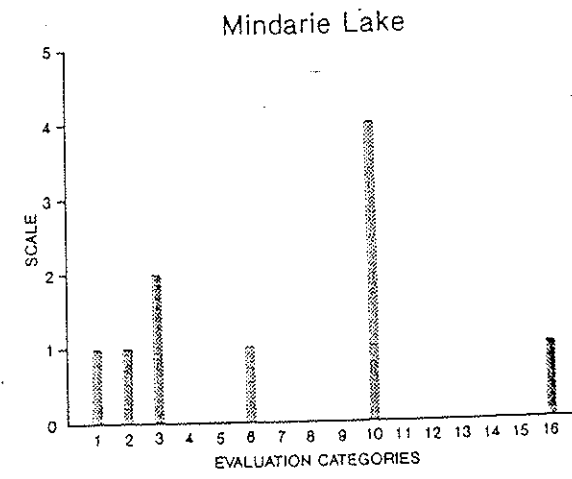
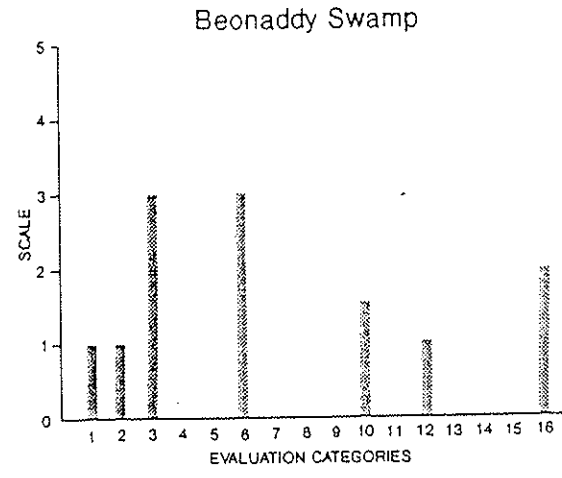
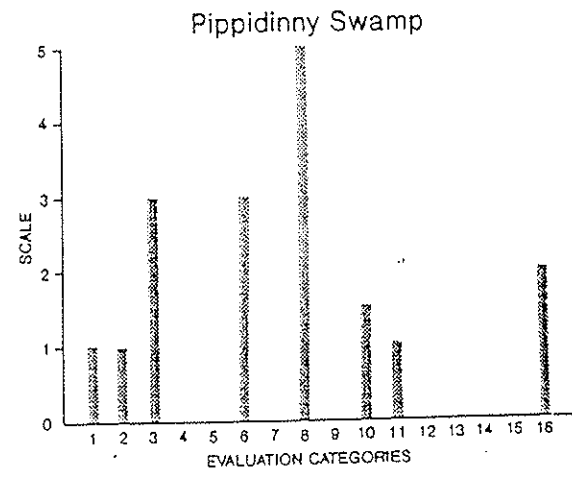
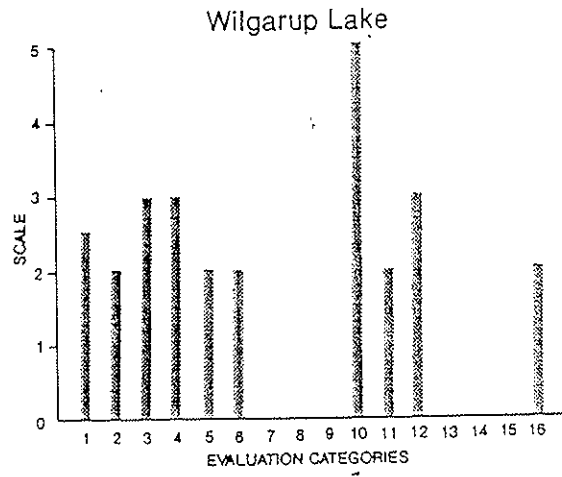
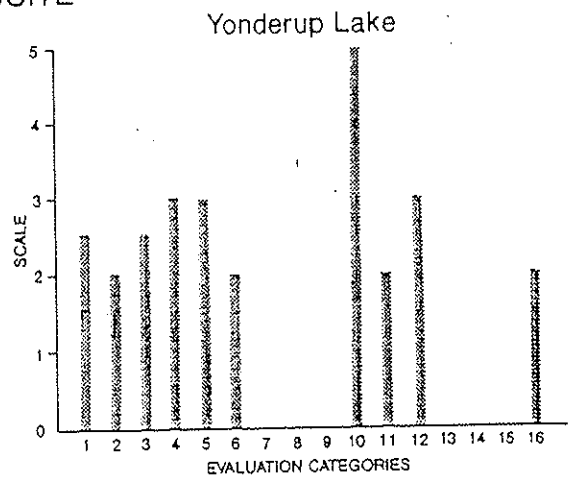
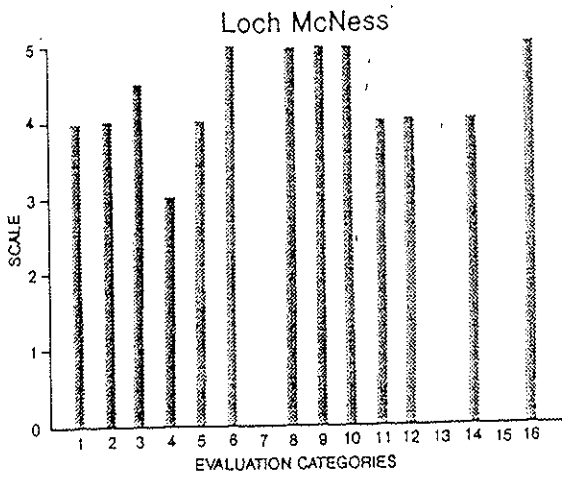
Figure 11

