MULTIPLEX CONSTRUCTIONS PTY LTD

EGERTON

STRUCTURE PLAN

CONSULTATIVE ENVIRONMENTAL REVIEW

ALAN TINGAY & ASSOCIATES

FEBRUARY 1994

REPORT NO: 93/61

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AN INVITATION TO COMMENT ON THIS CER

The Environmental Protection Authority (EPA) invites people to make a submission on this Consultative Environmental Review (CER).

The CER has been prepared by Multiplex Constructions Pty Ltd in accordance with the Environmental Protection Act, 1986 and describes an urban Structure Plan for the Egerton property in the Shire of Swan. At present the land involved is zoned Urban Deferred. The CER is available for public review for four weeks from 15 February 1994 to 15 March 1994.

Comments from Government agencies and from the public will assist the EPA to prepare an Assessment Report on the Structure Plan in which it will make recommendations to Government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated confidentially unless it is stated that they can be used publicly, then they may be quoted either in full or in part in each report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to ten people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the CER or with specific aspects. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific items in the CER:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.

- Refer each point to the appropriate section, chapter or recommendation in the CER.

- If you discuss different sections of the CER, keep them distinct and separate, so there is no confusion as to which section you are considering.

- Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name,
- your address, and
- the date.

The closing date for submissions is:

15 March 1994.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
8th Floor, Westralia Square
141 St George's Tce
PERTH WA 6000

Attention: Mr Ian Harvey

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SUMMARY

1. INTRODUCTION

This Consultative Environmental Review (CER) describes a Structure Plan for an urban estate on the Egerton property in the Shire of Swan. The land affected by the Structure Plan is adjacent to, and to the east of, the Ellenbrook Estate. Both the Egerton and Ellenbrook land are currently zoned Urban Deferred.

In 1993, the owners of the Ellenbrook land applied for the Deferred status to be lifted, i.e for the land to be zoned Urban, so that it would be available for development.

As Ellenbrook and Egerton are adjacent to each other and have a common zoning, it was considered appropriate that this application should include both parcels of land. In order for this to happen it was necessary for the owners of Egerton, Multiplex Constructions Pty Ltd, to prepare a Structure Plan to illustrate the main features of a future urban estate. This Structure Plan is an essential component of the application for changes to the zoning.

The Structure Plan also provides a basis for the Environmental Protection Authority (EPA) to assess the environmental implications of urbanisation at Egerton. These environmental implications are the subject of the present CER.

2. DESCRIPTION OF PROPOSAL

The Egerton Structure Plan has been developed on the basis of an analysis of the environmental features of the land involved and incorporates an urban structure which is designed to protect and preserve the most important natural environmental features. In particular, the Structure Plan provides for the retention of a chain of wetlands within Open Space. With sympathetic development these wetlands will become major community assets to future residents while still retaining their natural physical and biological values.

The major road system within the estate has also been determined by the dominant environmental features of the site. In particular, the road alignments have been selected so as to minimise the need for earthworks and to avoid the important wetlands.

Access within the development to the different neighbourhoods, wetland corridors and a zoological garden, which is based on an existing private zoo, is provided by dual use path networks.

Surface drainage will be via a conventional system of road gullies and underground pipes draining to detention basins within Open Space and ultimately to Ellen Brook. The detention basins will enable control of the quantity and quality of runoff prior to final discharge. Subsoil drainage will also be necessary in areas of high groundwater.

Water supply to the development will be derived from the Lexia borefield on the Gnangara Mound to the east, and the development will be deep sewered. Electricity will be supplied from the existing high voltage system on Gnangara Road, telephone connections can be provided by the extension of optic-fibre cables from the existing OTC facility and natural

gas can be made available via a connection to SECWA's existing Dampier to Bunbury pipeline.

3. EXISTING ENVIRONMENT

Groundwater

The Egerton property is located on the easternmost fringe of the Gnangara Mound. Groundwater flow within the Gnangara Mound is from west to east, so there is no possibility that the proposed development will have any effect on any Public Water Supply Area.

Wetlands

Two separate groups of wetlands have been identified on the Egerton property:

- the Ellen Brook Suite, and
- the Muchea Suite.

The Ellen Brook Suite comprises a creek system that provides the natural surface drainage to Ellen Brook whilst the Muchea Suite are small to medium scale sumplands and floodplains in depressions at the base of the Bassendean Dunes.

None of the wetlands on the property are within areas identified in the System 6 Study Report of the Environmental Protection Authority (EPA) or in the Environmental Protection (Swan Coastal Plain Lakes) Policy, 1991.

Surface Flows

Egerton is a discrete surface subcatchment of Ellen Brook as all surface flows originate entirely on the property. The Egerton property covers 0.8% of the total Ellen Brook catchment, and discharge from the property is estimated to be approximately 275,220m^3/yr.

Surface Water Quality

Based on a number of studies of the Ellen Brook catchment, it is estimate that nutrient loads discharged from Egerton are in the order of:

- Total Nitrogen 574.2kg/yr
- Soluble Reactive Phosphorus 143.55kg/yr
- Total Phosphorus 193.05kg/yr.

Land Capability

The eastern part of the Egerton property is dominated by the Yanga soil unit. The soils on the western side of the property belong to the Jandakot, Gavin and Joel units, which are all Bassendean Sands. Seasonal Swamps occur in the south-western half of the property

and a Drainage Line unit dissects the Jandakot unit at the base of the property. Karrakatta and Muchea sands occur along the south-eastern edge of the property.

The Yanga, Joel, Drainage Line and Seasonal Swamp units require fill and drainage prior to development. The Jandakot, Karrakatta and Muchea units are susceptible to wind erosion but this does not present a problem for urbanisation. The Gavin unit has a high capability for urban development.

Flora and Vegetation

Most of the native vegetation on the Egerton property has been cleared for pine plantations and agricultural use. A total of 158 native species were recorded on the Egerton property. No declared rare flora species were recorded, although a large population of the Priority 3 species *Aotus cordifolia* was located.

Twenty-four vegetation associations occur on the property. The vegetation types are similar in floristic composition to those on the adjacent Ellenbrook Estate, and all the associations at Egerton are represented within the proposed conservation areas on Ellenbrook Estate.

Vertebrate Fauna

Fifty species of indigenous (native) vertebrates have been recorded at Egerton together with four introduced mammal species and 2 introduced bird species.

The vertebrate fauna is typical of the region, and comprises a sub-set of that found in surveys of Whiteman Park and Ellenbrook.

The Southern-Brown Bandicoot is present and appears to be mainly associated with wetland habitats. This species is classified as rare and endangered.

Aboriginal Sites

There are 3 areas of significance to Aboriginal people on the Egerton property. Two of these being camp sites and the other an archaeological site located near the camp sites.

A Waugal or Rainbow Serpent Dreaming Track was also identified. However, it was noted that the Waugal is associated with all areas of open water.

4. ENVIRONMENTAL IMPLICATIONS AND MANAGEMENT

Wetlands

The sumplands are considered to be the primary environmental asset of the Egerton property, and have been substantially included within Public Open Space. A series of open ponds will also be created, which are intended to increase the variety of habitats available to waterbirds and other aquatic fauna, and to provide landscape diversity and aesthetic appeal in the POS system.

Hydrological issues

Surface drainage will be by conventional road gullies and underground pipes connected to disposal basins in Open Space areas. Retention basins will also be placed in the system to enable control of runoff quantity and quality.

Runoff following urbanisation is expected to increase by approximately 3% on current rates. If untreated, this runoff could increase phosphorus output. To counter this, detention basins will be lined with neutralised red mud to absorb phosphorus.

Data is presented in the CER which indicate that there will be a substantial reduction in phosphorus outflows from Egerton to Ellen Brook following urban development.

Flora and Vegetation

The proposal will have no significant implications in terms of the conservation of regional flora, as most of the flora on Egerton is typical of the northern and eastern uplands and wetlands of the Bassendean Dune Sands.

Most of the remnant vegetation on the property is associated with wetlands that are to be substantially included within POS. The Priority 3 species, *Aotus cordifolius* will also be protected within Open Space.

Vertebrate Fauna

The vertebrate fauna at Egerton is typical of the bushland and farmland areas of the local area and the Perth Metropolitan Region. The fauna at Egerton is not significant in terms of regional conservation, however the fauna has local intrinsic significance.

The retention of a large proportion of the remaining natural vegetation within POS at Egerton will continue to provide a variety of habitats for vertebrate fauna.

The Southern Brown Bandicoot requires special consideration due to its status of rare and endangered. The favoured habitat of this species is the dense vegetation associated with the principal wetlands, much of which will be substantially retained within the POS areas. One option for management of this species is to develop a specific management plan to protect the species from predation by domestic animals or foxes and their habitat from damage. The other option is to capture, remove and relocate the local bandicoot population to secure conservation reserves.

Aboriginal Sites

There is no potential for the disturbance of the majority of Aboriginal Sites under the current Structure Plan for Egerton. This includes the stream associated with the Waugal. However, part of one archaelogical site could be affected by the present proposal. It may become necessary to make an application to disturb this site.

5. CONCLUSIONS

The information presented in this CER suggests that the proposed urban development of the Egerton property will have no significant adverse environmental impacts. This is mainly because the Structure Plan for the estate takes into account the most important environmental features of the property. In particular, the Plan includes the Muchea Suite sumplands, and their associated high quality vegetation and important fauna habitats, within Open Space.

1. INTRODUCTION

1.1 Background

The Egerton property is located in the Swan Valley in the Shire of Swan. It is to the south-west of The Vines Resort and is immediately adjacent to, and east of, the proposed Ellenbrook Residential Estate.

In 1992, the owners of the Ellenbrook Estate (Sanwa Vines Pty Ltd, Homeswest, and Mount Lawley Pty Ltd) proposed that the area of land which they owned should be rezoned from Rural to Urban Deferred. This proposal was referred to, and was formally assessed by, the Environmental Protection Authority (EPA). Subsequently, the proposal received environmental approval from the Minister for Environment subject to certain conditions.

In its Assessment Report on the Ellenbrook proposal, the EPA also referred to Egerton. It indicated that in its view the two properties could be rezoned at the same time but that environmental issues associated with urban development of the Egerton property would require specific assessment. In effect, this meant that for the Urban Deferred zoning at Egerton to be lifted a Structure Plan would have to be prepared for consideration by the EPA and by the planning authorities.

In 1993, both Ellenbrook and Egerton were zoned Urban Deferred.

The owners of the Ellenbrook property, in accordance with normal planning procedures, then applied for the Deferred zoning to be lifted so that their property would be available for urban development. It was considered appropriate that an application should also be made at the same time for the lifting of the Urban Deferment at Egerton.

The owners of the Egerton property, Multiplex Constructions Pty Ltd, therefore prepared a Structure Plan to support the application for the removal of the Deferred status over their land. The environmental implications of this Structure Plan are the subject of this Consultative Environmental Review (CER). The CER has been prepared in accordance with guidelines provided by the EPA which are included in Appendix 1.

1.2 General Scope of the CER

The CER provides a description of the Structure Plan for Egerton, a description of the present environmental features of the property affected by the Structure Plan, an analysis of the environmental issues relevant to that Plan, and a description of strategies for environmental management that have been incorporated into the Plan.

1.3 The Proponent

The proponent for the lifting of the Urban Deferred zoning at Egerton is:

Multiplex Constructions Pty Ltd
15th Floor
214 St Georges Tce
PERTH WA 6000

1.4 The EPA Assessment Process

The Western Australian environmental impact assessment process is outlined in the Guide to the Environmental Protection Act (Environmental Protection Authority, 1987) and is illustrated in Figure 1. Essentially, the proponent (in this case Multiplex Constructions Pty Ltd) is required to notify the EPA of any proposal which may have significant environmental implications. The EPA then determines whether the proposal should be formally assessed. If a decision is made for a formal assessment, the EPA requires the proponent to prepare a detailed account of the environmental implications in a report such as the present Consultative Environmental Review (CER).

After the CER has been prepared, it is reviewed by the EPA to ensure that it provides sufficient detail and a comprehensive coverage of issues. When this has been established, the CER is released for a public review period. At the end of the public review period, a summary of submissions is supplied to the proponent and a response is sought. The EPA then undertakes to assess the development proposal.

The results of the EPA assessment are published in the form of an Assessment Report which includes recommendations made to the Minister for Environment. Interested parties can appeal against the level of assessment set by the EPA, and against the content of the EPA Assessment Report, or any of its recommendations. Ultimately the Minister for the Environment decides whether the proposal is acceptable and what conditions will be imposed upon it.

The environmental assessment process is designed to enable State authorities to consider in detail the environmental and social implications of development proposals. These considerations are based on technical assessments of the nature and extent of changes to the existing natural and social environments, on proposed management strategies designed to control or limit adverse changes, and on monitoring programs designed to document and analyse the effectiveness of such strategies.

The environmental assessment process also enables members of the public to obtain details of the proposal and to formally comment on any matters of interest to them. These inputs are required within a specified public review period and are considered together with the technical assessments. The public is encouraged to provide written comments to the EPA as part of the environmental review process. Details of the public review period for the Egerton proposal and advice on how to make a submission are provided at the beginning of this CER.

1.5 Public Consultation

During the preparation of the CER, a meeting was held on 12 October 1993 between the Chairman of the Ellenbrook Conservation Group (Mr Kingsley Dunstan), a Councillor from the Shire of Swan (Ms Jan Zeck), and the environmental consultants (Alan Tingay & Associates) in order to identify the issues which are of concern to the local community.

At this meeting the following environmental issues were raised.

"Mound Spring" - the Ellenbrook Conservation Group (ECG) were concerned about protection of a "Mound Spring" in the north-west corner of the property and associated vegetation.

The spring is in fact a groundwater seepage area and is described in Sections 3.7 and 3.8 of the CER. This area will be protected within Open Space.

The ECG stated their knowledge of the presence of two rare flora species in the area of "spring".

A specific flora survey for the CER identified two Priority Flora species (Section 3.12.3) but no Declared Rare Flora on the property. The Department of Conservation and Land Management (CALM) does not have any records of rare flora on the property nor does it expect any to occur there.

The potential to create a bushland corridor from Egerton to the Lexia Wetlands and Whiteman Park also was raised.

The Egerton Structure Plan has a system of POS linked internally and to Ellen Brook to the east. However it is not possible to link these areas to other bush areas outside the Egerton boundary given current planning for the Ellenbrook Estate and the lack of bush linkages to Whiteman Park.

The ECG indicated the possible presence of the Honey Possum (*Tarsipes spencerae*) in the area.

The presence of this species has been confirmed by the fauna survey (Section 3.13) but as only one individual was caught, the status of the population is not known.

The potential pollution of Ellen Brook and Henley Brook was a primary concern.

The effect of the urbanisation at Egerton on water quality is discussed generally in Sections 3.10 and 4.4 and will be modelled in detail in the Drainage Management Plan which the proponents have committed to prepare. It is expected that there will be a reduction in nutrient levels in runoff following urbanisation.

2. DESCRIPTION OF THE PROPOSAL

2.1 Location, Titles and Zoning

The Egerton property is located approximately 20km north of the City of Perth in the Shire of Swan (Figure 2). The land currently zone Urban Deferred comprises three titles as follows:

- Lot 148 98.1077ha
- Lot 30 174.9051ha
- Lot 2 222.3412ha

Total Area 495.3540ha

The land is part of a larger property owned by Multiplex Construction Pty Ltd which also is known as Egerton. The Urban Deferred zone at Egerton is part of a larger area to the west and north which is the Ellenbrook Urban Deferred zone.

2.2 Planning Framework

The State Planning Commission (SPC) through the Department of Planning & Urban Development (DPUD) is responsible for planning urban development within the Perth Metropolitan Region. The broad strategy for development of the region is described in Metroplan (DPUD, 1990a) while specific areas for urban development are identified in the Urban Expansion Policy Statement (DPUD, 1990b) and the Metropolitan Development Program 1991-92/1995-96 (DPUD, 1991). The Policy Statement identified Ellenbrook as one of the areas most likely to be developed in the short to medium term while the Development Program described it as the most significant opportunity for development in the north-east sector of the Perth Metropolitan Region in the period up to 1996. The location identified included all of the land now currently zoned Urban Deferred including both Ellenbrook and parts of Egerton.

The implementation of urban development requires appropriate zoning under the Metropolitan Region Scheme (MRS) administered by the SPC and the Town Planning Scheme (TPS) of the Shire of Swan which are the main statutory bases for planning in the region. Until recently, Egerton and Ellenbrook were zoned "Rural" under both the MRS and the Shire of Swan TPS No. 9 District Zoning Scheme. Both locations however, were rezoned to Urban Deferred after an application by the owners of Ellenbrook and environmental approval from the Minister for Environment. That approval was based on recommendations of the EPA following assessment of a Public Environmental Review (PER) for the Ellenbrook proposal (EPA, 1992).

The next step in the planning process involves rezoning the land from Urban Deferred to Urban under the MRS and to Residential Development or a similar zoning under the Shire of Swan TPS. These steps have been initiated. The EPA however, decided to formally assess the proposal for rezoning Egerton to Urban as specific details of this location were not included in the Ellenbrook PER. In particular, the EPA wishes to determine that the

rezoning from Urban Deferred to Urban is appropriate given a specific Structure Plan for future residential development of the land.
Assuming that the Minister for Environment gives environmental approval for the Structure Plan for Egerton, following assessment by the EPA, the necessary amendments to the MRS will occur in accordance with the provisions of the Metropolitan Region Town Planning Scheme Act, 1993. The equivalent amendment to TPS No. 9 of the Shire of Swan also will be processed in accordance with the normal procedures of the Town Planning and Development Act, 1928-1965 and Town Planning Regulations, 1967.

2.3 The Egerton Structure Plan

2.3.1 General Description

The Egerton Structure Plan is described in detail in a specific publication (Multiplex Constructions Pty Ltd, 1993). The Plan, which is illustrated in Figure 4, presents a framework for an urban estate which responds to the specific opportunities and constraints to the site. In particular, the environmental "constraints" on the site, which are the main wetlands and the creek lines, are converted into planning assets through their inclusion in a network of Open Space linked by walking and cycling trails. This Open Space network is the dominant feature of the Structure Plan and has been the primary determinant of the other components of the Plan.

The topography and remaining natural vegetation on the site have been used to produce distinctive character zones in the Structure Plan. The Plan uses these features to define individual linked neighbourhoods each of which will have special qualities created by the retention and enhancement of existing vegetation, retention of wetland areas, creation of new wetland habitats, views to major landscape features, and access to Open Space.

The road and dual purpose path network has also been substantially determined by the dominant environmental features of the site. These corridors focus on the "town centre" where shopping, commercial, and community facilities are concentrated.

The dual use paths network, as well as linking the neighbourhoods, also provides access to particular areas of interest such as the wetland corridors and the zoological gardens. The paths will allow a diverse choice of walks of varying distance and ready access to major Open Space and schools.

The zoological gardens are based on an existing private zoo which houses a small but diverse collection of birds and some other vertebrate fauna. The zoo is constructed to the highest standards and includes a completely enclosed wetland containing mature *Melaleuca preissiana*. This feature is considered to be a major potential educational, public and tourist asset for the area as well as a unique local attraction for future residents.

The road system will play a major part of defining the quality of the area. The roads will be flanked by tree plantings designed to suggest and reinforce a hierarchy. The primary distributor road running north from Gnangara Road will be a parkway with substantial roadside planting. This road has been located to the east of the primary wetland chain and elevated areas in the western sector of the site so that it can be constructed with minimum environmental disturbance. Land uses such as drainage detention basins, Open Space and

the high school have been located along the route to present users with an open aspect wherever possible.

In the elevated western sector the slopes are often steep and the roads have been aligned to take account of the existing contours and to reduce the need for earthworks in their construction.

The major road link to the Ellenbrook Estate in particular, has been specifically located in a "valley" like depression within the ridge system and crosses the wetland Public Open Space network at a location which has been significantly disturbed, in order to minimise environmental impacts.

2.3.2 Land Use Allocation

The Structure Plan makes provision for some 3,650 residential lots at an average density of approximately 7.4/ha. The projected maximum population at Egerton is in the order of 11,800 people. The proposed housing mix has been based on present market trends and a developable area of 358.9ha. The mix of lot sizes is given in Table 1.

TABLE 1

PROPOSED RANGE OF LOT SIZES

Average Land Per Unit (m^2)	Number of Units	Proportion %
570	730	20
700	1460	40
770	1095	30
450	182	5
250	182	5

The Structure Plan allows for a retail centre with floor space of approximately 15,000m^2 on a 6ha site. Provision is also made for future commercial units in an area of 3.4ha. There are two primary schools each comprising 4ha and 1 high school site of 10ha. A community use site, which may include a central community hall, church, daycare, and or other uses, comprising 2.05ha is located adjacent to the primary retail/commercial centre.