# GNANGARA SUITE

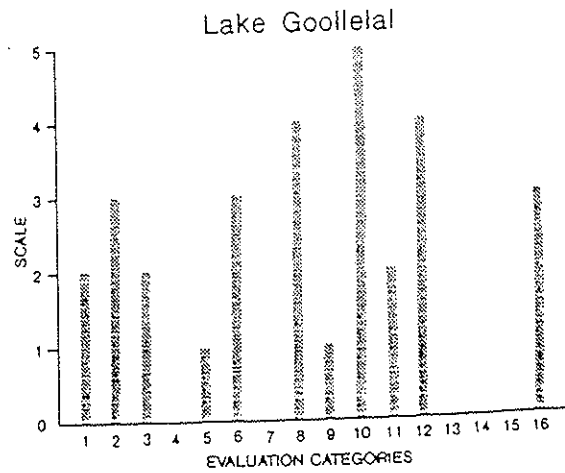
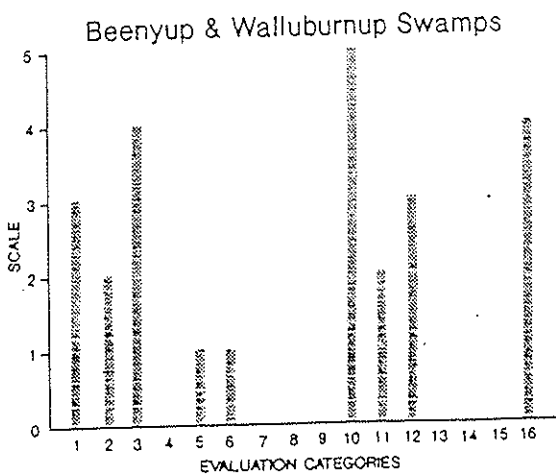
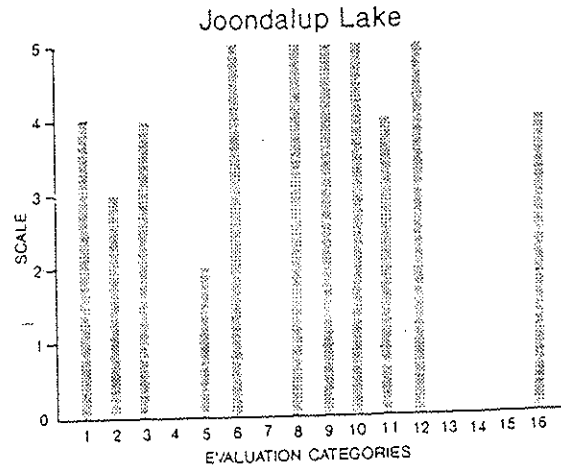
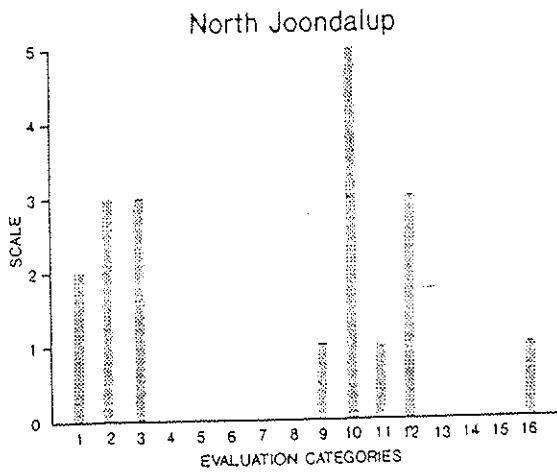
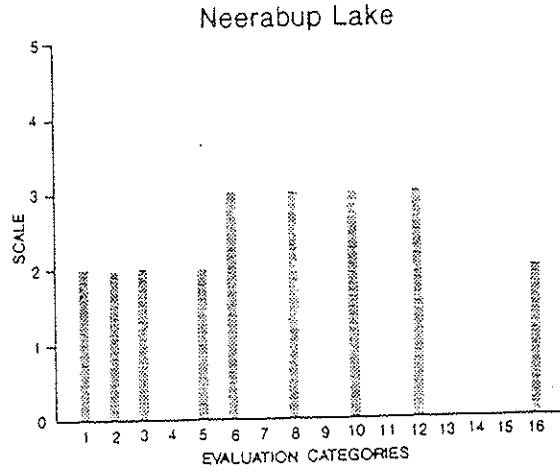
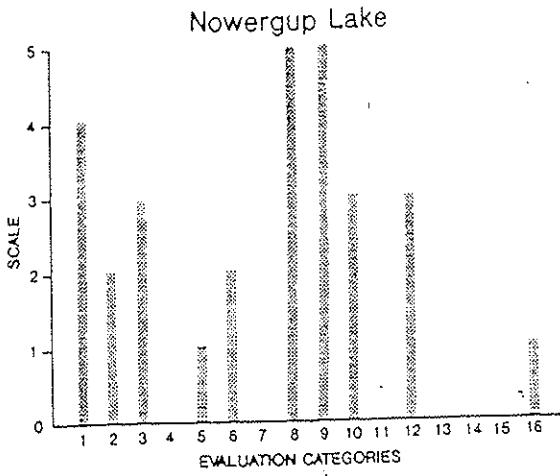


- Category H - High Conservation
- Category C - Conservation
- Category O - Conservation and Recreation
- Category R - Resource enhancement
- Category M - Multiple Use

# YANCHEP SUITE

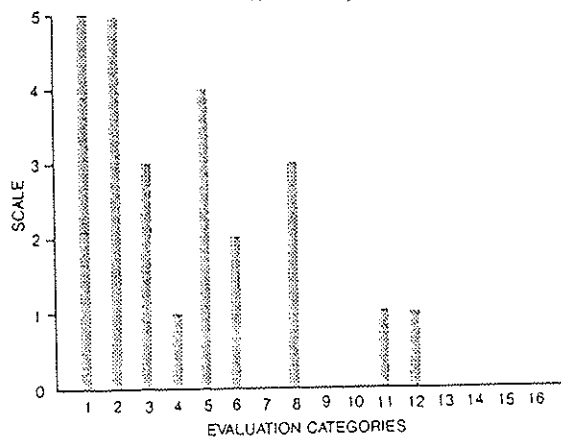


# YANCHEP SUITE



# PINJAR SUITE

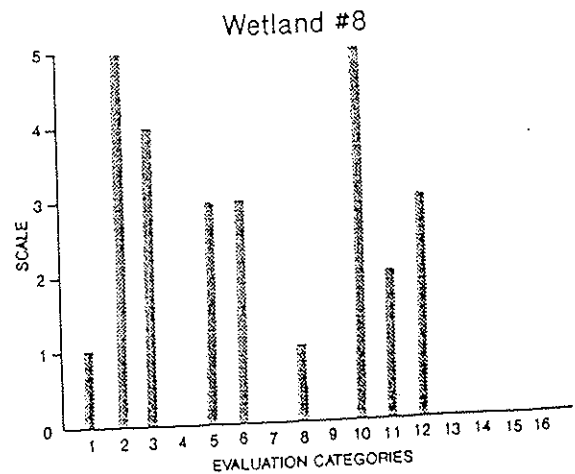