As mentioned above, the extent of Public Open Space is a feature of the Structure Plan. The total area of Open Space is 84ha which comprises approximately 17% of the development area compared to the statutory requirement of 10%. The Open Space will fall into a number of categories as described in Table 2.

TABLE 2

CATEGORIES OF OPEN SPACE

Open Space	Total Area (ha)
Major conservstion reserve: with managed public access.	34.5
Parkland corridors and water bodies.	27.8
Pocket parks, local play and incidental space.	3.0
Zoological Gardens	10.7
Sportsgrounds	8.0
TOTAL OPEN SPACE	**84.0**

It is possible that the zoological gardens may be privately owned and therefore may not constitute part of the Open Space.

2.3.3 Pedestrian and Vehicle Movements

The Structure Plan includes a comprehensive path system designed to encourage walking and cycling from residential areas to schools, Open Space and the town centre. The primary path system is located substantially within Open Space corridors or adjacent roadways. Secondary footpaths will link the primary paths to form circular routes to provide recreational opportunities as well as ease of access.

Motor vehicle traffic will be catered for by the primary distributor roads which cross the site and provide access from Gnangara Road and connections west to the Ellenbrook urban estate. The compatibility of the primary road network with the environmental features of the site has been described in Section 2.3.1 above.

The residential neighbourhoods will be served by a loop road system which also corresponds to the physical features of the site.

Traffic modelling for the Ellenbrook proposal has included the potential development of Egerton and indicates that traffic originating in Egerton with a destination outside the area will total approximately 11,100 trips per day. It is anticipated that the traffic flows on the regional and distributor roads will be of the order indicated in Table 3.

TABLE 3

PREDICTED TRAFFLIC FLOWS

Road	Volumes (VPD)
Lord Street extension south	3890
Lord Street extension north	1110
Rookwood Street south	2220
Great Northern Highway south	550
Great Northern Highway north	1000
Internal Roads north	660
Gnangara Road west	1670

2.3.4 Services

As a result of the presence of wetlands of particular significance and other areas of high groundwater within the Egerton property, particular attention will be given to the treatment of stormwater drainage. The drainage system will based on the broad principles established under the North-East Corridor Drainage Strategy of the Water Authority of Western Australia (WAWA). In general, it is expected that surface drainage will be via a conventional system of road gullies and underground pipes draining to disposal basins within the Open Space areas. The pipe system will be designed to cater for runoff from storms with a frequency of up to 1 in 5 years with flows from less frequent events provided for in overland floodways comprising road reserves and/or linear Open Space systems. In both cases a water sensitive approach will be adopted for design and construction of the drainage system to maximise the potential for groundwater recharge and minimise the risk of pollution of downstream receiving waters including wetlands within the site and Ellen Brook to the east.

Other elements of the drainage strategy will include the incorporation of retention basins within the system to control both runoff quantities and qualities prior to final discharge. These will combine dry basins which are landscaped as part of the Open Space areas and artificial or groundwater lakes developed within or adjacent to the existing wetlands or high groundwater level areas.

In the areas with high groundwater which are allocated for residential purposes it may be necessary to incorporate subsoil drainage as well as fill to provide adequate clearances between the groundwater and finished building levels. This drainage will be designed to ensure that the extent of groundwater export from the area is adequately controlled.

A model of both the surface drainage and groundwater flows associated with the Structure Plan is currently being developed and will form a component of a comprehensive Drainage Management Plan.

The water supply to Egerton will be derived from the Lexia borefield operated by WAWA on the Gnangara Mound to the east. Supply to both Ellenbrook and Egerton will be via trunk and distribution water mains linking to a main reservoir and treatment plant located

on higher ground along the State Forest boundaries west of Ellenbrook. Separate high level reservoirs may be required to service the higher sectors of Egerton.

The water supply facilities will be implemented in stages and it is expected that initial supply will be via permanent bores within the Lexia system on the Gnangara Mound to the west and a permanent high level reservoir or temporary on ground reservoir within the estate itself. Temporary treatment facilities will also be constructed either as a central plant or as separate plants at each bore site.

The Egerton urban estate will be deep sewered. WAWA's current planning for sewerage of urban areas in the north-eastern corridor of the Perth Metropolitan Region is to collect sewage and pump it to existing and future treatment plants to the west. This would involve an initial link to the existing Beenyup Treatment Plan but with ultimate connection to the proposed Alkimos Treatment Plant. The capital costs of these projected works will be very high and, as a result, a number of alternative schemes are being considered as part of the planning for Ellenbrook and Egerton.

These alternative schemes include systems for the on-site treatment and disposal of sewage incorporating both permanent and temporary facilities staged to suit the pattern and rate of urbanisation. Such treatment would be in package plants incorporating secondary and tertiary process systems as necessary to meet any environmental requirements for effluent disposal. A range of disposal options exist including on-site irrigation, dual water supply, seepage, etc. These will need to be investigated as part of more detailed planning, however, initial assessments suggest that the concepts involved are feasible. It is possible that on-site facilities may become the long term permanent scheme for sewerage of the area.

The proponent recognises that the use of on-site effluent treatment and disposal will need to be investigated as part of more detailed development planning and that specific proposals may require further assessment by the Environmental Protection Authority.

Electricity supply to Egerton will be from the existing high voltage system on Gnangara Road. This system has sufficient capacity to service the intial development. Telephone connections can be provided by the extension of optic-fibre cables from the existing OTC facility off Gnangara Road, west of the Egerton property. Natural gas can also be made available to the area via a connection from SECWAs existing Dampier to Bunbury pipeline which runs through the south-east corner of the State Forest, west of Egerton.

3. EXISTING ENVIRONMENT

3.1 Introduction

The main existing features of the Egerton property are:

- An elevated sandy ridge in the western sector which slopes down to the east.
- A series of wetlands mostly located at the base of the ridge which are manifestations of a shallow groundwater level.
- A plain which extends from the wetlands beyond the eastern boundary of the present Urban Deferred zone to the valley of Ellen Brook.
- some intermittent and perennial streams which run from the wetlands across the plain to Ellen Brook.
- The general absence of indigenous vegetation and fauna habitat over much of the land, except the wetland areas, as a result of clearing for agriculture and the development of an extensive pine plantation.

The Structure Plan for Egerton has been developed in accordance with the opportunities and constraints presented by the existing features of the site as explained in Section 4 of this CER. The present section provides a basis for that explanation and includes a detailed description of the existing environment.

3.2 Climate

A description of the climate at Egerton is important for an understanding of site conditions and particularly the dynamics of wetlands and the proposed groundwater and drainage management plans. These plans are an integral part of the development proposal.

The Perth Metropolitan Area, of which Egerton is a part, is described as having a 'warm mediterranean' climate regime and experiences seasonal changes with warm to hot dry summers and mild wet winters. The actual definition of a 'warm mediterranean' climate regime is related to the annual distribution of rainfall. This relationship is illustrated in Figure 5 as an ombrothermic diagram in which monthly mean rainfall is plotted against temperature on double the scale (Beard, 1979). Months in which rainfall plots above the temperature line are considered 'wet' while months in which rainfall plots below the temperature line are considered dry.

At Egerton, the dry period extends from approximately mid October to the end of March. Rainfall in the summer months (December to March) is less than 20mm per month. Rainfall at Egerton occurs mostly during the winter months (June to August) with mean monthly totals during this period in excess of 100mm and up to nearly 160mm in July. Seasonal rainfall results from westerly frontal systems bringing moist air from the Indian Ocean to coastal and inland areas.

Local rainfall information is available from the Upper Swan Research Station which is located approximately 3km north-east of Egerton. The exact location of the Research Station is 31°45' South and 116°01' East and the data covers a 35 year period from 1957 to 1992 (Figure 6a and 6b).

The average yearly rainfall at the Research Station is 737mm.

As the dry period at Egerton is in summer, and the wet in winter the climate fits the pattern of 'mediterranean'. This description is used in a global context where mediterranean climates are unusual and occur only in California (USA), Chile, South Africa, Southern Australia and adjacent to the Mediterranean Sea.

The length of the dry season determines the type of mediterranean climate attributable to an area. For example, a regime with only 3 to 4 dry months is classified as 'moderate mediterranean', whilst a regime with 5 to 6 dry months is a 'warm mediterranean' climate (Beard, 1979). Egerton experiences 6 dry months and may be described as a temperate mediterranean climate.

Based on records from the Upper Swan Research Station, winds from the south-west are most common in spring and summer afternoons (30 to 40% occurrence at 1500hrs). During summer, winds are common from the east (55%) at 0900 hours, but not at 1500 hours (25%) (Figure 7).

Prevailing winds tend to be easterly in the morning and south-westerly in the afternoons.

3.3 Geology

The Egerton locality comprises four distinct geological formations which are associated with various origins (Gozzard, 1986) (Figure 8). The north and mid-western section of the property has areas of peaty clays which are dark grey and black with variable sand content. These two areas are of lacustrine (wetland) origin and were formed in the Holocene (less than 10,000 years before present).

To the north and south of the peaty clays on the western half of the property is Bassendean Sand which is very light grey at the surface and yellow at depth. The sand is fine to medium grained, with subrounded, moderately well sorted quartz. This formation is of aeolian origin.

Associated with these sands is another formation which consists of a thin veneer of Bassendean Sands over the Guildford Formation. In this case, the Guildford Formation consists of pebbly, strong brown silt. Also present are fine to occasional coarse-grained, subrounded laterite quartz with heavily weathered granite pebbles. Quartz sand is present and is fine to medium grained and of alluvial origin.

The north-eastern sector of the locality consists of the Guildford Formation (as described above) without the Bassendean Sand veneer. The Guildford Formation derives from river (alluvial) sediment deposits which are associated with Ellen Brook and the nearby Swan River.

3.4 Geomorphology

Egerton is situated approximately 5km west of the Darling Scarp on the Swan Coastal Plain. This plain is an undulating lowland bounded to the east by the dissected uplands of the Darling and Dandaragan plateaus and to the west by the Indian Ocean.

The main geomorphic features that make up the Swan Coastal Plain are aligned sub-parallel to the present coastline. The most easterly of these is the Ridge Hill Shelf, which is a series of laterite covered spurs forming the foothills of the Darling Scarp (McArthur, 1976). There is then a series of dune systems which extend westward to the coast. The easternmost is the Bassendean Dune System, then the Spearwood Dune System, and closest to the coast the Quindalup Dune System.

The Egerton property is located on the eastern margin of the Bassendean Dune System.

There are three distinct geomorphic units present at Egerton. These units are illustrated in Figure 9 and include:

- Bassendean Dunes: a geomorphically degraded surface of aeolian origin.
- Alluvial Flood Plains at the north-east of the property. These are associated with drainage lines which run from damplands in the north-western portion of the property to Ellen Brook.
- Lacustrine marshes in interdunal swales which are situated in the north to mid-western part of the property. These areas are associated with damplands.

3.5 Topography

The most elevated area of the property is along the north-western boundary at 61m AHD (Figure 10). The western third of the property is dominated by prominent ridges with slopes generally between 3° and 10° but steeper in some places. The ridge lines generally run north to south with undulations forming swales between the dunes. To the east, the topography is less steep with slope of 0° to 3°. The elevation drops gradually to between 25 and 16m AHD at the eastern boundary.

3.6 Groundwater

The Bassendean Sand Formation, which is the dominant surface geological unit at Egerton, contains groundwater. This groundwater is referred to as a shallow or superficial aquifer and it has formed, and is replenished by, infiltration of rainwater.

The superficial aquifer under Egerton is a component of a much larger groundwater system which underlies the Bassendean Sand Formation on the Swan Coastal Plain between the Swan River northwards to near Gingin Brook. This very large aquifer is known as the Gnangara Mound, a large part of which is a major source of public water supply for the Perth Metropolitan Region. Active and potential water supply areas are

defined on the Gnangara Mound by the Water Authority of Western Australia (WAWA) and specific requirements are imposed on land use within these areas.

The Egerton property is located within the defined Swan Groundwater Area and is to the east of the Mirrabooka Public Water Supply Area. While the Swan Groundwater Area is not a designated Public Water Supply Area, WAWA nevertheless requires groundwater and surface water management strategies within this area to be evaluated on the basis of their potential regional impact on the groundwater system and the environment.

As the Mirrabooka Public Water Supply Area is to the west of Egerton and the groundwater flow in the Gnangara Mound is from west to east (see Figure 11), there is no possibility that urbanisation will have any effect on the Public Water Supply Area.

In 1992, a draft policy, referred to as the Environmental Protection (Gnangara Mound Private Land Groundwater) Policy 1993, was established by the EPA to protect groundwater supplies of the private land portion of the Gnangara Mound from pollution. The Egerton property is located outside of this policy area.

The surface of the groundwater (i.e. the water table) under Egerton is at a variable depth below the ground surface depending on the surface topography. For example, in the north-west corner of the Egerton property, ground surface elevations may be in the order of 50m AHD while the water table is at about 40m AHD. In the south-east corner of the property the ground level is 25m AHD while the watertable is at about 20m AHD. As the groundwater results from rainfall, the water table fluctuates by about 1 to 1.5m according to the season, with peak levels from September to October and minimum levels from April to May.

The thickness of the aquifer (i.e. the saturated zone within the sand) is about 10m.

As the water table levels become progressively lower across the property from west to east the groundwater flows "downhill" towards the eastern side of the property and Ellen Brook (Figure 11). Some groundwater "leaks" to a lower geological formation (the Marine Sands) and some groundwater also leaks upwards from this lower deposit into the superficial aquifer.

3.7 The "Mound Springs"

Some public submissions to the Ellenbrook Public Environmental Review (PER) drew attention to the presence of a "mound spring" on the Egerton property as did the Ellenbrook Conservation Group in discussions associated with this CER. The EPA also specifically referred to the spring in its Assessment Report on the Ellenbrook PER.

Mound springs derive from deep aquifers and deposit materials over time on the surface which forms a characteristic prominent mound above the surrounding land.

The location of the spring was said to be in the north-west sector of the Egerton property. In the course of studies associated with the present CER however, the entire property was closely inspected and no evidence of a mound spring was found.

A notable seepage area is located near the sumpland in the north-west sector of the property. It may be that the term mound spring has been used to refer to this seepage of water associated with the Gnangara Mound rather than with a true mound spring. It is assumed therefore that the water seepage in the north-west sector is the spring which has been referred to previously.

The results of an assessment of the seepage area by the Geological Survey of Western Australia indicates that the water is relatively recent (aged 90 years) and that it has a chemical signature which reflects this age (i.e. a low pH, salinity, alkalinity, temperature, and high dissolved carbon dioxide content) (see Appendix 2). In contrast, groundwater sampled from the Leederville Formation aquifer at a depth of about 200m below ground level, had an age of 12,700 years and a mature chemical signature shown by moderate salinity, alkalinity and temperature, and low dissolved carbon dioxide content. The assessment concluded that the groundwater flowing from the seepage area originates from relatively young shallow groundwater within the Bassendean Sand aquifer to the west known as the Gnangara Groundwater Mound. Groundwater discharge from this aquifer results in seepage where the contact between the Bassendean Sand and underlying clayey Guildford Formation is exposed. This type of seepage is common in the Swan Valley area in areas of low elevation.

3.8 Wetlands

The wetlands of the Swan Coastal Plain have been classified into related or consanguineous suites by Semeniuk (1988) on the basis of their geomorphic setting. Two separate groups of wetlands on the Egerton property have been identified:

- The Ellen Brook Suite, and
- The Muchea Suite.

The Ellen Brook Suite comprises very small creeks meandering across a floodplain, which formed as a result of fluvial incision and surface runoff. This creek system is the natural surface drainage to Ellen Brook and is of particular importance in the proposed urban drainage scheme.

The Muchea Suite are small to medium scale sumplands and floodplains which occur along depressions at the base of the Bassendean Dunes, and at the headwaters of the tributaries of creeks.

The wetlands at Egerton also have been mapped by the Western Australian Water Authority for the compilation of the Wetland Management and Conservation Estate Map Series (1993) (Figure 12). While there are a series of distinct 'swamps' on the site and the remainder has the appearance of farmland, two-thirds of property is shown as wetlands of various types and significance on this map. In particular, the map indicates that a chain of sumplands (seasonally inundated basins) occurs in the western section of the property, and a palusplain (seasonally waterlogged flat) covers the majority of the property to the east of the sumplands. These wetlands are the Muchea Suite identified above.

As part of the present assessment each of these wetland areas were investigated. This investigation indicated that one area shown as a sumpland on the WAWA map is actually

a palusplain. This area is in the south-west sector adjacent to the western boundary. The wetland map shown in Figure 12 therefore has been modified accordingly. There are also indications that peat has been extracted in the past from one of the sumplands located in the western central sector of the property.

The wetlands are typical of the eastern margin of the Bassendean Dunes in this region and of the associated Gnangara Groundwater Mound and are a subset of a wetland system which extends a considerable distance north of Egerton. This is illustrated in Figure 13.

None of the wetlands on the property are within areas identified in the System 6 Study Report of the EPA (Department of Conservation and Environment, 1983) or in the Environmental Protection (Swan Coastal Plain Lakes) Policy, 1991.
The sumplands on the property can be classified in the Resource Enhancement category in terms of the management strategies referred to in EPA Bulletin 374 - A Guide to Wetland Management in Perth (1990). This category includes wetlands that have been modified to some degree and have no clearly recognised human uses. The management objectives for resource enhancement are to maintain and enhance the existing ecological functions of the wetlands. Opportunities may exist, however, for commercial development to enhance the conservation values of wetlands (ie. the wetland resource) in this category and development may be recommended for approval by the EPA provided that:

- The wetland function is retained within the development, or

- An equivalent area of wetland of a similar type is constructed or rehabilitated to fulfil equivalent functions.

The EPA Bulletin 374 has recently been updated (Environmental Protection Authority, 1993). In terms of the revised classification system, the sumplands remain in the Resource Enhancement Category in terms of their general attributes but some also can be included in the High Conservation Category as a result of the presence of a rare and endangered species, the Southern Brown Bandicoot (*Isoodon obesulus*). Further information on this species is provided in Section 3.13

The palusplains on the Egerton property are categorised as Multiple Use in terms of Bulletin 374 and its update, indicating that they have been significantly degraded, and possesses few natural attributes. They are therefore considered to be of limited human interest. Despite this, management objectives need to be considered in the context of catchment and land use planning (especially drainage, nutrient enrichment, surface and groundwater pollution).

3.9 Surface Water Flows

Surface water and shallow groundwater flows into Ellen Brook from the Egerton property. While the groundwater flow is a component of a larger regional system as described in Section 3.6, the surface flows all originate entirely on the property. The Egerton property therefore is a discrete surface subcatchment of Ellen Brook.

The entire catchment area of Ellen Brook covers approximately 640km^2 and is located from just west of the Darling Scarp between Gingin and Upper Swan, to just south-east of

Egerton where the brook joins the Swan River (Waugh & Ng, 1987). About 65% of the catchment area has been cleared, mainly for sheep and cattle grazing but also for vines and orchards. The townships of Bullsbrook and Muchea (including the TiWest Mineral Sands processing plant) are within the catchment area.

The Egerton property essentially is a micro-cosm of the total Ellen Brook catchment. It covers an area of 495ha (or 0.8% of the total catchment area), and mostly comprises pasture used for cattle and sheep grazing and pine plantations, but with some remnant vegetation.

Although the volume of water in Ellen Brook and flowing from Egerton varies from year to year depending on rainfall and other factors, estimates of annual flows are available in, or can be derived from, the report of Deeley et al (1993). These authors estimated the total discharge from the entire catchment of Ellen Brook during the period 1987 to 1992 to be in the order of 37 million m^3/yr or 556m^3/ha/yr.

As the area of Egerton is 495ha, the discharge from the property in the same period therefore can be estimated at approximately 275,220m^3/yr.

3.10 Surface Water Quality

Information on water quality can be derived from Deeley et al (1993). These authors document the average total load of nutrients in Ellen Brook and the export rate from each hectare in the catchment as listed in Table 4.

TABLE 4

AVERAGE NUTRIENT LOADS IN ELLEN BROOK AND EXPORT RATES FROM THE ELLEN BROOK CATCHMENT AREA (1987-1992)

	LOAD (tonnes/yr)	EXPORT (kg/ha/yr)
Total Nitrogen	77	1.16
Soluble Reactive Phosphorus	19	0.29
Total Phosphorus	26	0.39

Using the above export rates, the load of nutrients discharged each year from Egerton in the period 1987-1992 can be estimated at:

- Total Nitrogen 495ha x 1.16kg/ha = 574.2kg
- Soluble Reactive Phosphorus 495ha x 0.29kg/ha = 143.55kg
- Total Phosphorus 495ha x 0.39kg/ha = 193.05kg

However, the data collected by Deeley et al. (1993) suggests that the export rates of nutrients from Egerton actually were lower in 1992 compared to the Ellen Brook catchment north of Egerton.

GB Hill & Partners (1992) in the drainage and groundwater management study for the Ellenbrook Public Environmental Review, assume that the phosphorus export from active rural areas is 0.019kg/person/yr plus 4kg/ha/yr. For present purposes the rate of 4kg/ha/yr may be used to calculate a possible load from Egerton. As approximately 50% (or 247.5ha) of the Egerton property can be classified as active rural, the load would be 247.5ha x 4kg/ha = 990kg. This load is considerably larger than that estimated in the empirical study of Deeley et al (1993) and it would appear therefore that the assumptions made by GB Hill & Partners (1992) are very conservative.

The actual application rates of fertilisers on the Egerton property are listed in Table 5. The study by Deeley et al (1993) indicates that the majority of the fertiliser applied at Egerton is effectively taken up by vegetation and that relatively little is exported.

TABLE 5

FERTILISER APPLICATION AT EGERTON FARM

Fertiliser	Location	Application	%P	%N	Annual P Load (tonnes)	Annual N Load (tonnes)
Superphosphate	Whole property (except pines)	80t per year	21	-	16.8	-
Superphosphate + trace elements	Whole property (except pines)	80t per 3 years	21	-	5.6	-
Superphosphate	Irrigated pastures & lawns	40t per year	21	-	8.4	-
Agras	Irrigated pastures & lawns	12t every 6 weeks in summer	7.6	17.5	2.7	6.3
Urea	Irrigated pastures & lawns	12t every 6 weeks in summer	-	46	-	16.6
Complete	Lawns	5t every 12 weeks	1.8	12.3	0.4	2.5
Poultry litter	Lawns	10t per year	1	1	0.1	0.1
					34.0	25.5

3.11 Land Capability

Land capability assessments have been developed by soil and agricultural scientists to provide an indication of the ability of sites to sustain different land uses given the physical features of those sites. For example, a site which is prone to waterlogging in its natural condition will be classified as having low capability for house construction.

It is emphasised however, that this does not mean that houses should not be built on such sites. Rather, the land capability assessment indicates the natural features of the site that need to be managed or modified to make that site suitable for the proposed land use. Thus, in the above example, a site which is subject to waterlogging may be made suitable for house construction by appropriate filling, drainage and other measures.

A land capability assessment for the Shire of Swan has been prepared by McArthur (1985). This assessment includes the Egerton property. In addition, the Department of Agriculture is currently undertaking the Metropolitan Regional Soils Project which will include soils information on the rural areas on the outskirts of Perth. These two sources have been combined to produce the land capability map for Egerton shown in Figure 14.

The soils on the western side of the property belong to the Jandakot, Gavin and Joel Units, which are all Bassendean Sands. The Jandakot unit (Ja) predominates, and the soil is an iron podzol with a grey surface, an almost white subsurface and a yellow sandy subsoil at 1 to 2m.

Seasonal swamps (Ws), which are depressions that contain free water in winter, occur in the south western half of the property within the Jandakot unit. These seasonal swamps are characterised by humus podzols and peats.

The Joel unit (J), which often has a peaty surface and a black indurated hardpan, covers a small area in the south-west corner of the property. The Gavin (1) unit is an iron-humus podzol with a dark grey subsurface, and a dark brown, sometimes indurated, subsoil. There may also be iron concretions in the subsoil. This unit forms a small pocket at the southern end of the property.

A Drainage Line (DL) unit dissects the Jandakot unit at the base of the property and partially encloses the Gavin unit. Drainage Lines are characterised by broad shallow canals and peaty soils.

The remainder of the Egerton property is dominated by the Yanga unit (Ya), interspersed with pockets of the Jandakot unit (Ja), along the north to north-eastern edge of the property. The Yanga unit is characterised by variable soil types, and includes shallow sand over heavy clay, shallow sand over limestone, and deep sand.

Karrakatta sands (Ks) which are of aeolian origin, are deep sands with grey sand and organic matter to a depth of 30cm over yellow sand. These sands are found in the south-eastern corner of the property.

A small area of Muchea sand (Mus) occurs along the south eastern boundary of the property. Muchea sands are deep, light grey sands and are also of aeolian origin.

3.12 Flora and Vegetation

3.12.1 Introduction

The native vegetation on Egerton has largely been cleared with most of the sand ridges occupied by a pine plantation and much of the plain used for agricultural purposes. The

remaining native vegetation belongs to the Southern River Vegetation Complex as mapped by Heddle et al, (1980). This unit typically consists of open woodlands of Marri-Jarrah and *Banksia* species with fringing woodlands of Flooded Gum - Paperbark along creek beds. The *Banksia* Woodland in the north-west corner of the site is more closely aligned to vegetation of the Bassendean Complex North which abuts the property to the west.

A survey of the remnant native vegetation was undertaken in spring and early summer of 1993 with the aim of compiling a flora list and a vegetation map for this CER.

3.12.2 Methods

No previous flora or vegetation surveys have been undertaken at Egerton. Therefore a thorough field survey was initiated in September 1993.
Records of rare and priority species known to occur or likely to occur in the area were provided by CALM. In addition, advice was sought from CALM botanists familiar with the flora of the region.

The Flora and Vegetation report prepared by Weston et al, (1993) for the Ellenbrook Estate was used extensively in assessing the significance of the Egerton results.

Plant nomenclature follows that of Green (1985) in the Census of the Vascular Plants of Western Australia. The Priority flora were assessed using the most up to date list published by CALM (28 October 1992). Vegetation descriptions use the system of Beard as adapted by Aplin (1979).

3.12.3 Flora

(a) Flora Recorded

A total of 159 native species have been recorded in the Egerton property (Appendix 3). This total is comprised of 1 fern species, 1 Gymnosperm, 43 Monocotyledons and 114 Dicotyledons. The families represented by the most species include the Pea family (Papilionaceae - 21 species), Myrtle family (Myrtaceae - 19), Proteaceae (11), Orchid family (Orchidaceae - 9) and Heath family (Epacridaceae - 9).

The total number of 159 species is low compared to nearby Ellenbrook Estate (427 species), Melaleuca Park (at least 300 species) and Whiteman Park (at least 250 species) (Weston et al, 1993). The low number of species is considered to be related to the small area (approximately 106ha) of native vegetation remaining.

The distribution of the species according to habitat types (i.e. dryland, transitional, wetland), shows that the dry upland areas support more species (98 species) than the areas influenced by high water tables (53 species) and the fringing areas in between (24 species). Only one species, *Eucalyptus marginata,* was found in all three categories, although it does not occur where water is above ground level.

(b) Significant Species

No Declared Rare Flora species have been recorded at Egerton. Two species currently listed on the CALM Priority List occur on the property. *Aotus cordifolia* and *Conostephium minus* are Priority 3 species which means that they have several poorly known populations with some on conservation lands.

Aotus cordifolia is a straggling shrub that occurs in swamps on the Coastal Plain and Darling Range in the Perth Region from Ellenbrook Estate south to Dwellingup. At Egerton, the species occurs abundantly in the swampy areas. The largest population of hundreds, if not thousands, of individuals is located in the northern wetland under an *Agonis linearifolia* Scrub.

Conostephium minus is a much branched shrub up to 50cm high that occurs in sandy soils on the Coastal Plain from near Perth to Gingin. It extends outside this area north to Badgingarra. At Egerton, *Conostephium minus* has been located in two small populations in *Banksia attenuata* Low Woodland on dry sandy soil.

3.12.4 Vegetation

(a) Vegetation Recorded

A vegetation map for Egerton and a map of vegetation quality are provided in Figures 15 and 16 respectively. A total of 24 vegetation associations was recorded from the property (see Appendix 4).

The diversity of vegetation types is influenced predominantly by the relationship to groundwater levels.

The dry upland areas in the north-west corner of the property contain *Banksia attenuata/B. menziesii* Low Woodlands. *Eucalyptus todtiana* (Prickly Bark) is also present but not in such large numbers as to be co-dominant with the Banksias. The understorey of the dry *Banksia* Low Woodland consists of a Low Open Heath dominated by *Scholtzia involucrata, Eremaea pauciflora* and *Hibbertia hypericoides*.

Towards the bottom of the sand dunes the Banksia Low Woodlands give way to *Eucalyptus calophylla* (Marri) Woodlands and *E. marginata* (Jarrah) Woodlands with a sub-canopy including *Banksia grandis* (Bull Banksia), *B. ilicifolium*, and *Adenanthos cygnorum* (Woolly Bush). The shrub layer under the *Eucalypt* Woodlands is generally quite sparse with *Hibbertia hypericoides* common and a larger number of hardy liliaceous species such as *Xanthorrhoea preissii, Dasypogon bromeliifolius, Patersonia occidentalis* and *Phlebocarya ciliata*.

Downslope from the *Eucalyptus* Woodland and *Banksia* Low Woodlands, the vegetation changes usually fairly abruptly to *Melaleuca preissiana* (Moonah Paperbark) Low Open to Low Woodlands and a variety of Closed Heath and Scrub vegetation types. Areas that were dry at the time of survey but which had the water table close to the surface are dominated by *Pericalymma ellipticum* and *Astartea fascicularis* Closed Heath, often in association with *Hypocalymma angustifolium*. Some Heath areas also have scattered *Melaleuca preissiana* trees in a Low Open Woodland formation over the Closed Heath.

Pteridium esculentum (Bracken fern) is also common around the fringes of the *M. preissiana* Low Woodlands.

In one area only, *Eucalyptus rudis* (Flooded Gum) forms an Open Forest over a dry *M. preissiana* Low Woodland.

In areas where the water table was at or just above ground level during the survey the understorey of the *Melaleuca preissiana* Low Woodlands is dominated by *Agonis linearifolia* and *Juncus pallidus*. Towards the northern part of the property *Banksia littoralis* and *Eucalyptus rudis* are also dominant with *M. preissiana* in a Closed Forest type formation which is so dense in part as to preclude the development of much understorey.

Several areas of permanently wet drainage lines or seepage areas exist along the eastern part of the wetlands on the plain. These areas support *Melaleuca rhaphiophylla* (Swamp Paperbark) instead of the *M. preissiana* that occurs on drier swamp soils. The *M. rhaphiophylla* is present as a Low Closed Forest, often with *Eucalyptus rudis*. The understorey of these areas is limited due to the dense tree canopy, but occasionally includes stands of *Baumea articulata* and *Juncus pallidus*.

One large stand of *Baumea articulata* (Jointed Twig Rush) Sedgeland occurs in the central wetland within the Bassendean dunes. This area was reportedly excavated for peat more than 20 years ago. The surface level of the wetlands is now lower than normal and therefore is inundated to deeper levels and for longer periods than would have existed prior to removal of the peat. The *Baumea articulata* Sedgeland may not have been there previously and may have colonised the area following the altered hydrological regime.

Significant areas of palusplain have been severely impacted upon by grazing. These areas consist of *Melaleuca preissiana* Low Woodlands over an understorey almost entirely of *Juncus pallidus* and introduced pasture species. Further degradation of these areas has resulted in large areas of *Juncus pallidus* Sedgelands with the tree canopy completely removed.

One small area of *Acacia saligna* Low Woodland over *Agonis linearifolia* Open Heath occurs towards the southern part of the site. While other small stands of *Acacia saligna* occur between wetland areas and pine plantations, it is not clear whether these are natural associations or a part of the buffer rows of native trees planted around the pine plantation.

(b) Vegetation Condition

Most of the native vegetation at Egerton has been cleared or is in a severely degraded condition (Figure 16). The main areas considered to be in a near natural condition or to have a low degree of disturbance include the Banksia and Eucalypt Woodlands in the north-west corner and three wetland areas in the north-west, west and central west parts of the property. A narrow zone of Paperbark and Marri woodland in poor condition links the two wetland areas at the base of the dunes.

Other areas containing native vegetation have been disturbed by partial clearing of either the understorey (e.g. remnant Paperbark stands and drainage lines) or tree canopies (e.g.

Juncus Sedgelands) to assist grazing by cattle and sheep. As a result, these areas have an abundance of introduced pasture species.

The areas of good quality remnant vegetation are protected from stock grazing by a network of fences.

One small area was identified which has signs consistent with the presence of dieback caused by *Phytophthora cinnamomi*. The small pocket of Jarrah and *Banksia* woodland on the southern edge of the north-west wetland contains stag-horned Jarrah trees, dead *Banksia* trees and dying *Xanthorrhoea preissii* shrubs. A few other areas exist which have dead *Banksia* trees, however there are no additional signs which would indicate infection by dieback.

(c) Regional Significance

An assessment of the significance of the remnant vegetation at Egerton needs to consider the following points:

- Presence of rare, priority or unusual species,
- Diversity of native flora,
- Presence of unusual vegetation types,
- Representation of flora and vegetation in conservation reserves,
- Value of the area as a fauna habitat and/or wildlife corridor, and
- Condition of the vegetation.

While the area does not contain any known populations of Declared Rare Flora, the wetland heaths and Paperbark Woodlands and Forests contain possibly the largest known population of the Priority 3 species *Aotus cordifolius*.

The site does not have a high number of native species compared to the Ellenbrook Estate, Melaleuca Park, or Whiteman Park. This is due to the small area of native vegetation remaining and the low percentage of this which is species rich *Banksia* woodland. Only 6 of the 158 native species at Egerton have not been found at Ellenbrook, with 3 of these 6 possibly just differences in plant identification. Therefore only 3 species at Egerton, *Verrauxia reinwardtii*, *Burtonia conferta* and *Daviesia divaricata* do not occur at Ellenbrook. None of these species are considered rare or endangered, and all are represented in conservation reserves.

While a rigorous comparison of the vegetation at Egerton with other nearby areas has not been made it can be concluded that the vegetation types at Egerton are similar with regards to floristic composition to those at Ellenbrook.

Moreover, all of the associations are represented on the Ellenbrook Estate within the proposed conservation area (Weston et al, 1993). Conversely, particular associations considered to be important at Ellenbrook also occur at Egerton, namely:

- *Melaleuca preissiana* Low Woodland over *Agonis linearifolia* Closed Heath
- *Eucalyptus calpohylla* (Marri)/*M. preissiana* Woodland, and
- *Acacia saligna* Low Woodland.

TABLE 5

NUMBER OF FAUNA SPECIES RECORDED IN FIVE MAJOR HABITAT UNITS ON THE EGERTON PROPERTY

Habitat	Number of Native Species Recorded					
	# Traps	Frogs	Reptiles	Birds	Mammals	Total
Pericalymma Heath	18	3	0	4	2	9
Pinus Woodland with some native vegetation	16	1	3	9	1	14
Melaleuca Forest	35	3	3	6	3	15
Banksia/Eucalyptus Woodland	38	2	2	12	2	18
Juncus Sedgeland	10	2	0	-	2	4
Farmland	-	-	-	20	1	21
Ornamental Lake	-	-	-	9	-	9
Mill Pond	-	-	-	6	-	6

The vertebrate fauna is typical of the region and comprises a sub-set of that found in surveys of Whiteman Park and at Ellenbrook. A smaller number of species has been recorded at Egerton to date compared to these other localities, probably as a result of the smaller area and less diverse habitats at Egerton and differences in survey time.

Nevertheless, 3 species recorded at Egerton are of interest for various reasons. The Burrowing Frog (*Heleioporus inornatus*) generally occurs in the Darling Range from Chidlow, south of the vicinity of Nannup, and east to Walpole and Mt Barker. Its occurrence at a site on the Swan Coastal Plain is unusual, however Egerton is relatively close to the escarpment of the Darling Range.

The Honey Possum (*Tarsipes rostratus*) was recorded in *Melaleuca* Woodland at Egerton. This species is seldom recorded in the Perth Metropolitan Region but does occur at the nearby Whiteman Park. It is not classified as rare or endangered.

The Southern Brown Bandicoot (*Isoodon obesulus*) was recorded at Egerton in all major habitats surveyed except for the pine plantations. However, they appeared to be restricted to areas within and surrounding wetlands possibly as a result of the denser cover in these areas. A total of 9 individual Bandicoots were captured during the survey.

The Southern Brown Bandicoot is a ground dwelling marsupial about the size of a small cat. The species has a relatively extensive distribution across southern Australia but is most abundant in the south-west of Western Australia, and in Victoria and Tasmania. In Western Australia there is concern that the species may be declining as a result of continuing loss and predation pressures primarily due to the introduced European Fox

(*Vulpes vulpes*). This concern has led to the species being gazetted as rare and endangered under the provisions of the Western Australian Wildlife Conservation Act, 1950-1979.

3.14 Cultural Significance

3.14.1 Aboriginal Sites

A specific archaeological and ethnographic survey of the Egerton property has been made in accordance with the provisions of the Aboriginal Heritage Act, 1972-1980 and to provide information for this CER and for the development of the Structure Plan (McDonald Hale & Associates, 1993).

The ethnographic survey included consultation with 11 Aboriginal informants. These informants identified 3 areas of significance to Aboriginal people. Two of these were camp sites used until the 1950's on a seasonal basis. Both of these camp sites are associated with one of the sumplands.

A Waugal or Rainbow Serpent Dreaming Track was also identified by one informant. This track runs westward along one of the small tributaries of Ellen Brook which crosses the Egerton property. All of the informants however, indicated that the Waugal is associated with all areas of freshwater.

The archaeological survey located a single site which comprises a sparse scatter of stone artefacts. This was located adjacent to one of the sumplands and close to the camp sites identified.

3.14.2 European Sites

There are two recognised sites of European cultural significance on the Egerton property but both are outside of the urban deferred zone. One of these is the house and associated buildings generally known as Henry Bulls Cottage. This is located on the eastern bank of Ellenbrook. The other site is a pond which is located on one of the streamlines which cross the Egerton property a short distance from Ellen Brook. This pond was constructed at about the same time as the farm complex on the opposite side of the river. Both of these sites date from the early period of occupation of the Swan River colony.

4. ENVIRONMENTAL IMPLICATIONS AND MANAGEMENT

4.1 Introduction

The environmental description of Egerton presented in Section 3 of this CER indicates a number of features which are relevant to the urban development proposal. The most important of these features are hydrological in nature and are:

- the defined wetlands or swamps are their associated natural vegetation and fauna habitats.
- the drainage lines and dams leading to Ellen Brook, and
- the damplands in various parts of the property which are currently developed for pasture but which will require drainage and/or fill to make them suitable for development.

The implications of urban development in terms of possible effects on the underlying groundwater (and the surface wetlands which are expressions of the groundwater), and on the quantity and quality of surface water flowing into Ellen Brook and on to the Swan River also need to be considered.

Essentially, these principal issues have been addressed through the preparation of an environmentally sensitive urban development proposal which will be combined with a drainage management plan specifically designed to ensure preservation of the major wetlands and their habitats, and acceptable drainage outflows to Ellen Brook.

These and other issues are discussed in detail below.

4.2 Topography

The development of properties for urban purposes can involve significant modification of existing topography due to earthmoving required for roads, housing lots, etc. In the present case however, the structure plan has been designed specifically to take account of the main existing topographical features and to minimise earthworks.

In particular, the western ridge on the property is considered to be an asset as it will provide future residents with views to the east across the Swan Valley to the escarpment of the Darling Range. The elevation and general slope of the ridge therefore will be maintained.

Major roads in the Egerton proposal also have been located specifically to minimise disturbance to the western ridge and to the wetlands at the base of that ridge. The main south to north road is located well to the east of the ridgeline on a relatively level section of the plain. The main east to west road is aligned in a depression or valley in the western ridge both to reduce the need for earthworks and to reduce the prominence of the road in the landscape. This alignment also enables the road to cross the south to north linear wetland chain at a narrow and significantly disturbed location. Most of this wetland chain will be preserved within Public Open Space (POS) (see Section 2.3).

These road alignments are considerably different from earlier proposals. In earlier plans the roads traversed the western ridge and wetland chain and their construction would have involved considerable environmental modification and damage.

Significant earthworks will be required, however, for certain parts of Egerton. In particular, some low lying areas will need to be filled to provide a suitable surface and depth of soil for the development of houses and the installation of services. The areas requiring fill correspond to parts of the Yanga, Seasonal Swamp, Drainage Line, and Joel land use capability units described in Section 3.11.

The areas involved include seasonally inundated sumplands and seasonally waterlogged palusplain areas in the south and south-west sectors of the property and much of the extensive palusplain in the central east and north-east sectors. Virtually all of these are currently used for agricultural purposes and consist of pasture with remnant trees. The filling therefore has minor implications for the existing environment.