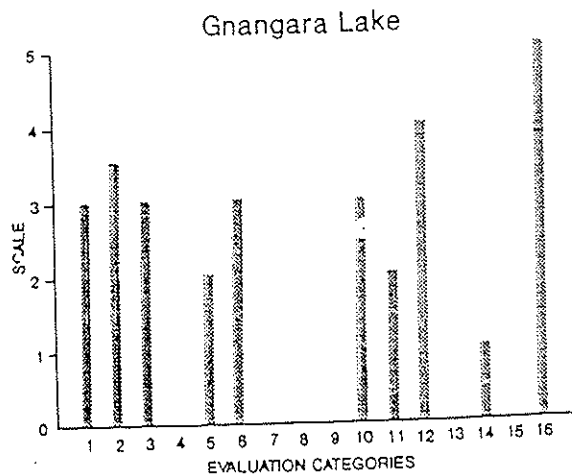
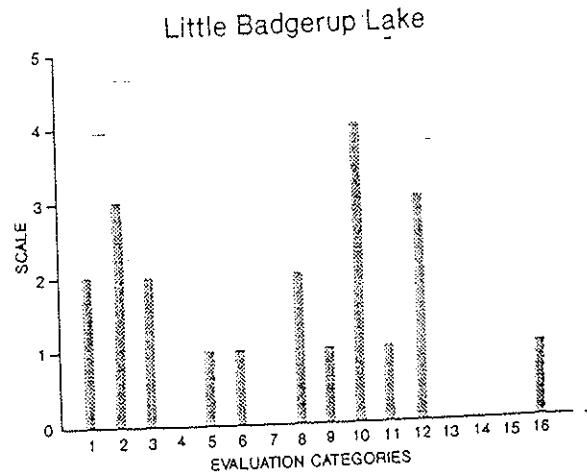
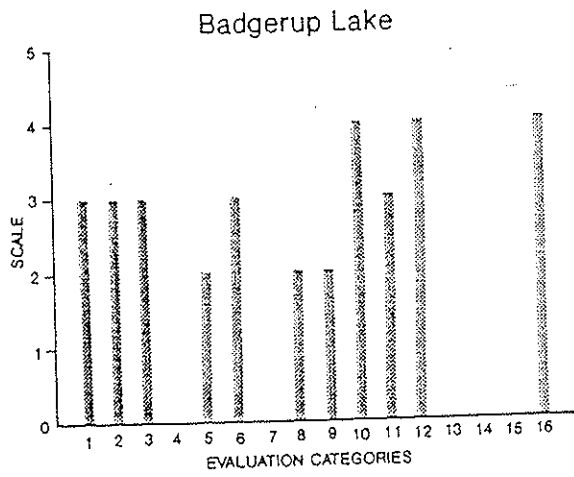
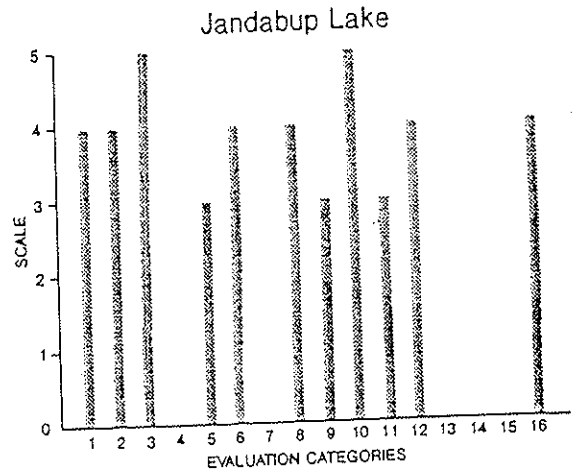
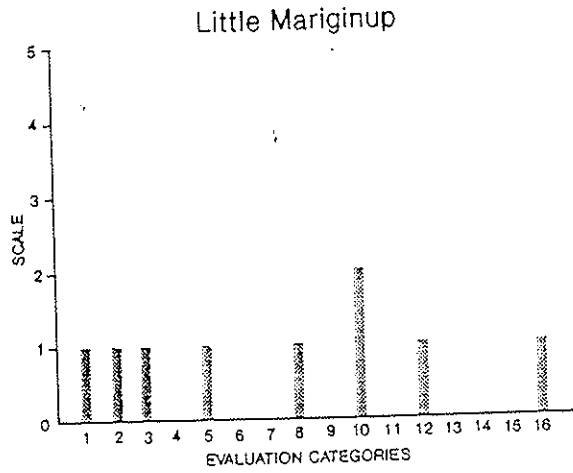
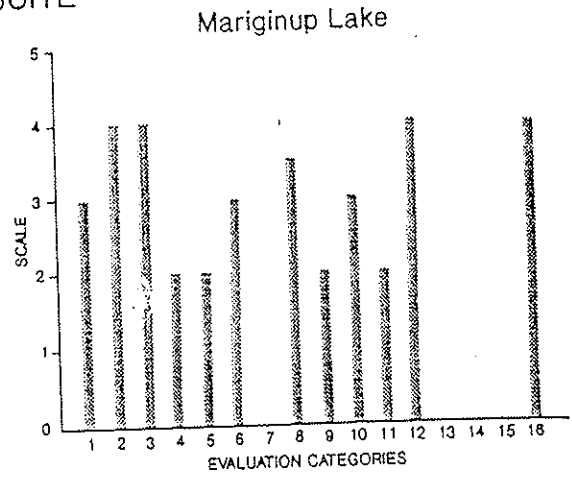
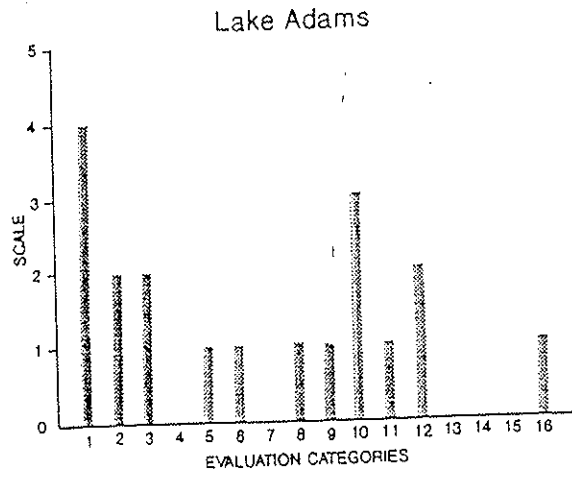
## Lake Pinjar