4.3 The Wetlands

In strictly scientific terms, considerable areas of the Egerton property are classified as wetlands (see Section 3.8 and Figure 12). Much of these wetlands however, comprise land which is waterlogged in winter (ie. the palusplain areas) and which is currently used to provide grazing pasture. There is very little natural vegetation on these seasonally waterlogged areas and they provide no significant fauna habitat. The filling of most of these areas therefore is not considered to have important environmental implications.

The second group of wetlands on the Egerton property comprises seasonally inundated sumplands and seasonal creeks.

The sumplands are located within, and at the eastern base of, the western ridge area and mostly support *Melaleuca* forest and other wetland vegetation of good quality and high aesthetic appeal.

The sumplands are considered to be the primary environmental asset of the Egerton property and therefore they substantially have been included within POS. The Structure Plan also includes a series of open ponds within the POS system which are intended to increase the variety of niches or habitats available to waterbirds and other aquatic fauna and to provide more landscape diversity and aesthetic appeal in the POS system. The ponds will be located so that there is no need for disturbance of the best swamp paperbark areas.

This system of ponds also will serve a drainage management function.

The seasonal creeks at Egerton cross the palusplain mainly in the north-east sector of the property and flow to Ellen Brook. In places the creeks have been dammed to provide water for agricultural purposes and at least one of these dams has heritage significance (see Section 3.14.2).

This creek and dam system will form the basis of the surface drainage network for the urban estate. The creeks will be modified as necessary for drainage purposes but

substantially will remain in their present state and alignment. The remaining natural vegetation along the creek lines and around the dam will substantially be left intact and will be supplemented by appropriate landscaping and further tree planting. The entire surface drainage network will form the basis of a linear system of POS that will eventually link to Ellen Brook. This network will also be integrated with the POS containing the high quality sumplands and will incorporate walking and bicycle trails and elevated boardwalks through some of the best quality paperbark areas.

4.4 Hydrological Issues

The management of groundwater levels and surface water runoff will be emphasised in the detailed design for the Egerton urban estate and a specific Drainage Management Plan is being prepared for this purpose. This plan will be based on a model of both the groundwater and surface water flows and will seek to minimise:

- adverse changes to water levels and water quality,
- changes to the water regime of the wetlands within the Open Space areas,
- changes to storm runoff peak flows entering Ellen Brook and the Swan River, and
- nutrient loads transported from the urban area by the drainage system.

The drainage scheme will be based on the broad principles established under the WAWA North-East Corridor Drainage Strategy as noted in Section 2.3.4 of this CER. In general, the surface drainage will be by conventional road gullies and underground pipes connecting to disposal basins located in Open Space areas. These will include the existing basins or dams in the creek lines. There also will be retention basins within the system to enable the control of runoff quantity and quality.

For the purposes of this CER, an estimate can be provided of the impact of urbanisation at Egerton on the quantity and quality of runoff compared to the existing land uses.

GB Hill & Partners Pty Ltd (1992) in an assessment of the Ellenbrook development, assumed that in flood events in urban areas 25% of total rainfall falls on impervious surfaces while 75% falls on pervious surfaces. Similarly, it is assumed that 90% of the rainfall falling on the impervious surfaces becomes run-off, i.e. 22.5% of the total rainfall. Runoff from pervious areas is assumed to be 12%, i.e. 9% of total rainfall.

Therefore, in total about 31.5% of the total rainfall during flood events in urban areas is assumed to be converted into run-off. By comparison, the run-off during equivalent events in existing non-urban conditions is considered to about 12% of the total rainfall.

In areas with no subsoil drainage, the remaining rainfall is lost due to evaporation, infiltration into the soil and transpiration (i.e. take up by plants). In areas with fill and subsoil drainage (which will be the case at Egerton) about 52.5% of the rainfall which is not converted directly to run-off is collected by the drains and the remainder is lost due to evaporation etc. Studies in progress for the preparation of a Drainage Management Plan for Egerton, suggest that this percentage is likely to be an overestimate.

In terms of water quality, phosphorus is of primary concern (Section 3.10). GB Hill & Partners Pty Ltd (1992) assumed that the population of urban areas at Egerton will be about 36 people/ha and the phosphorus load will be about 0.019kg/person/yr. In fact, the Structure Plan for Egerton provides for a maximum of about 25 people per hectare. The estimated phosphorus load at Egerton with these assumption therefore is 25 people x 495ha x 0.019kg/yr or 235kg/yr. This is likely to be an over estimate as it assumes total urban development of the Egerton property.

In comparison, the estimated present phosphorus loads to Ellen Brook from the Egerton property based on Deeley et. al. (1993) is about 193.05kg/yr. Therefore, the urban runoff if untreated may involve an increase in phosphorus output.

If this conclusion is supported by the more detailed studies that will form a component of the drainage management plan, the detention basins in the drainage system at Egerton will be lined with neutralised red mud which has a significant capacity to absorb phosphorus. It is estimated that this will achieve a 78% reduction in phosphorus output which, on the basis of the above figures, would mean 52kg of phosphorus export each year.

While it is not possible at this stage to present a more detailed account of nutrient export from Egerton, it is apparent from the information presented in this CER that there will be a substantial reduction in phosphorus export to Ellen Brook as a result of urbanisation and the associated more effective management of drainage.

However, while this will be a positive environmental benefit, the improvement of water quality flowing from Egerton and from the Ellenbrook Estate further east, is not likely in itself to cause a substantial improvement in water quality in Ellen Brook. This is because the present water quality in the brook does not appear to be substantially affected by nutrient exports from the lower catchment area as export rates from the remainder of the catchment are so high.

The total nitrogen levels in Ellen Brook in the period 1987-1992 were the second highest of 15 tributaries and drains of the Swan River System monitored by Deeley et al (1993). The total phosphorus levels were the highest of any recorded by a substantial margin. The average annual flow weighted concentration of total nitrogen was 1.97mg/L and the concentration of total phosphorus was 0.71mg/L. A high proportion of the phosphorus is in the soluble reactive form as noted above.

Furthermore, the nitrogen to phosphorus ratio is considered to be very low and this, together with the high loads, favour the growth of nitrogen fixing blue-green algae. While blue-green algae are considered to be a relatively unimportant component of the phytoplankton community in the upper Swan River at present, the nutrient ratio and loads in Ellen Brook are considered to pose a risk of encouraging increases in the blue-green algae populations.

The authors comment that there are several possible point sources for nutrients from Ellen Brook including sewage treatment plants and piggeries in the catchment.

Areas of *Melaleuca preissiana/Agonis linearifolia* occur in all three main wetland areas in good condition. They generally indicate the wettest phase of tolerance for *M. preissiana* compared to drier areas where *Pericalymma ellipticum* is dominant in the understorey.

The Marri - *M. preissiana* woodlands occur on the eastern margin of the wetland springs. They therefore tend to be in a disturbed condition due to partial clearing or from grazing pressures.

The *Acacia saligna* Low Woodland is a small, isolated stand which occurs towards the south-west of the property in a wetland palusplain largely cleared for grazing by sheep.

The diversity of vegetation types at Egerton is most noticeable in the north-west wetland or spring area where Closed Heaths and Low Closed Forests interchange within short distances. The variety of different formation types i.e., heath, woodland, forest, provides for a variety of fauna habitats as evidenced by the results of the fauna survey.

3.13 Vertebrate Fauna

A vertebrate fauna survey of the Egerton property was carried out by Alan Tingay & Associates in October 1993. The survey was designed to encompass the major habitat types on the property, and included pine plantation with an admixture of *Eucalyptus* spp., Heath, *Banksia* Woodlands, *Melaleuca* Woodland, and *Melaleuca* Forest.

Fifty species of indigenous (native) vertebrates were recorded during the survey including 5 species of frogs, 6 reptiles, 36 birds and 3 species of mammals. In addition, 4 introduced mammal species and 2 introduced bird species were encountered. A complete list of vertebrate species is provided in Appendix 5.

The largest number of vertebrate species was recorded on the farmland areas and included 20 species of birds and 1 mammal, the Western Grey Kangaroo (*Macropus fuliginosus*). The relatively high number of bird species reflects the diversity of habitats provided by open areas and remnant trees, and other vegetation.

The next largest number of native species was recorded in *Banksia* Woodland with 12 species of birds, 2 frogs, 2 reptiles and 2 mammals. Species number was relatively high also in the *Melaleuca* Forests associated with the sumplands (15 species), and in remnant native vegetation within the pine plantation (14 species). The distribution of fauna species according to the major habitat units is listed in Table 5.

4.5 The Seepage Area

The water seepage in the north-west sector of the property which has been referred to as a "mound springs" will be retained within Open Space and the proposed Drainage Management Plan will seek to ensure that the seepage continues.

4.6 Land Use Capability

As noted in Section 3.11, the land capability assessments for Egerton indicate that the certain areas of the property have low natural suitability for house and road construction and that fill and drainage measures will therefore be required in these areas. These requirements apply to the Yanga, Joel, Seasonal Swamp and Drainage Line land capability units.

The remaining land capability units (the Jandakot, Gavin, Muchea, and Karrakatta units) are considered to be suitable for house and road construction with the only potential problem being wind erosion of sand. Blown sand, however, is usually no more than a transient nuisance in the early stages of urban development on Bassendean Dune areas.

According to the Geological Survey 1:50,000 Environmental Geology Map Series (Gozzard, 1982), there appear to be few problems associated with road construction and excavation on the property, except in the peaty wetland areas. Possible problems may also occur with urban development in the southern area of the property, due to the potential for waterlogging and inundation. These areas will be filled prior to development as described above. There are few constraints to urban development in the northern section of the property, providing that the peaty swamp areas are avoided as is proposed.

4.8 Flora and Vegetation

4.8.1 Flora

The flora at Egerton is typical of the uplands and wetlands of the northern and eastern sectors of the Bassendean Dune Sands of the Swan Coastal Plain. The Structure Plan therefore has no significant implications in terms of conservation of the regional flora.

Within the property itself, most of the remnant vegetation is associated with the wetlands which will be substantially protected within open space. The flora of the *Banksia* and *Eucalypt* Woodlands in the north-west sector, however, will largely be removed. This flora is typical of these vegetation associations which are common in the region.

No declared rare flora occurs on the Egerton property but 2 Priority Three species, *Aotus cordifolius* and *Conostephium minus* are present. The *Aotus cordifolius* populations occur exclusively in the swampy habitats. As mentioned above, the wetlands where this species occurs at Egerton, are protected within Open Space in the Structure Plan. The small *Conostephium minus* populations will not be retained. However, local populations of *C. minus* will be protected in the Ellenbrook Estate conservation reserve.

4.8.2 Vegetation

Most of the areas affected by the residential components of the Egerton Structure Plan are currently substantially cleared of native vegetation or support pine plantations. Urban development of these areas therefore is considered to have no significance in terms of vegetation removal.

Of the remaining areas of natural vegetation, the sumplands and associated high quality vegetation are protected within public open space, which has been designed specifically for the conservation of vegetation and fauna habitat. Much of *Banksia* and *Eucalypt* Woodland in the north-west sector, however, would be removed. These woodlands are extensive in state forest and conservation reserves in the region, as well as in parts of the Ellenbrook Estate allocated for conservation purposes. They are not considered to be as important at Egerton as the protection of the wetlands and their associated vegetation.

It is recognised that the majority of vegetation associations which will be retained at Egerton are influenced by their relationship to the water table. Subtle differences in the degree of inundation or depth to watertable can mean the difference between a fringing eucalypt woodland, a Closed Heath or a Paperbark Forest. The relationship between the different associations and the water table fluctuations has not been quantified. However, it is evident that any shift in the hydrological balance which caused the wetlands to become drier or wetter in the long term would result in a change in vegetation and a decrease in the variety of vegetation types. A fundamental objective of the Drainage Management Plan therefore will be to minimise changes to the water regime of the wetlands in the Open Space areas (see Section 4.4).

4.9 Vertebrate Fauna

The vertebrate fauna at Egerton is typical of bushland and farmland areas of the Perth Metropolitan Region and more particularly of the local area. This is illustrated by the fact that virtually all of the species recorded by the vertebrate fauna survey have been recorded at Ellenbrook and Whiteman Park.

Given the extent of land allocated for conservation purposes at Ellenbrook, and the provisions for the protection of vegetation and fauna habitat at Whiteman Park, it can be concluded that the vertebrate fauna at Egerton is not significant in terms of regional conservation. Nevertheless, the fauna has local intrinsic significance and certain features of the Structure Plan have been specifically designed to promote the possibility that the majority of the vertebrate fauna species will continue to occur at Egerton following urban development.

In particular, the extent of natural vegetation that is proposed within Open Space in the Structure Plan represents a large proportion of the natural vegetation remaining on the property, as most of the area has been converted to farmland and pine plantations. This vegetation, and the wetlands it is associated with will continue to provide a variety of habitats for vertebrate fauna including frogs, reptiles, birds and mammals. The present diverse habitat for birds in the farmland areas also should continue to be provided through the relatively extensive areas of parklands and playing fields as well as on adjacent properties which are not likely to be developed for urban purposes.

The primary natural habitat that will be removed by the development will be the Banksia Woodland. At Egerton the extent of these woodlands is relatively limited but extensive areas will be protected at Ellenbrook, and in other parts of the northern Bassendean Dunes within State Forests and Conservations Reserves. The loss of this habitat at Egerton may cause a reduction in populations of bird species such as honeyeaters but all of the species currently present should continue to occur within the urban context.

The particular species of fauna at Egerton which requires special consideration is the Southern Brown Bandicoot as it is gazetted as a rare and endangered species. The vertebrate fauna survey indicated that the favoured habitat of bandicoots at Egerton is the relatively dense vegetation associated with the principal wetlands. This finding is consistent with other surveys of this species in the Perth Metropolitan Region which indicate that in localities where there are no active control measure for foxes, it prefers dense vegetation.

These wetland habitats at Egerton will be substantially retained within Open Space. There is the basis therefore, for the bandicoots to continue to exist on the property. There remains however, the question as to whether the bandicoot population can survive in the urban context given possible predation from cats and dogs, interference from human activities, and the possibility of habitat destruction due to an increased potential of fires.

There are two possible management strategies in this case. These are:

- To develop a specific management plan for the Southern Brown Bandicoot at Egerton with the objectives of protecting the species from predation and their habitat from damage. Such a plan would include specific fire control measures, signage and general education of the urban population, and possibly protective fencing of certain vegetation.

- Capture, removal and relocation of the local bandicoot population to secure conservation reserves.

Both of these strategies are currently being applied by land owners in association with the Department of Conservation and Land Management (CALM) at a number of localities within the Perth Metropolitan Region where urban development is occurring. The first alternative however, is experimental in the sense that the factors which may be relevant to the survival of bandicoot population in urban contexts are not known. Nevertheless, the species does occur in a number of urban areas where there are no specific management provisions designed to promote its survival (for example, in the foothills region). As the possibility of cat or dog predation is presumably high in these areas, it does not appear that predation pressures from domestic pets is necessarily a significant factor in the local survival of bandicoots. This suggests that the principal factor controlling survival may be the presence of absence of foxes together with the continued presence of suitable habitat.

It is considered reasonable therefore, to assume that there is a significant probability that bandicoots would survive at Egerton given specific management measures.

The second strategy above has proved to be successful to date and CALM has relocated bandicoots to recolonise conservation reserves where the species was formerly extinct. In these cases, the extinctions were considered to be the result primarily of predation by

foxes, and active fox control measures are in place to protect the new bandicoot populations.

Multiplex Constructions Pty Ltd will seek the advice of the Minister for the Environment in determining which of the above strategies will be applied. The Minister has the ability under the provisions of the Wildlife Conservation Act, 1950-1978 to determine measures for the protection of rare and endangered species.

4.10 Cultural Significance

4.10.1 Aboriginal Sites

The Aboriginal Heritage Act, 1972-1980 requires specific approval from the Minister for Aboriginal Affairs for the disturbance of any archaeological or ethnographic site. Any decision of the Minister in such cases is taken after advice is received from the Aboriginal Cultural Materials Committee. If approval is granted this may include a requirement to salvage the archaeological materials.

The Structure Plan for Egerton does not involve the potential for disturbance of the majority of the sites identified by the archaeological and ethnographic surveys including the stream associated with the Waugal. At least part of an archaeological site, however, would be affected. The proponent has considered the possibility of adjusting the Structure Plan at the detailed subdivision design stage to incorporate the whole site within open space. However, it is not likely that this measure would prevent incidental and continued disturbance of the site by users of the open space. Therefore, it is likely that an application will have to be made to disturb the site and to salvage the archaeological material if required.

4.10.2 European Sites

The features of the Egerton property that have European significance are outside of the area directly affected by the Structure Plan and will not be disturbed.

5. COMMITMENTS

Multiplex Constructions Pty Ltd, will:

5.1 Prepare management plans for the Open Space areas at Egerton which will have the objective to provide for the retention of the majority of the natural vegetation and associations of the Muchea Suite sumplands. The management plans will be prepared prior to final subdivision approval to the satisfaction of DPUD and the Shire of Swan.

5.2 Prior to the commencement of any major works, prepare a Drainage Management Plan for Egerton to the satisfaction of the EPA.

5.3 Seek advice from the Minister for the Environment on the preferred method for management of the Southern Brown Bandicoot population and prepare and implement a strategy based on that advice to the satisfaction of the Minister prior to development.

5.4 Comply with all requirements of the Aboriginal Heritage Act, 1972-1980.

6. CONCLUSIONS

The information presented in this CER suggests that the Structure Plan for the Egerton property in the Shire of Swan has no significant adverse environmental implications. This is primarily because the Plan takes into account the most important environmental features of the property and proposes that they become key community assets. In particular, the Structure Plan provides for the inclusion of the Muchea Suite sumplands, and their associated high quality vegetation and important fauna habitats, within Open Space. This major wetland Open Space system will eventually be linked to Ellen Brook along the natural drainage lines which cross the property and will incorporate a network of footpaths and cycleways.

In addition, in the preparation of the Structure Plan, careful attention has been paid to road alignments and the topography of the site in order to reduce the amount of earthworks required during the development phase.

Finally, the proponents recognise the importance of managing surface and groundwater in the urban context to ensure that the hydrological regime of the wetlands is maintained and that the quantity and quality of water discharged to Ellen Brook is environmentally acceptable. These issues will be addressed in a specific Drainage Management Plan which will be submitted to the EPA for its approval.

The proponents, Multiplex Constructions Pty Ltd, submit that the Egerton Structure Plan provides an example of the way in which a sensitive approach to environmental features in urban planning can provide an attractive and unique living environment for future residents.

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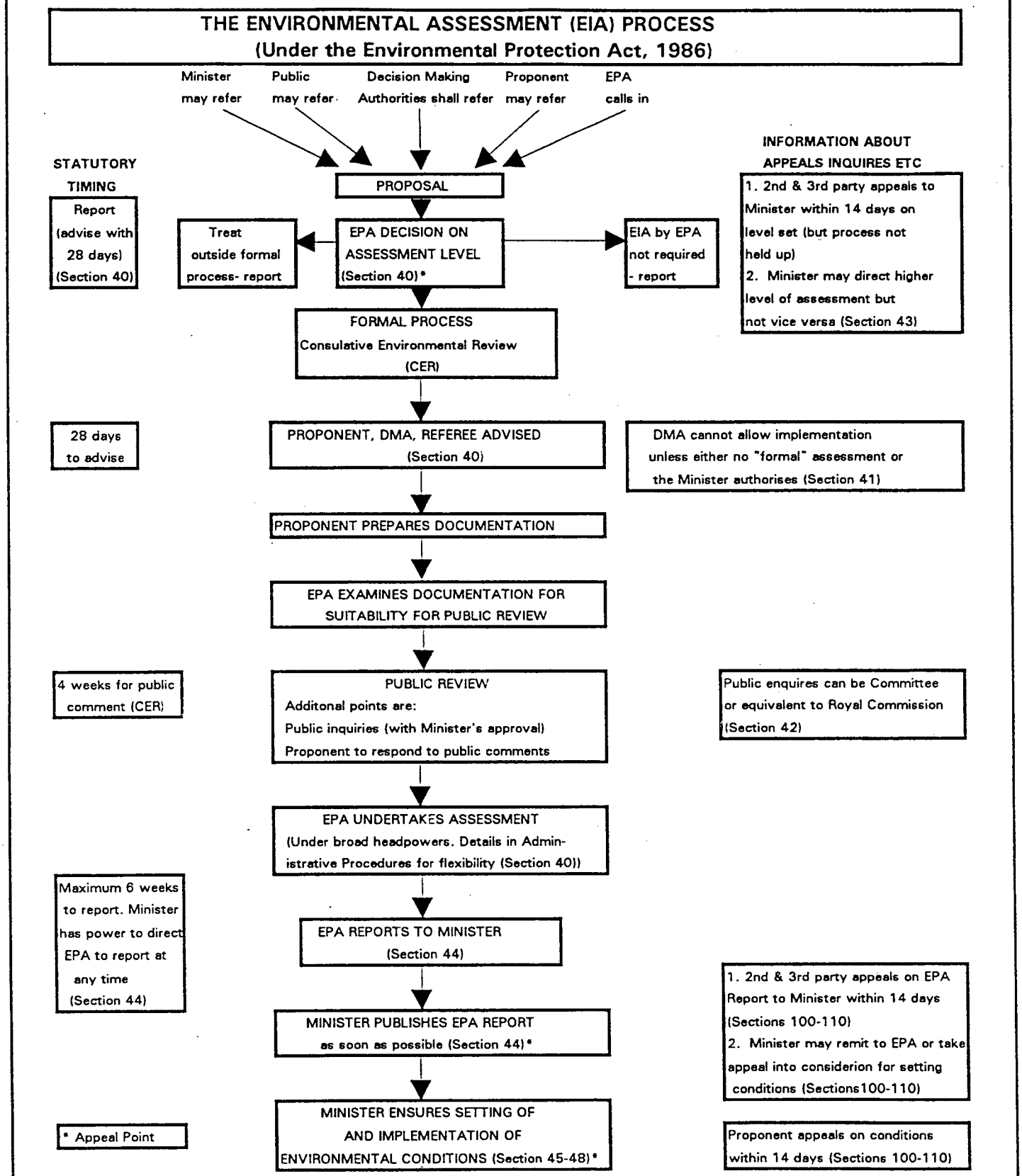
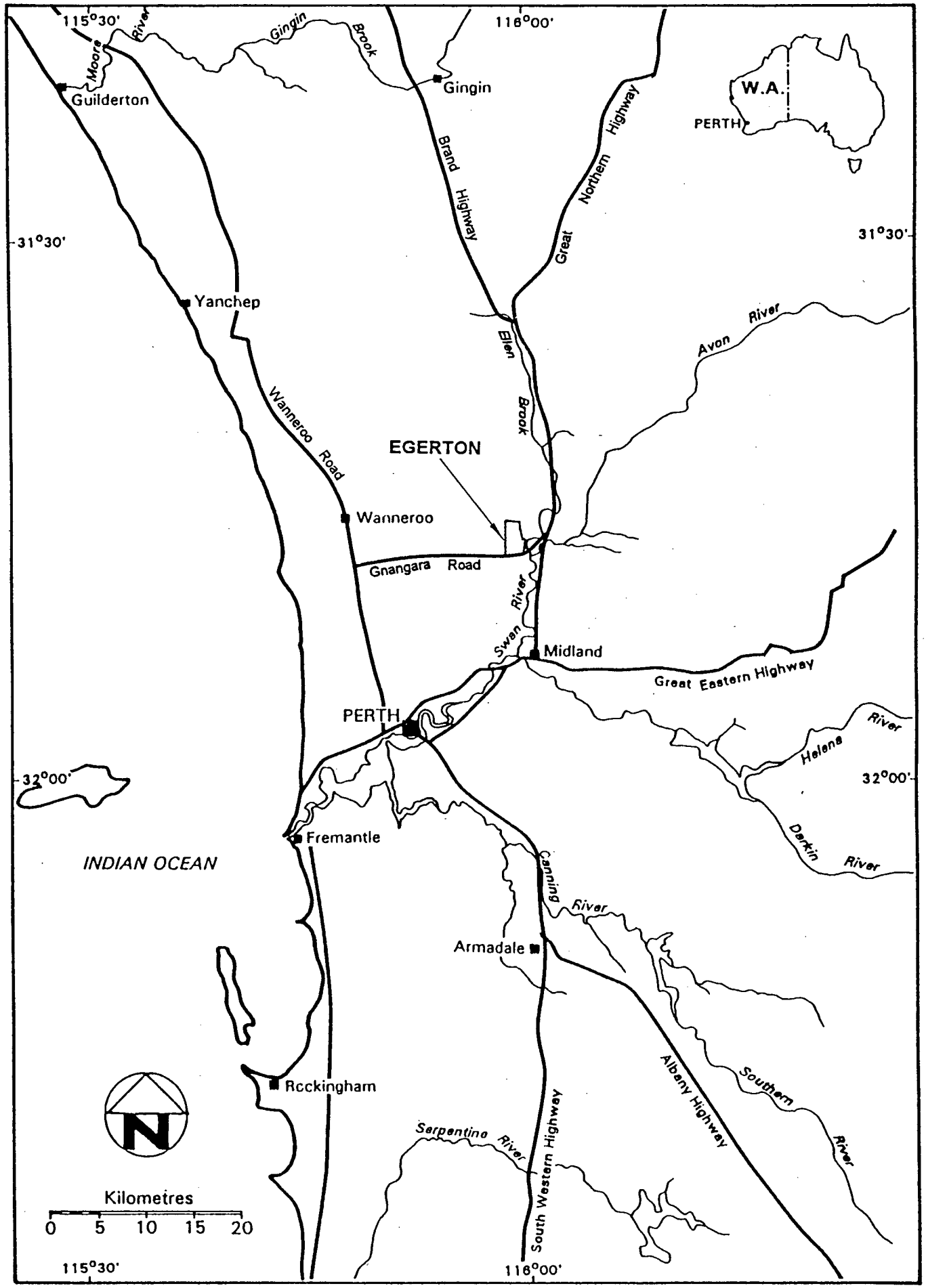
FIGURES