WETLANDS EVALUATION  
using criteria - Table VI

Figure 13

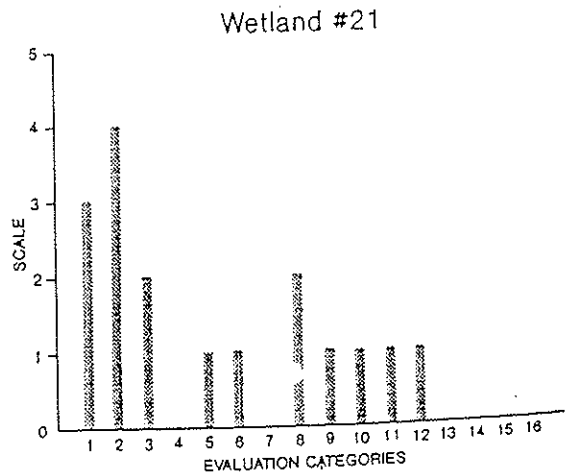
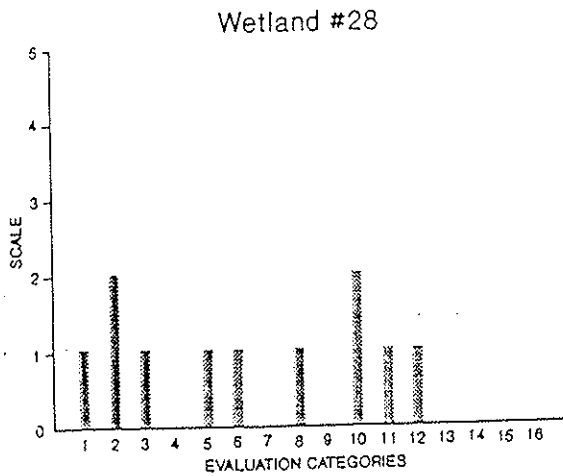
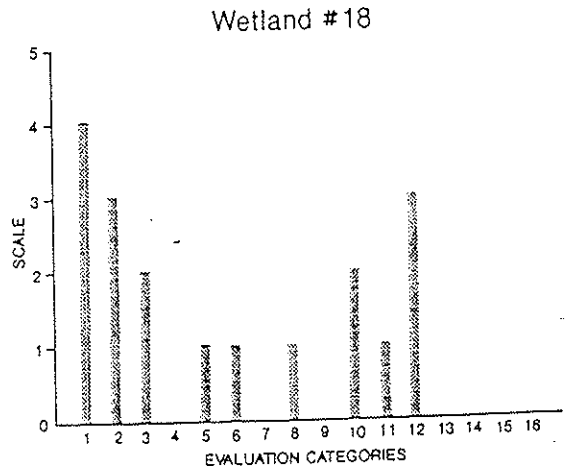
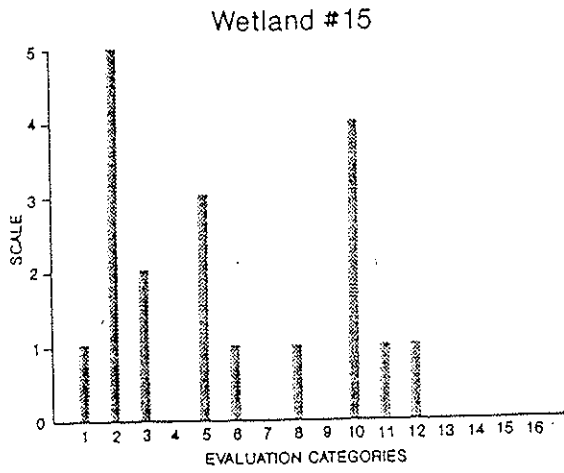
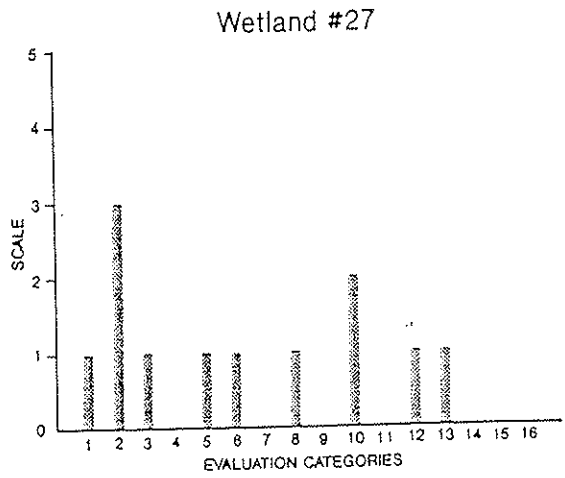
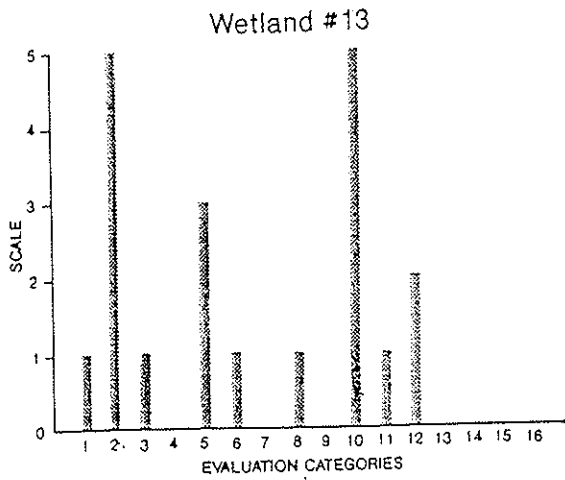
# GNANGARA SUITE