THE CONSULTATIVE ENVIRONMENTAL REVIEW (CER) PROCESS

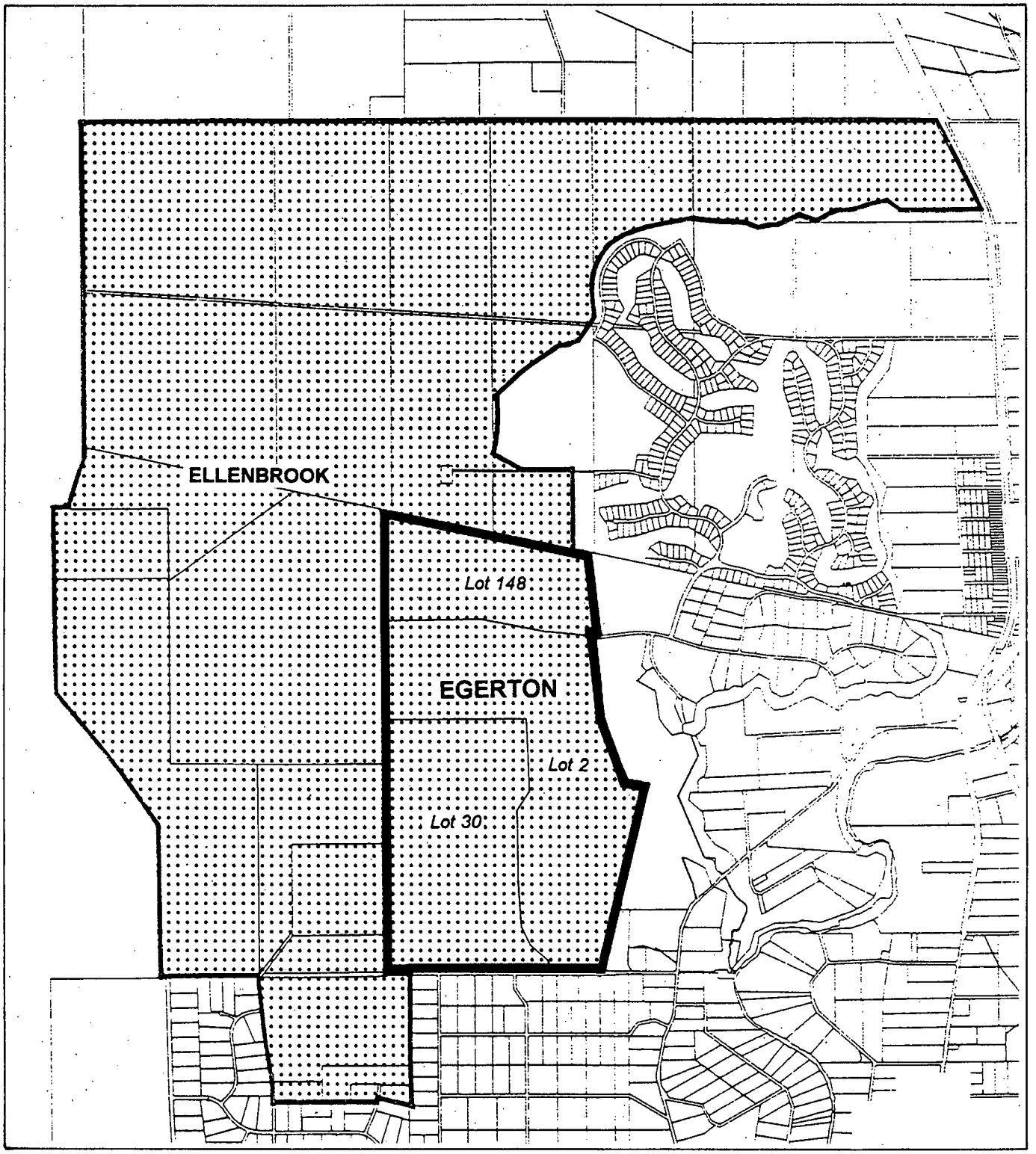
FIGURE 1



ALAN TINGAY & ASSOCIATES

EGERTON REGIONAL LOCATION

FIGURE 2



SOURCE: FEILMAN PLANNING CONSULTANTS, 1993

LEGEND

Property Owned by Multiplex Constructions Pty Ltd

Land Zoned Urban Deferred

N

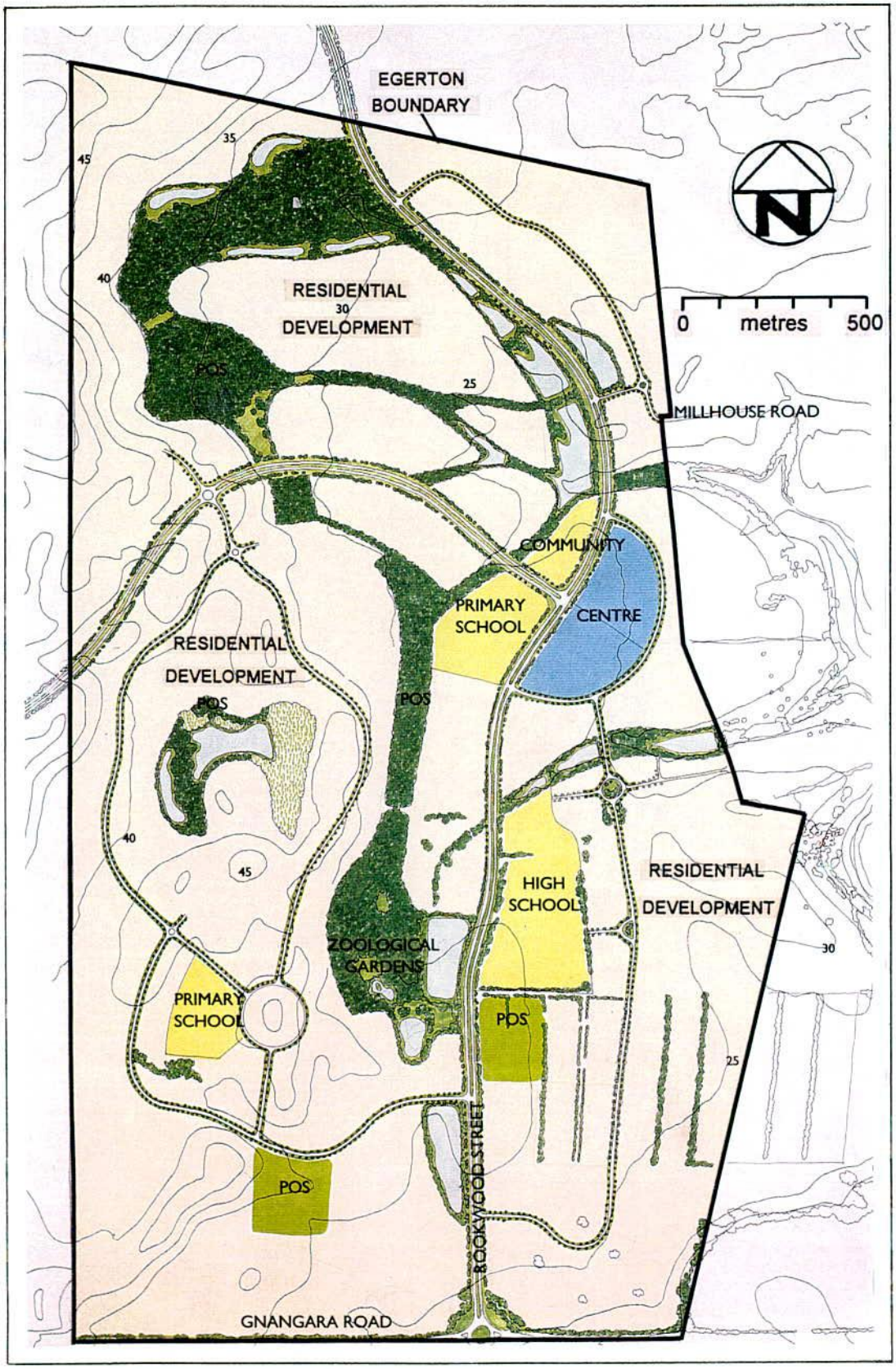
SCALE 1:40,000

0 Kilometres 1

ALAN TINGAY & ASSOCIATES

EGERTON CADASTRAL BOUNDARIES & ZONING

FIGURE 3

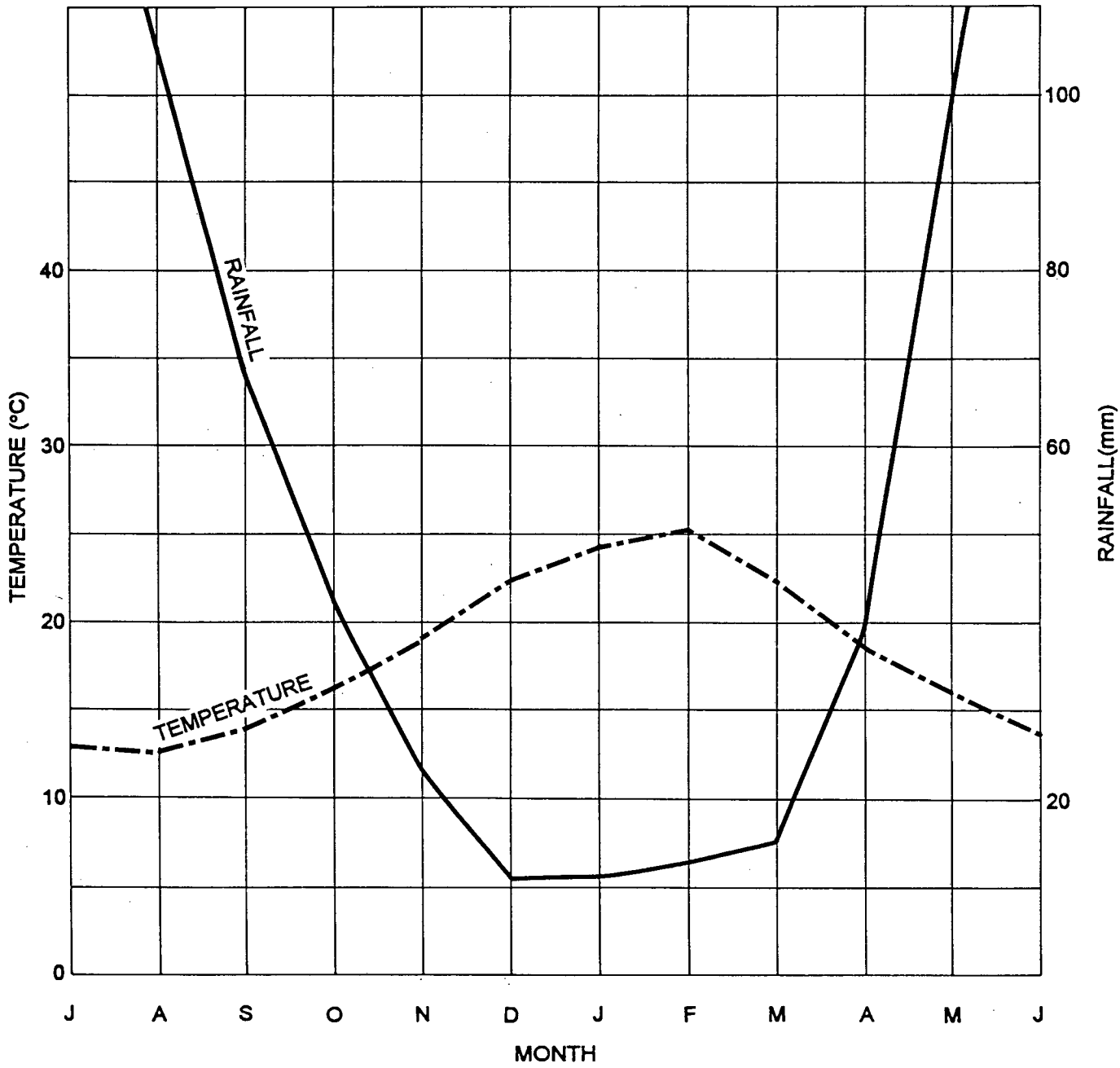


SOURCE: MULTIPLEX CONSTRUCTIONS PTY LTD, 1993

ALAN TINGAY & ASSOCIATES

EGERTON STRUCTURE PLAN

FIGURE 4



Temperature Data - 20 Years of Record

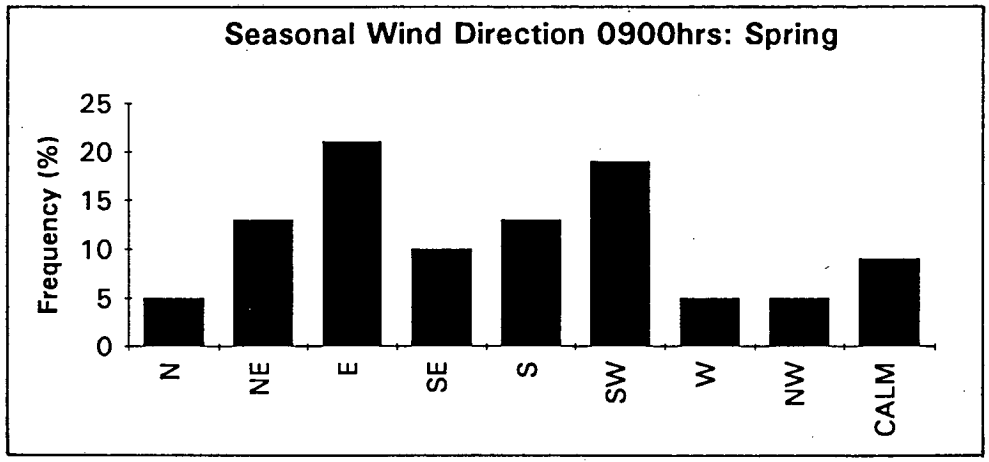
Rainfall Data - 32 Years of Record

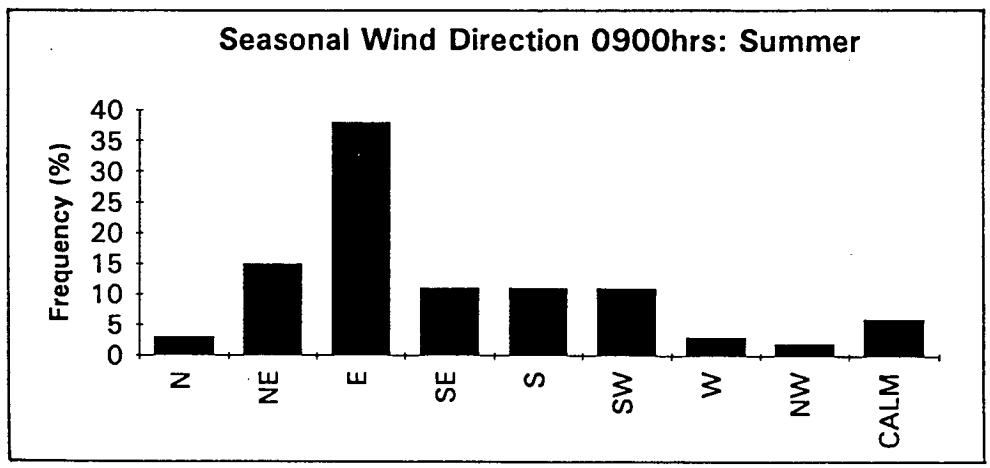
SOURCE: BUREAU OF METEOROLOGY, UPPER SWAN RESEARCH STATION

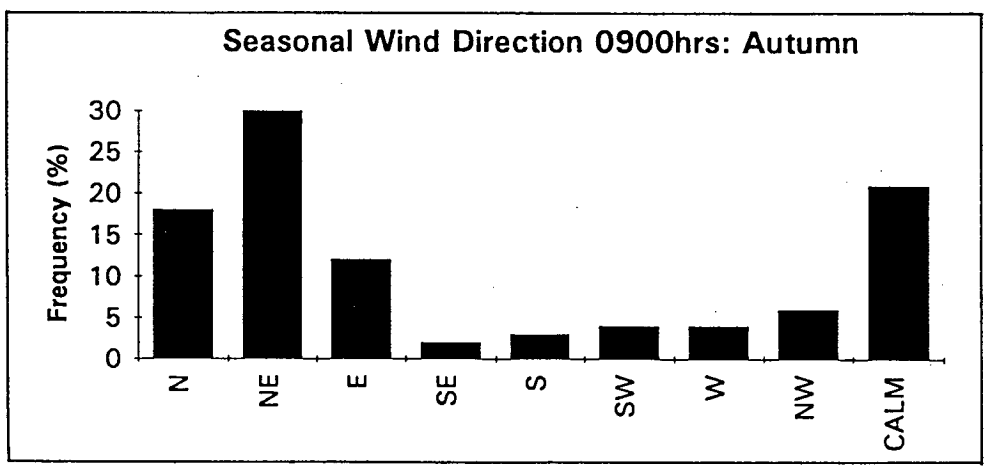
ALAN TINGAY & ASSOCIATES

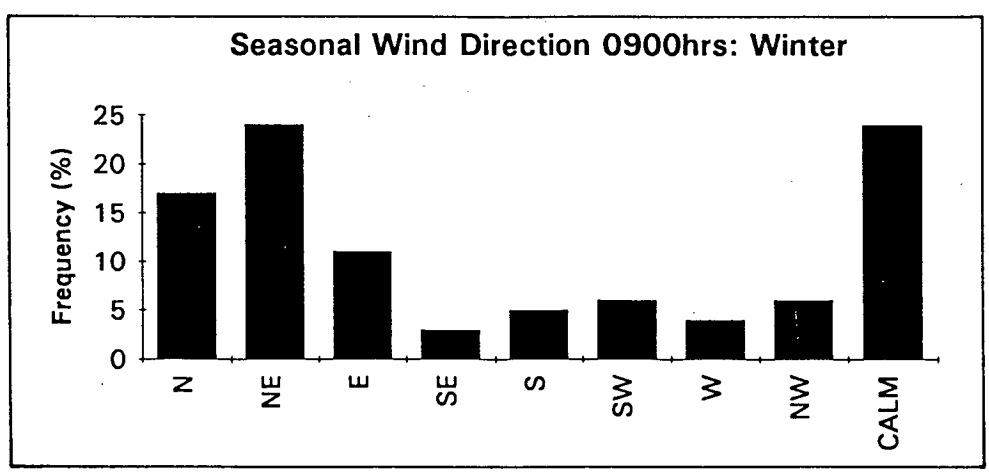
OMBROTHERMIC DIAGRAM FOR EGERTON

FIGURE 5





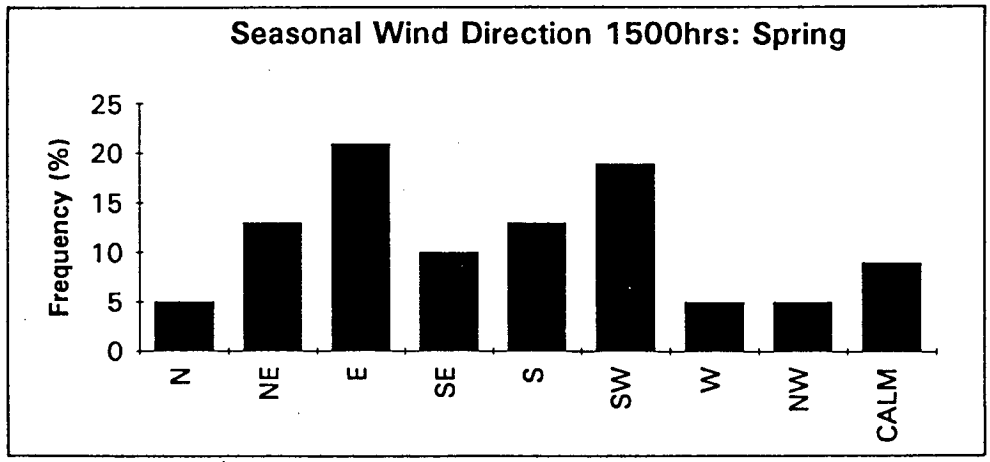


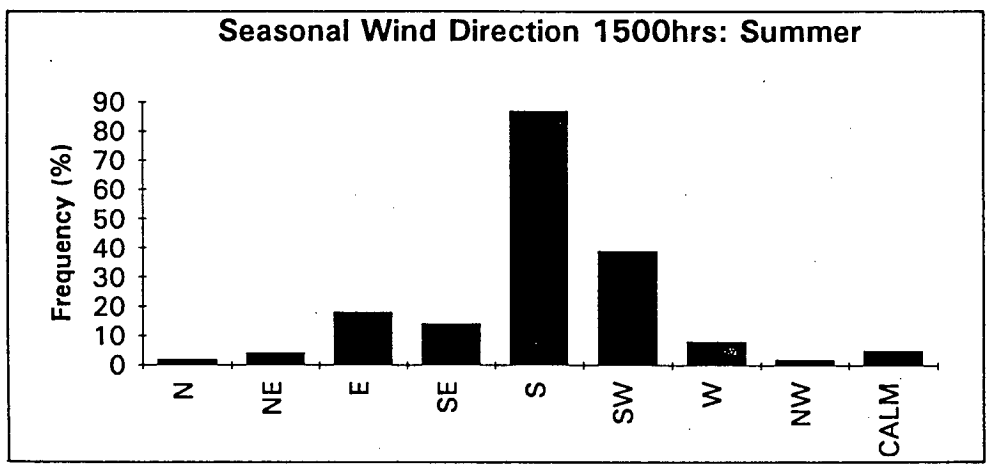


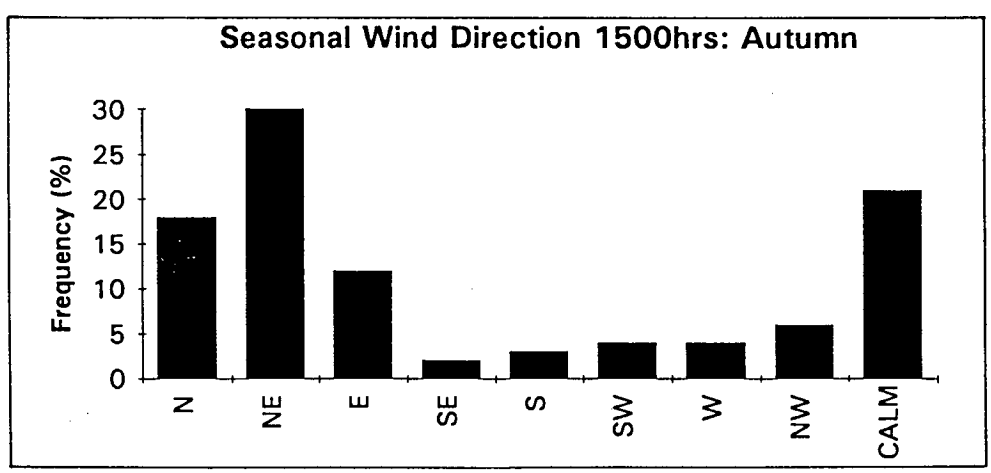
ALAN TINGAY & ASSOCIATES

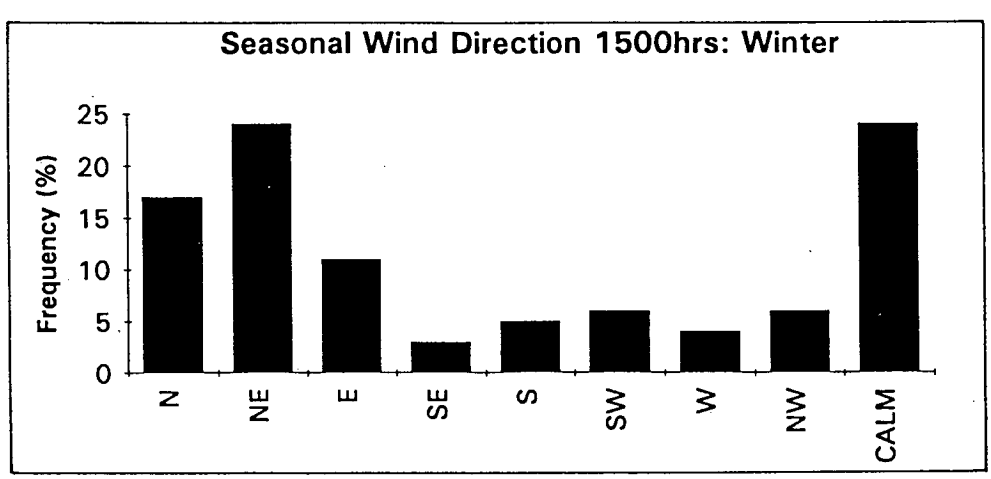
EGERTON SEASONAL WIND DIRECTIONS 0900HRS

FIGURE 6A





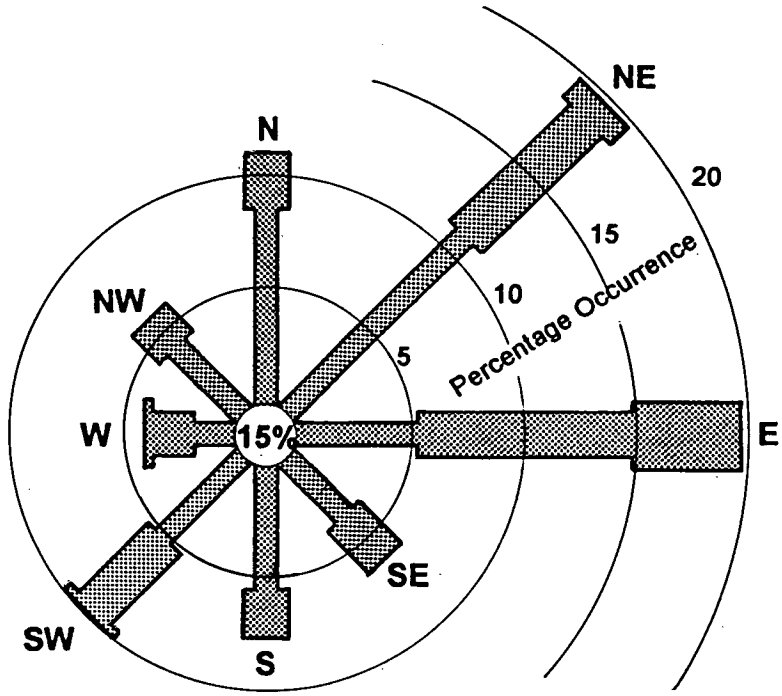




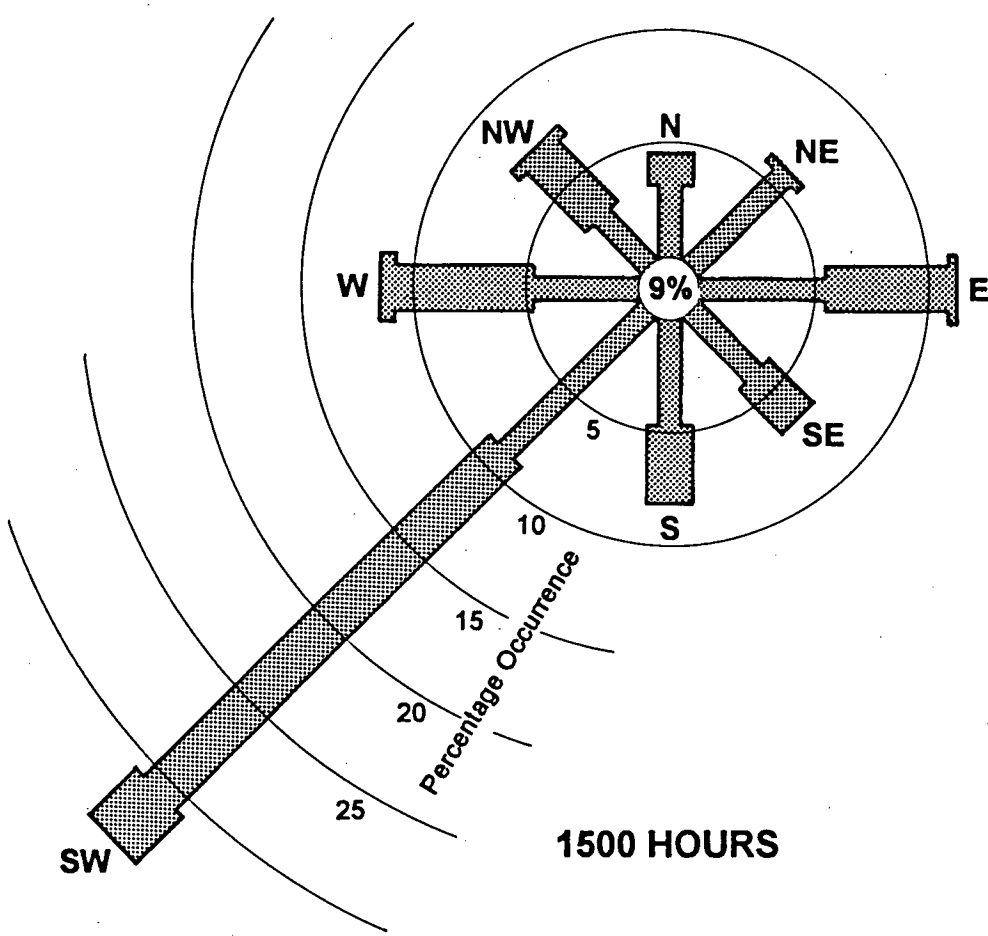
ALAN TINGAY & ASSOCIATES

EGERTON SEASONAL WIND DIRECTIONS 1500HRS

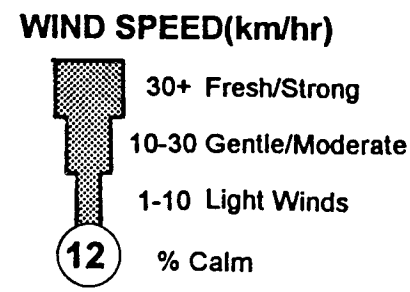
FIGURE 6 B



0900 HOURS



1500 HOURS



SOURCE: BUREAU OF METEOROLOGY, UPPER SWAN RESEACH STATION

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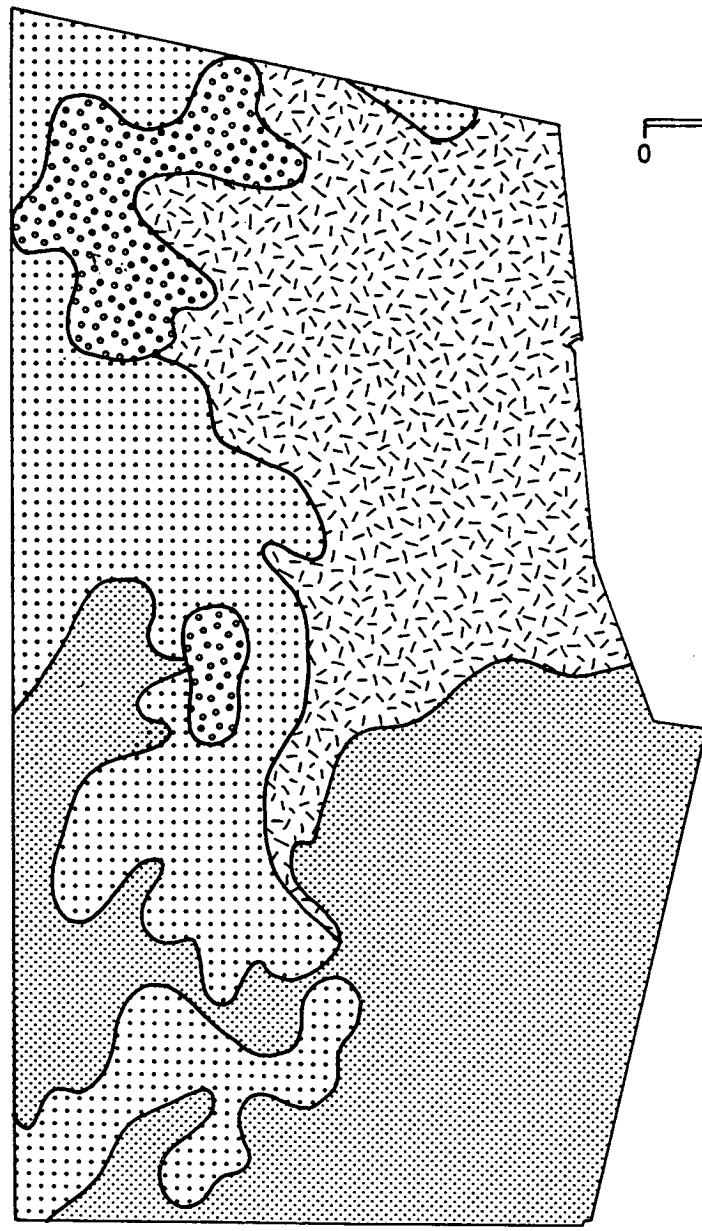
ANNUAL WIND ROSES - EGERTON

FIGURE 7



0 Kilometre 1

SCALE 1:20 000

LEGEND

	S_8	Bassendean Sand. Sand - very light grey at surface, yellow at depth. Fine to medium grain, sub-rounded quartz. Moderately well sorted. Aeolian origin.
	S_{10}	Thin Bassendean Sand over Guildford Formation Sand - as for S_8, forming a thin veneer over Guildford Formation(Mgs_1)
	Mgs_1	Guildford Formation Pebbly Silt - Strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble. Some fine to medium grained quartz sand. Alluvial origin.
	Cps	Swamp Deposits Peaty Clay - dark grey & black with variable sand content. Lacustrine origin.