WETLANDS EVALUATION  
using criteria - Table VI

Figure 13

# GNANGARA SUITE




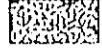
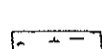


WETLANDS EVALUATION  
using criteria - Table VI

Figure 13

Diagram A  
LANDFORM AND SOIL UNITS

Diagram B  
VEGETATION ASSEMBLAGES

-  Kl Bare limestone
-  Ky Karrakatta sand
-  Sp Spearwood sand - Banks of depressions Sand and limestone.
-  B Beonaddy sand - Flat topography often surrounding lakes and swamps in floors of depressions.
-  W Wetlands

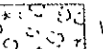



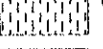
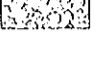
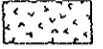

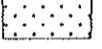
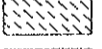

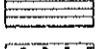
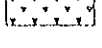
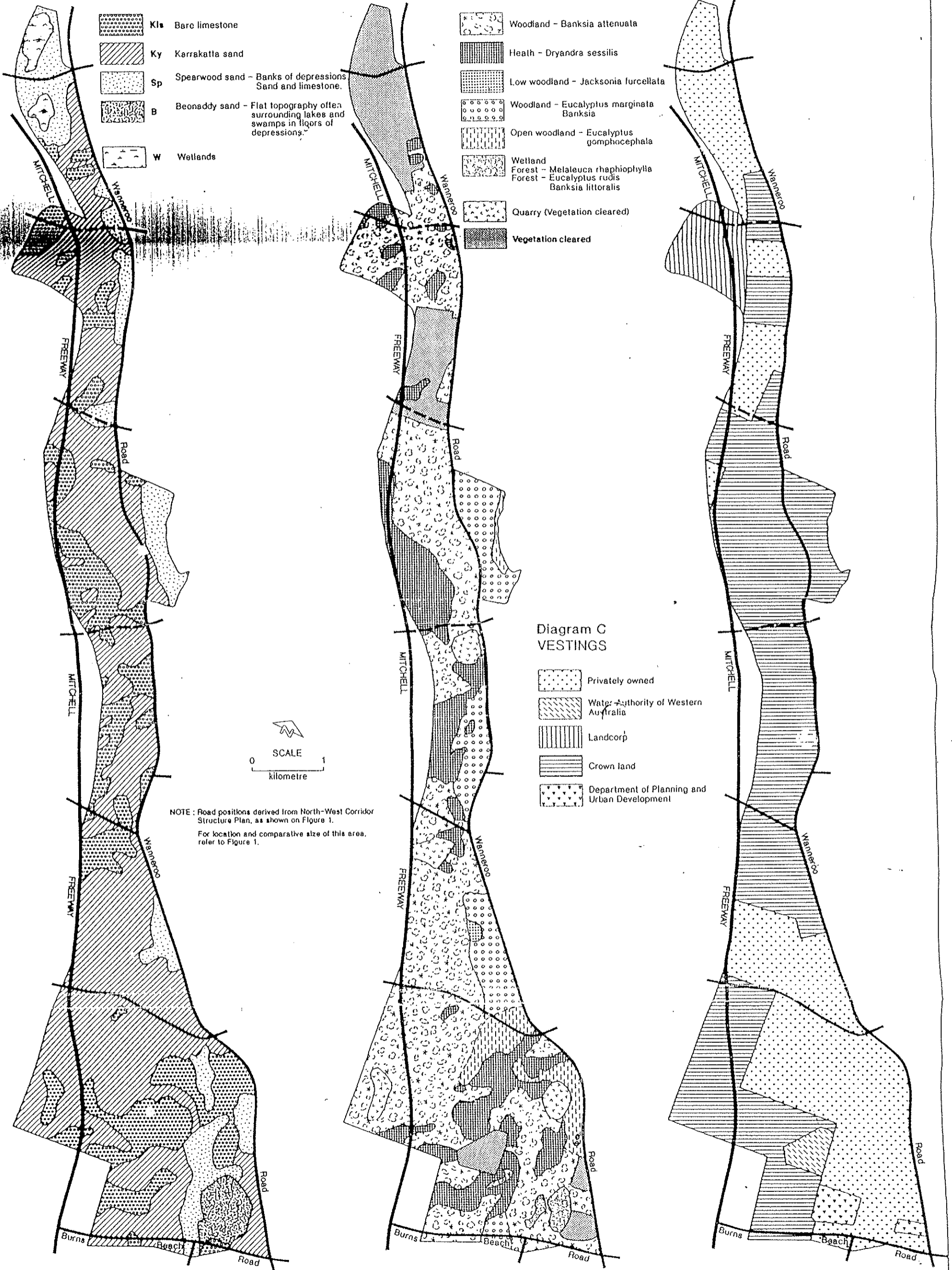
-  Woodland - *Banksia attenuata*
-  Heath - *Dryandra sessilis*
-  Low woodland - *Jacksonia furcellata*
-  Woodland - *Eucalyptus marginata* Banksia
-  Open woodland - *Eucalyptus gomphocephala*
-  Wetland Forest - *Melaleuca raphiophylla* *Eucalyptus rudis* *Banksia littoralis*
-  Quarry (Vegetation cleared)
-  Vegetation cleared

Diagram C  
VESTINGS

-  Privately owned
-  Water Authority of Western Australia
-  Landcorp
-  Crown land
-  Department of Planning and Urban Development

SCALE  
0 1  
kilometre

NOTE: Road positions derived from North-West Corridor Structure Plan, as shown on Figure 1.  
For location and comparative size of this area, refer to Figure 1.





**REVIEW OF PROPOSED  
CHANGES TO  
ENVIRONMENTAL  
CONDITIONS**

**Gnangara Mound  
Groundwater Resources**  
*(Section 46)*

551.491  
(941)  
REV  
Copy A

BS 147  
MARGINIUP  
SPEAR N

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BS 383  
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SPEAR N

BS 399  
MELALEUCA  
BASS N

# REVIEW OF PROPOSED CHANGES TO ENVIRONMENTAL CONDITIONS

BS 193  
GNANGARA  
BASS N

BS 324  
JANDARUP  
BASS N

BS 299  
JOONDAUP  
SPEAR N

BS 462  
RAAF

Gnangara Mound  
Groundwater Resources

BASS N

(Section 46)