SOURCE: GOZZARD, 1986

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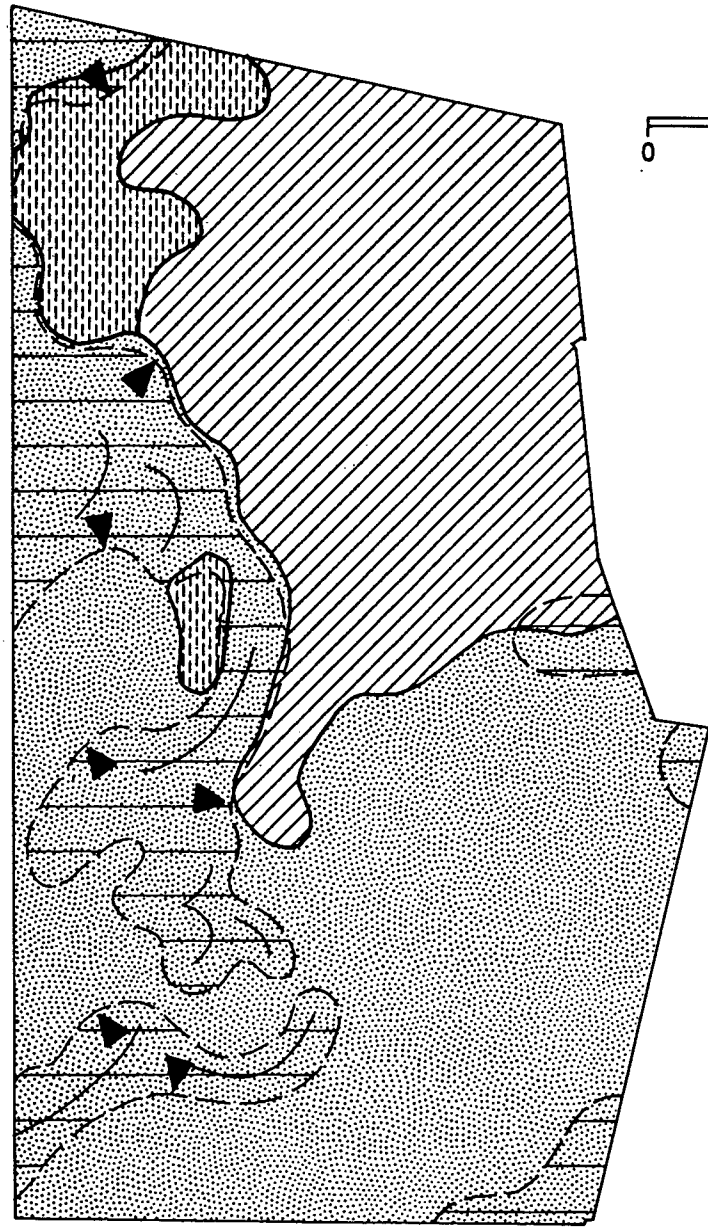
EGERTON GEOLOGY

FIGURE 8



0 Kilometre 1

SCALE 1:20 000

LEGEND

Degraded surface of aeolian origin - Bassendean Dunes

Marsh in interdunal swales

Alluvial plain

Slopes

0°-3°

3°-10°

Prominent ridge

Sharp concave break of slope

SOURCE: GOZZARD, 1986

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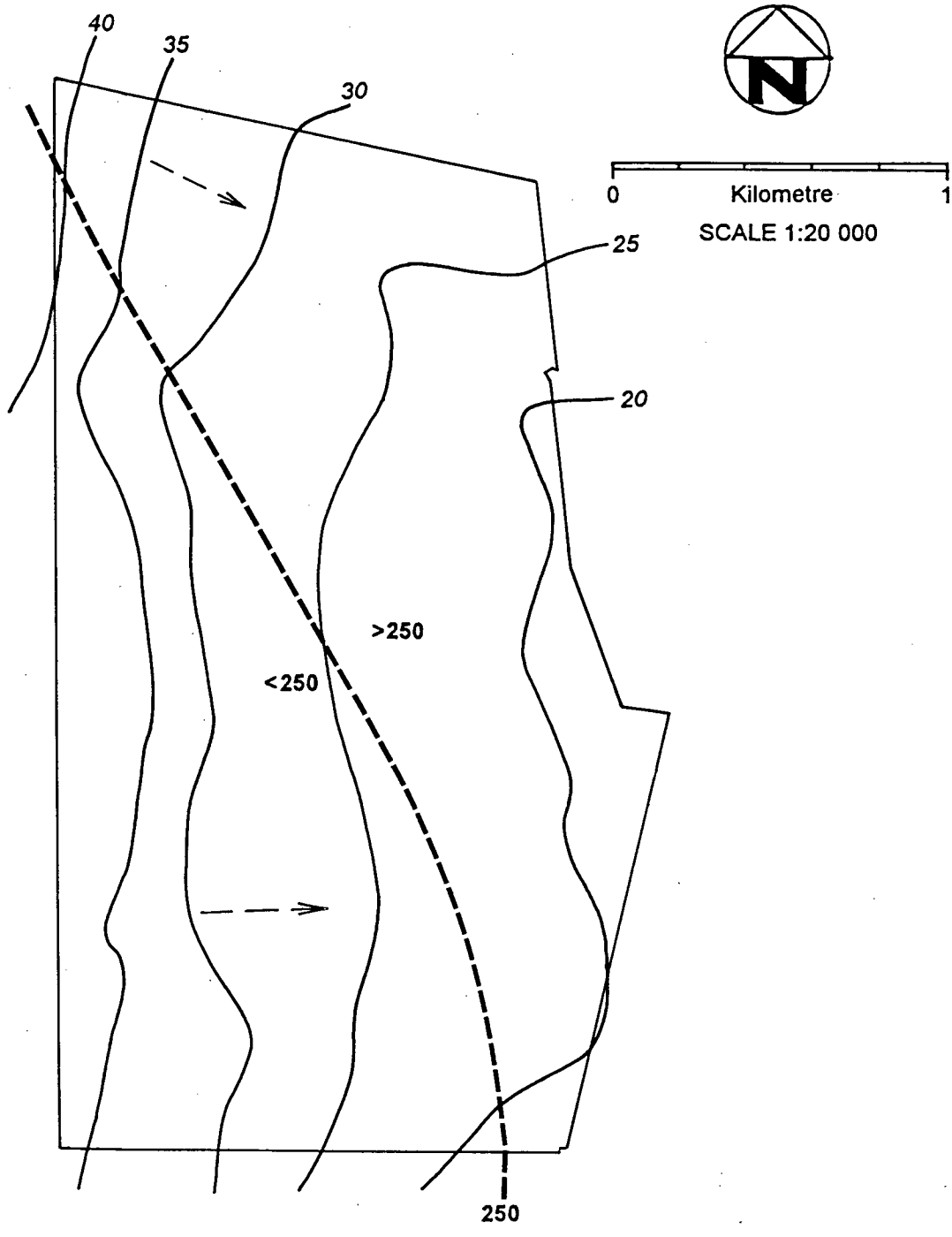
EGERTON GEOMORPHOLOGY

FIGURE 9

ALAN TINGAY & ASSOCIATES

EGERTON TOPOGRAPHY

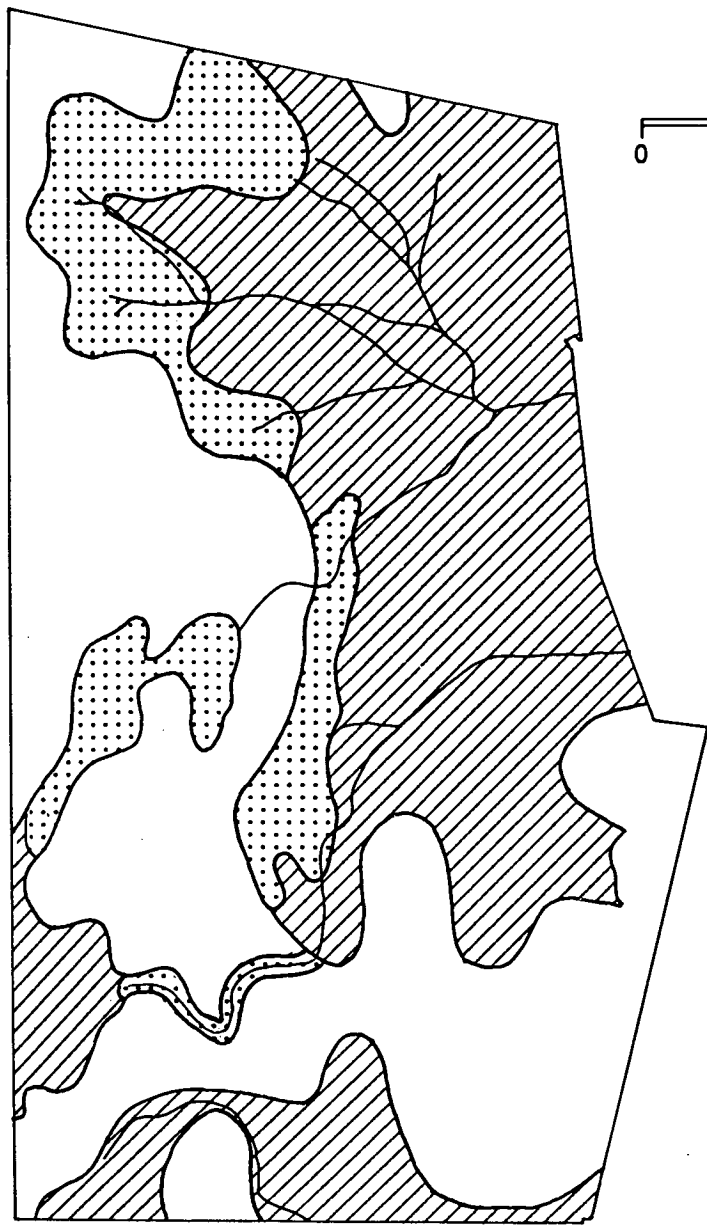
FIGURE 10



ALAN TINGAY & ASSOCIATES

EGERTON GROUNDWATER & ISOHALINE CONTOURS

FIGURE 11



N

0 Kilometre 1

SCALE 1:20 000

LEGEND

Creek (seasonally inundated drainage channel)

Dampland & Sumpland (seasonally waterlogged/inundated basin)

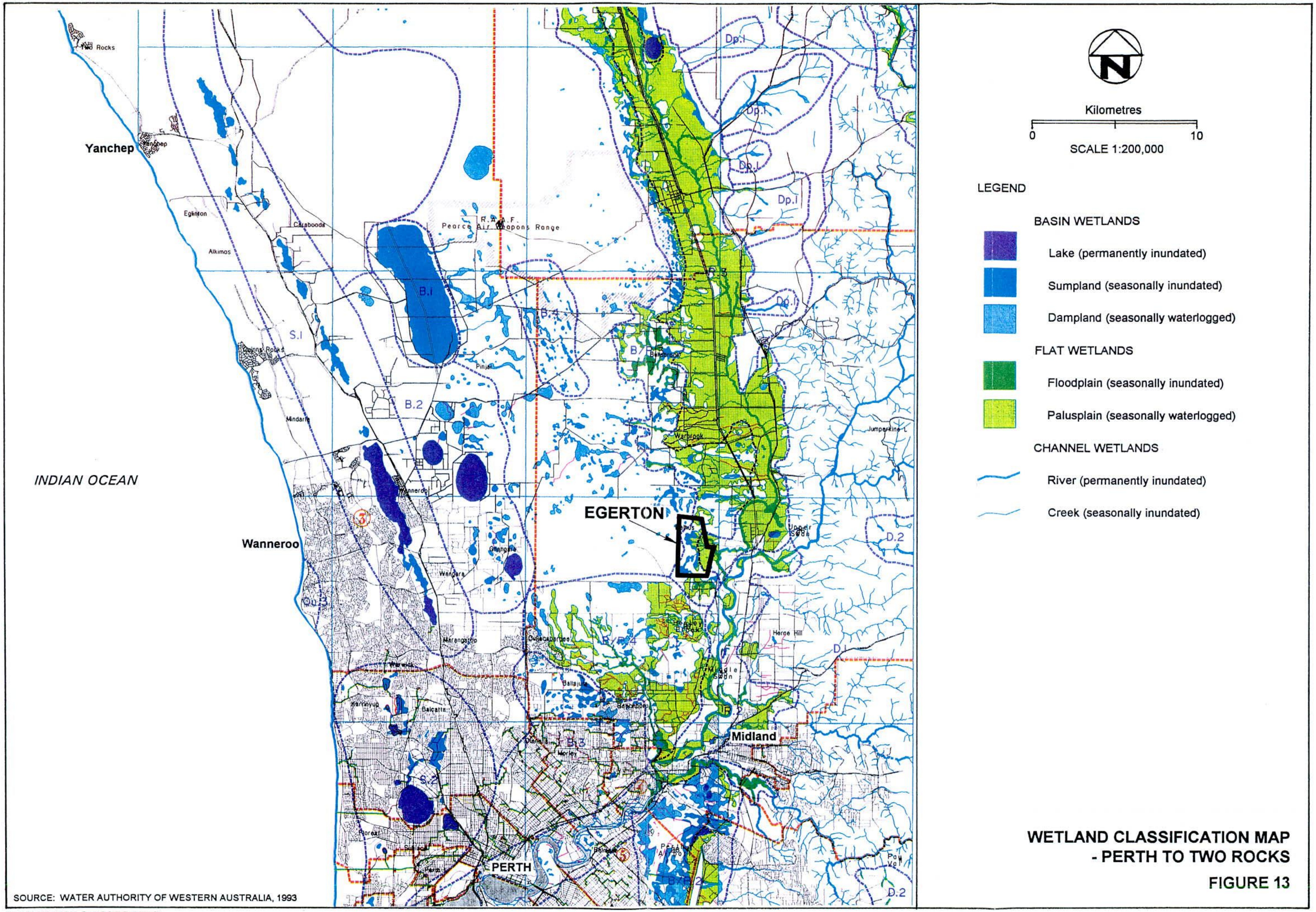
Palusplain (seasonally waterlogged flat)

SOURCE: MODIFIED AFTER WATER AUTHORITY OF WESTERN AUSTRALIA, 1993

ALAN TINGAY & ASSOCIATES

EGERTON WETLANDS

FIGURE 12



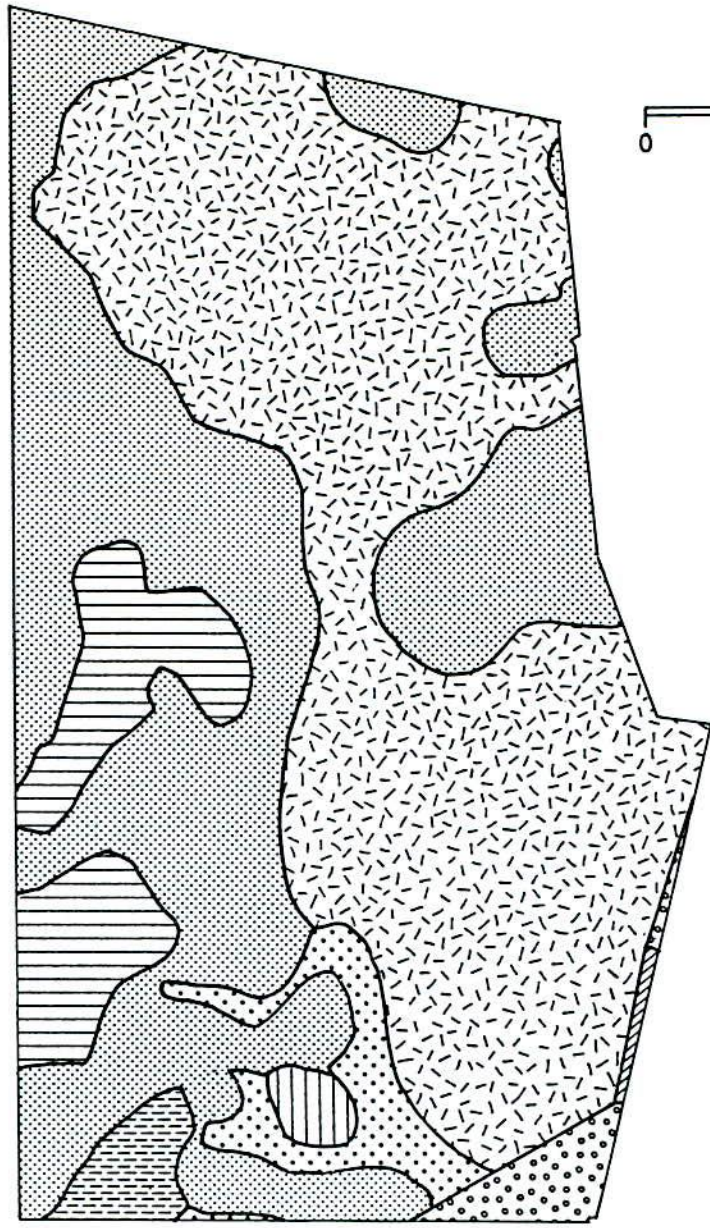
Two Rocks
Yanchep
Eglinton
Carabooda
Alkimos
R.A.A.F.
Pearce Air Weapons Range
B.1
B.2
B.3
B.4
S.1
S.2
Dp.1
D.2
Pinjar
Mindarie
Wanneroo
INDIAN OCEAN
Wangara
Gnangara
EGERTON
Warbrook
Bullsbrook
Upper Swan
Jumperkine
Herne Hill
Middle Swan
Marangaroo
Quinns Rocks
Warwick
Balcatta
Ballajura
Beechboro
Midland
Morley
Floreat
PERTH
Kilometres
0
10
SCALE 1:200,000
LEGEND
BASIN WETLANDS
Lake (permanently inundated)
Sumpland (seasonally inundated)
Dampland (seasonally waterlogged)
FLAT WETLANDS
Floodplain (seasonally inundated)
Palusplain (seasonally waterlogged)
CHANNEL WETLANDS
River (permanently inundated)
Creek (seasonally inundated)

WETLAND CLASSIFICATION MAP - PERTH TO TWO ROCKS

FIGURE 13

SOURCE: WATER AUTHORITY OF WESTERN AUSTRALIA, 1993

ALAN TINGAY & ASSOCIATES



N

0 Kilometre 1

SCALE 1:20 000

LEGEND

Land Capability Unit

Ya Yanga

Ja Jandakot

Ws Seasonal Swamps

DL Drainage Lines

Land Capability Unit

J Joel

1 Gavin

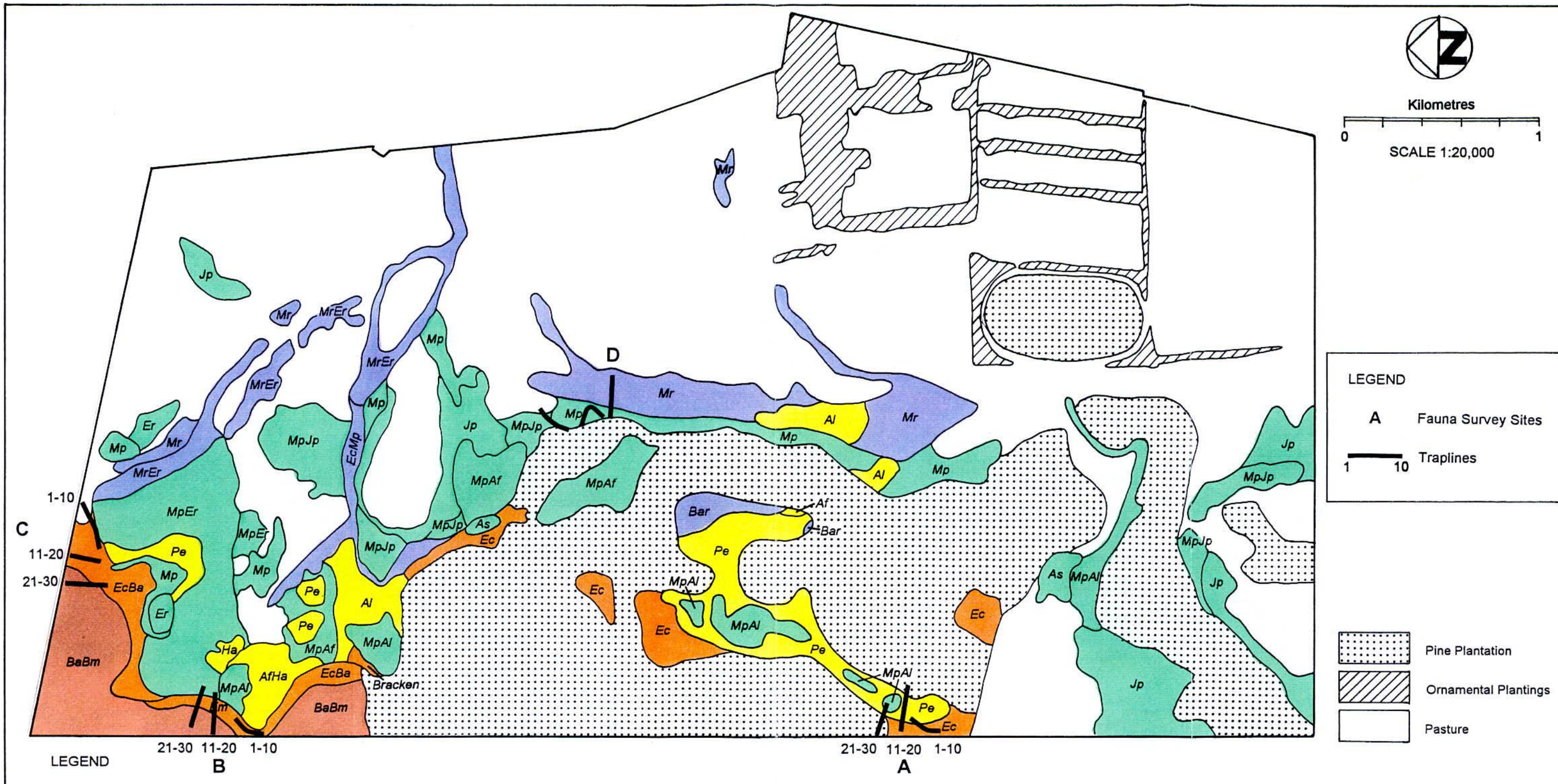
Ks Karrakatta Sand

Mus Muchea Sand

ALAN TINGAY & ASSOCIATES

EGERTON LAND CAPABILITY MAP

FIGURE 14



LEGEND

Dry/Woodlands

BaBm - *Banksia attenuata/B. menziesii* Low Woodland

Transitional/Woodlands

Ec - *Eucalyptus calophylla* Woodland

EcBa - *Eucalyptus calophylla/Banksia attenuata* Woodland

Em - *Eucalyptus marginata* Woodland

Dampland/Heaths & Sedgelands

Pe - *Pericalymma ellipticum* Closed Heath

Al - *Agonis linearifolia* Open Heath over *Juncus pallidus* Sedgeland

Af *Astartea fascicularis* Closed Heath

AfHa - *Astartea fascicularis/Hypocalymma angustifolium* Closed Heath

Ha - *Hypocalymma angustifolium* Closed Heath

Dampland/ Forests, Woodlands & Heaths

Er - *Eucalyptus rudis* Open Forest

MpEr - *Melaleuca preissiana/Eucalyptus rudis* Closed Forest with *Banksia littoralis*