SPEAR N  
COOKIEE  
SPRINGS  
BS 129

BS 288  
YANCHEP  
SPEAR N



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## APPENDICES

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Bulletin 230 November 1985

A

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of the Ningana area and

Conservation Issues affecting it

Prepared for Landcorp

by

Malcolm Trudgen

Consultant Botanist

assisted by Bronwen Kieghery

February 1990

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of the Alkimos area and

Conservation Issues affecting it

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by

Malcolm Trudgen

Consultant Botanist

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January 1990

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7.7 LAKE NOWERGUP BS 383

7.7.1 GENERAL INFORMATION

AMG REF: 649500 379500
LOCAL AUTHORITY: City of Wanneroo
MRS ZONE: Rural
RESERVE NOS: A24581;8398
PURPOSE: Sanctuary for Fauna; access to lake
MANAGEMENT: CALM
SYSTEM 6 RECOMMENDATION: M6 (Neerabup N.P.)
WAC CLASSIFICATION: LE.b.l.p.o.
DRAINAGE: informal - piggery effluent

Full document available on request

7.7.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

See also General Setting (Section 7.1). Nowergup is higher in the landscape than either Neerabup to the south or Carabooda, 500 m to the north. It is situated between the 19 m groundwater contour to the east and the 18 m contour on the west. Its maximum water levels are some 4 m above those of Lake Neerabup and its minimum levels are some 6 m above Lake Neerabup. The basin appears simpler in structure than either of the nearby lakes, lacking karstic features.

7.7.3 AREAS AND BATHYMETRY (Figure 7.13)

Table with 2 columns: Description and Area (ha). Rows include Total area of Reserves (116.4 ha), Area of wetland (54.3 ha), Area of sedgeland (6.9 ha), Area of paperbark (7.8 ha), Area of open water zone (34 ha), and Area of modified wetland (5.6 ha).

A series of soundings was carried out on the lake on 7 November 1986 to obtain some information about the lake basin. From data from the Water Authority of Western Australia, the water level at that time was 17.106 m AHD.

The greatest depth measured was 4.0 m (13.106 m AHD).

The soundings enabled approximate lake basin contours to be drawn. On the basis of these data the following approximate areas have been estimated from a tracing on squared paper:

Table with 2 columns: Description and Area (ha). Rows include Area of lake to water level 17.1 m AHD (44.7 ha, 100%), Area of lake below 16.1 m AHD (27.1 ha, 61%), Area of lake below about 15.5 m AHD (14.8 ha, 33%), and Area of lake below about 14.5 m AHD (7.7 ha, 17%).

Further detailed bathymetric surveys have since been undertaken and the results are presented as Figure 7.13.

7.7.4 HYDROLOGY (Figure 7.12)

The water level record differs from those of the adjacent lakes in that there is no evidence of an overflow system at high water levels.

7.5 SMALL LAKE NORTH OF BURNS BEACH ROAD (NO NAME - identified Joondalup, North)

7.5.1 GENERAL INFORMATION

AMG: 6491000 383500  
LOCAL AUTHORITY: City of Wanneroo  
MRS ZONE: Rural  
RESERVE No: privately owned  
PURPOSE: rural uses  
MANAGEMENT: Private  
SYSTEM 6 STUDY RECOMMENDATION: M6  
WAC CLASSIF: LE.f.m.p.sc  
WATER RESERVE: West of Wanneroo Groundwater Area  
DRAINAGE: no formal drains



7.5.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

The physiography of the lake is similar to Joondalup with a strongly marked rise on the western side of the lake and a less severe slope up to Wanneroo Road on the eastern side. High land to the north of this wetland separates it from Lake Neerabup, the next of the north-south series of the Wanneroo wetland chain. Continuity between this wetland and Lake Joondalup to the south is indicated by surface contours.

7.5.3 AREAS

Total area of wetland .....	42.0 h
Reed/sedgeland .....	3.4 h
Closed paperbark .....	32.5 h
Open water zone .....	3.1 h
Modified and cultivated .....	3.0 h

7.5.4 HYDROLOGY

There is apparently no record of water levels in this wetland. The water body appears to be permanent.

It is likely that changes in land use around the wetland would be reflected in water level changes, with any significant sustained rises in water level leading to death of the closed paperbark woodland on the western part.

During cycles of high rainfall, it is to be expected that the continuity between this lake and Joondalup would be more marked.

7.5.5 WATER QUALITY - No data available.

7.5.6 LAND USE - Refer to Figure 7.7

7.5.7 VEGETATION (Figure 7.7)

The western part of the wetland is closed paperbark wetland with Melaleuca raphiophylla being the dominant species and some M. lateritia. The eastern half of the wetland is open water to closed Typha swamp. This section is directly affected by horticulture and grazing stock.

Some large M. preissiana in deep grey sand to the south of this wetland appear to represent an uncharacteristic occurrence of this species which is normally found in Bassendean sands.