Mp - *Melaleuca preissiana* Low Woodland

MpJp - *Melaleuca preissiana* Low Woodland over *Juncus pallidus* Sedgeland

MpAl - *Melaleuca preissiana* Low Open to Low Woodland over *Agonis linearifolia* Closed Heath

MpPe - *Melaleuca preissiana* Low Open Woodland over *Pericalymma ellipticum* Closed Heath

MpAf - *Melaleuca preissiana* Low Open Woodland over *Astartea fascicularis* Closed Heath

As - *Acacia saligna* Low Woodland over *Agonis linearifolia* Open Heath

Jp - *Juncus pallidus* Sedgeland

Sumpland & Creeks/Forests, Woodlands & Sedgelands

Mr - *Melaleuca rhaphiophylla* Low Closed Forest

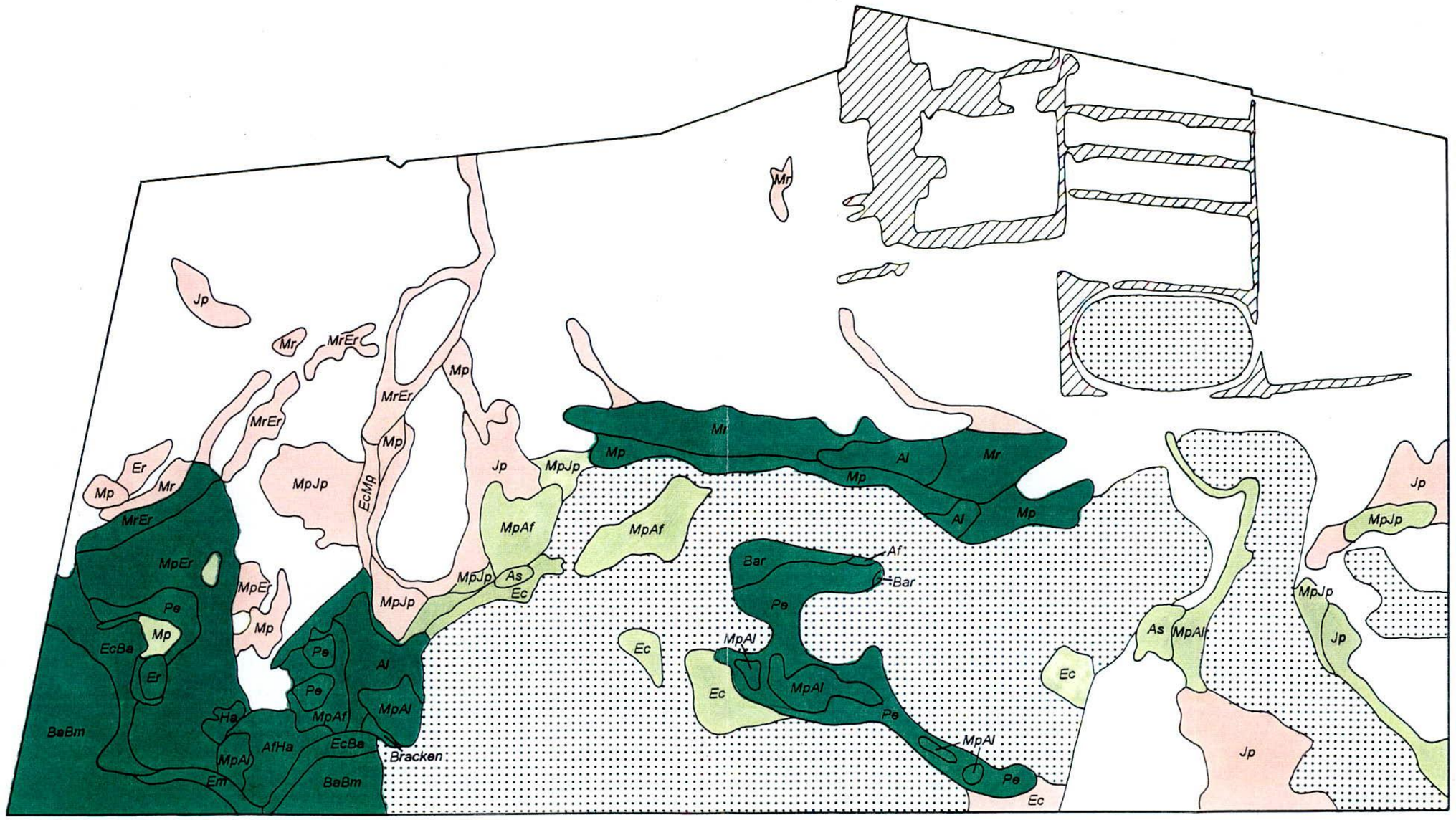
MrEr - *Melaleuca rhaphiophylla/Eucalyptus rudis* Low Closed Forest

EcMp - *Eucalyptus calophylla* Woodland over *Melaleuca preissiana* Low Woodland

Bar - *Baumea articulata* Closed Sedgeland

EGERTON VEGETATION TYPES **FIGURE 15**

ALAN TINGAY & ASSOCIATES



LEGEND

- Slightly Disturbed
- Obvious Disturbance
- Severely Disturbed
- Degraded

EGERTON
NATIVE VEGETATION QUALITY MAP
FIGURE 16

ALAN TINGAY & ASSOCIATES

APPENDIX 1

EPA GUIDELINES FOR THE EGERTON CER

PROPOSED REZONING OF LAND FROM URBAN DEFERRED TO URBAN AT EGERTON (ADJACENT TO ELLEN BROOK)

CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

Overview

In Western Australia all environmental reviews are about protecting the environment. The fundamental requirement is for the proponent to describe what they propose to do, to discuss the potential environmental impacts of the proposal, and then to describe how those environmental impacts are going to be managed so that the environment is protected.

If the proponent can demonstrate that the environment will be protected then the proposal will be found environmentally acceptable; if the proponent cannot show that the environment would be protected then the Environmental Protection Authority (EPA) would recommend against the proposal.

Throughout the process it is the aim of the EPA to advise and assist the proponent to improve or modify the proposal in such a way that the environment is protected. Nonetheless, the environmental review in Western Australia is proponent driven, and it is up to the proponent to identify the potential environmental impacts and design and implement proposals which protect the environment.

For this proposal, protecting the environment means that the natural and social values associated with Ellen Brook and its associated tributaries, wetlands, including palusplain, on the site are protected. Where they cannot be protected, proposals to mitigate the impacts are required.

Purpose of a CER

The primary function of a CER is to provide the basis for the EPA to provide advice to Government on protecting the environment. An additional function is to communicate clearly with the public so that EPA can obtain informed public comment. As such, environmental impact assessment is quite deliberately a public process. The CER should set out the series of decisions taken to develop this proposal at this place and time and why.

Objectives of the review

The Consultative Environmental Review should have the following objectives:

- to place this project in the context of the progressive environmental management for the region;
- to explain the issues and decisions which led to the choice of this project at this place at this time;
- to set out the environmental impacts that the project may have; and
- for each impact, to describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate that impact.

The CER should focus on the major issues for the area and anticipate the questions that members of the public will raise. Data describing the environment should be directly related to the discussion of the potential impacts of the proposal. Both should then relate directly to the actions proposed to manage those impacts.

Key issues

The critical issue for the proposal is likely to be the management of water quality and quantity for the site. An integrated study of groundwater, surface water run off and environmental issues is required to address the surface and subsurface water quality and quantity aspects for key elements of the proposal. The CER needs to show a detailed understanding of the conservation, landscape, and social values in the area, and whether they are represented elsewhere. The conservation values of areas to be disturbed should he examined in detail.

The key issues for this project should be clearly identified and the content of succeeding sections determined by their relevance to these issues.

In this case the key issues should include:

- the reasons for the proposal and the alternatives considered;
- management of water quality and quantity with particular reference to Ellen Brook and the Swan River, wetlands on the site, including palusplain, the possible presence of a mound spring and the impacts to local water balance (downstream);
- management of wetlands and the mound spring which are not protected by legislation;
- initiatives such as water sensitive urban design should be considered and discussed, it may be necessary to include nutrient stripping basins to ensure satisfactory quality of recharge to the groundwater and run off to Ellen Brook and the Swan River;
- the status and implementation, of the foreshore reserve for Ellen Brook should be discussed;
- flora, fauna and ecosystems:
    - land units and their secure representation elsewhere;
    - rare and poorly known flora, fauna and communities, shown on distribution maps;
    - inter-relationships of the biota and environment, including consideration of wildlife corridors;
- landscape and recreation values, including protection of Ellen Brook and the Swan Valley Policy Area;
- the relationship and compatibility between this proposal and those of adjoining landholders with particular reference to water quality and quantity management of surface and subsurface water. It is important to show that this proposal will not adversely affect wetland water level criteria and groundwater criteria established through the Ellenbrook proposal;
- local environmental issues associated with transit access to the site;
- cultural impact on Aboriginal people with traditional affiliation to the land;

plus any other key issues raised during the preparation of the report.

Public partition and consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the CER. It should describe the activities undertaken, the dates, the groups and individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management for the proposal which should clearly indicate how community concerns have been addressed. Where these concerns are dealt with via other departments or procedures, outside the EPA process, these can

be noted and referenced here.

Detailed list of environmental commitments

The commitments being made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of:

a who will do the work;

b what the work is;

c when the work will be carried out; and

d to whose satisfaction the work will be carried out.

- All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list.

APPENDIX 2

GROUNDWATER ISOTOPE STUDIES OF SPRINGS AT EGERTON, WEST SWAN ROAD, ELLENBROOK

GROUNDWATER ISOTOPE STUDIES OF SPRINGS AT EGERTON, WEST SWAN ROAD, ELLENBROOK

by Dr P M Thorpe

Client: Paul van der Mezel, Tingay Allen and Associates, 35 Labouchere Rd, South Perth. Telephone/Fax: 474 1300/ 474 3394.

AIM: To determine the age and source of water issuing from springs on the north eastern part of the Egerton property using isotope groundwater age dating techniques.

The spring water may originate from two possible sources:

- Discharge of young, shallow groundwater (<2000 years) from the unconfined Quaternary Bassendean Sand aquifer on the eastern edge of the property may occur at the contact of the Bassendean Sand and the underlying clays of the Guildford Formation.

- Discharge of old groundwater (20 000 to 30 000 years) derived by upward leakage from the underlying deep confined artesian Cretaceous Leederville Formation aquifer.

Existing information from an extensive groundwater age dating study of the confined aquifers in the Perth metropolitan area conducted by the Geological Survey (Thorpe and Davidson, 1991) shows that groundwater in the Leederville Formation in the area is likely to be from 20 000 to 30 000 years in age as shown in the Figure.

METHOD

Samples for isotope dating were taken from the following sources on November 18 and 19 1993 by officers of the Geological Survey to asertain the origin of the groundwater at the springs :

1. The springs. Samples were collected from a shallow creek supplied by the springs at about 20m from their source. Dense vegetation and marshy ground conditions prevented direct access to the spring source.

2. The Leederville Formation aquifer. A representative sample was collected from the artesian monitoring bore AM31A located near the Egerton property, about 4.5 km south east of the springs on Swan Street. This bore is screened in the middle part of the Leederville Formation at 200 to 203 m depth.

3. The shallow aquifer. A sample was collected from the only available equipped shallow depth production bore on the property located near the Old Mill adjacent to Ellen Brook. The depth of this bore is estimated to be about 40 m, however construction details including depth of screen were not available Groundwater from this source is not representative of groundwater in the Bassendean Sand on the eastern edge of the property. The bore probably intersects groundwater produced from thin sand beds within the Cretaceous Osborne Formation beneath the Quaternary deposits.

RESULTS

The isotope and field chemical data from the three water sources are given in the Table and show the following:

1. Water collected from the springs has a relatively young Carbon-14 age of 90 years. It also exhibits an immature chemical signature, that is, a low pH, salinity, alkalinity, temperature and high dissolved carbon dioxide content.

2. Groundwater from the Leederville Formation aquifer (AM31A) is relatively old at 12 700 years and has a mature chemical signature shown by a moderate salinity, alkalinity and temperature; and low dissolved carbon dioxide content.

3. Groundwater from the shallow production bore on the property is relatively old at >28 800 years and shows a mature chemical signature.

CONCLUSIONS

The age dating studies show the following:

1. The groundwater issuing at the springs on the north eastern part of the Egerton property does not originate from discharge by upward leakage from the artesian Leederville Formation aquifer. The groundwater discharging from the springs is substantially younger in age than that found in the Leederville Formation aquifer in the area.

2. Groundwater flowing from the springs originates from relatively young shallow groundwater within the Bassendean Sand aquifer to the west known as the Gnangara Groundwater Mound. Groundwater discharge from this aquifer results in springs where the contact between the Bassendean Sand and underlying clayey Guildford Formation is exposed. This type of spring development is probably common in the Swan Valley area in areas of low elevation.

3. Groundwater from the shallow production bore sampled on the Egerton property is not representative of groundwater in the Bassendean Sand on the eastern edge of the property. The bore probably intersects old groundwater from thin sand beds within the Cretaceous Osborne Formation beneath the Quaternary deposits.

REFERENCES

Allen, A. D., 1981, The hydrogeology of the Swan Valley, Perth Basin, Western Australia: Western Australia Geological Survey, Annual Report 1980, p. 12-26.

Thorpe, P. M. and Davidson, W. A., 1991, Groundwater age and hydrodynamics of the confined aquifers, Perth, Western Australia, in Proceedings of the International Conference on Groundwater in Large Sedimentary Basins, Perth, Western Austraia, 1990: Australian Water Resources Council, Conference Series no. 20, p. 420-436.

P. M. Thorpe 29/12/93

Dr P M Thorpe (Isotope Hydrogeologist, Geological Survey Of Western Australia).

TABLE. ISOTOPE AND FIELD CHEMICAL DATA

Bore/ source	AMG	Sample interval (m depth)	Formation sampled	C-14 age (years BP)	Error (years BP)	C-14 activity (pmC)	Error (pmC)	T (oC)	EC (mS/cm)	Salinity TDS *	pH	DO *	Alkalinity (as CaCO3*)	CO2 dissolved*
Springs	N 6484350 E 403400	surface	-	90	90	98.9	1	15.6	0.29	160	5.07	13.1	12	620
AM31A	N 6480550 E 406030	200-203	Kl	12 700	110	21.6	0.3	23.3	1.05	570	6.13	1.9	113	137
Property bore	N 6483300 E 405250	? 40	? Ko	>28 800	-	1.5	0.8	21.6	0.62	330	6.51	1.5	107	54

Where:

BP	= before present (1950 AD)
pmC	= percent modern carbon
T	= temperature
EC	= electrical conductivity
TDS	= total dissolved solids estimated from EC
DO	= dissolved oxygen
*	= mg/L
Ko	= Osborne Formation
Kl	= Leederville Formation

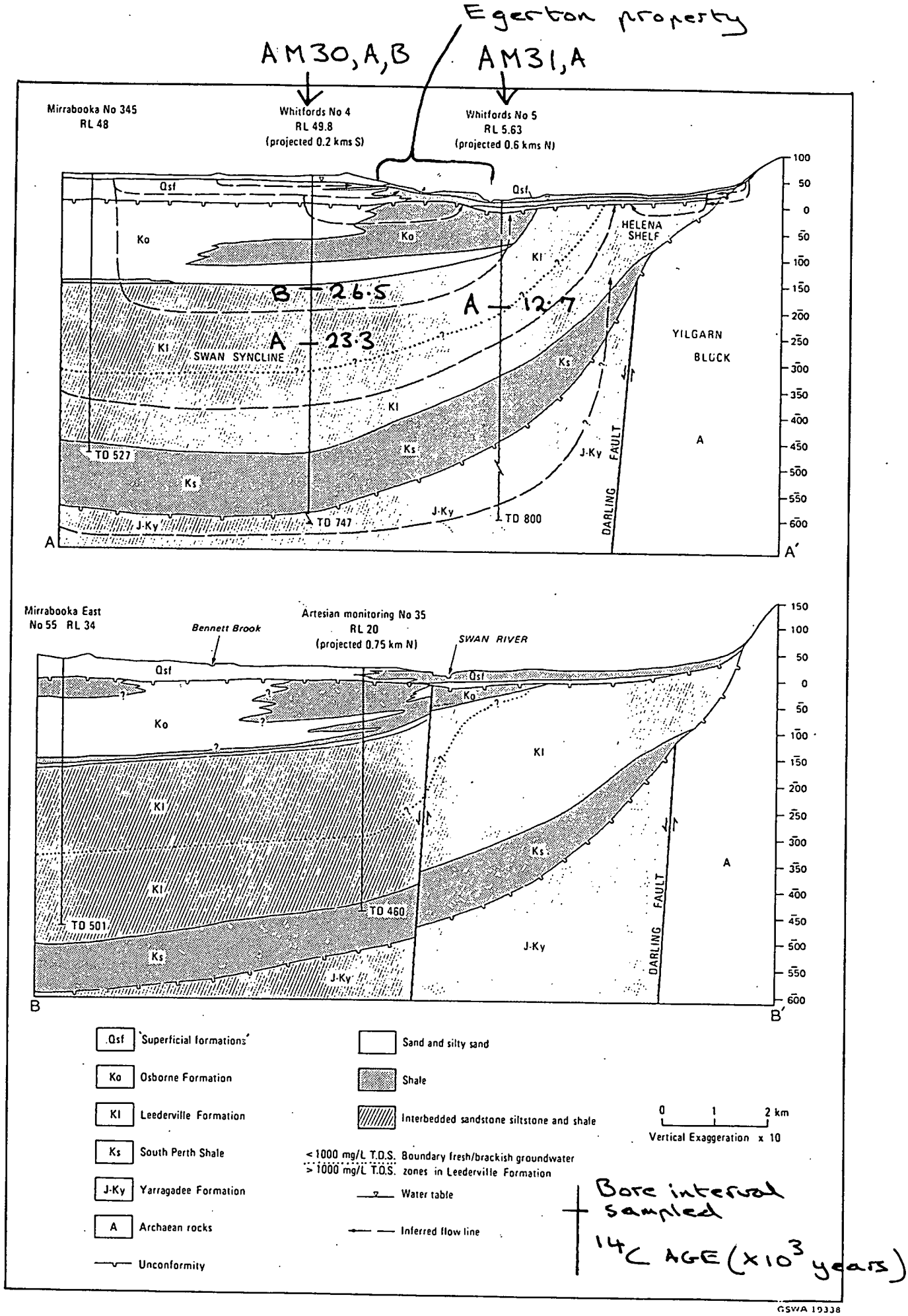


Figure : Hydrogeological cross-sections of the Swan Valley.

(After Allen, 1981)

APPENDIX 3

LIST OF NATIVE FLORA RECORDED AT EGERTON

Species	Dry	Transitional	Wet
FERNS			
Dennstaedtiaceae		x	x
Pteridium esculentum			
CYCADS			
Zamiaceae			
Macrozamia riedlei	x		x
MONOCOTYLEDONS			
Anthericaceae			
Laxmannia squarrosa	x		
Thysanotus manglesianus	x		
Colchicaceae			
Burchardia umbellata	x		
Wurmbea dioica			x
Cyperaceae			
Baumea articulata			x
Isolepis marginata	x		
Lepidosperma angustatum		x	
Lepidosperma leptostachyum	x		
Mesomelaena pseudostygia	x		
Schoenus curvifolius	x		
Tetraria octandra			x
Haemodoraceae			
Anigozanthos humilis	x		
Anigozanthos manglesii	x		
Conostylis aculeata	x		
Conostylis aurea	x		
Conostylis juncea		x	
Haemodorum laxum	x		
Haemodorum paniculatum	x		
Phlebocarya ciliata		x	
Iridaceae			
Patersonia occidentalis	x		
Potamogetonaceae			
Potamogeton sp.			x
Juncaceae			
Juncus pallidus			x
Juncus planifolius			x
Juncaginaceae			
Triglochin procera			x
Dasypogonaceae			
Calectasia cyanea	x		
Dasypogon bromeliifolius		x	
Lomandra odera			x

Species	Dry	Transitional	Wet
Orchidaceae			
Caladenia flava	x		
Caladenia aff heugelii			x
Caladenia sp.	x		
Elythranthera brunonsis	x		x
Elythranthera emarginata		x	
Lyperanthus nigricans			x
Microtis unifolia			x
Pterostylis vittata			x
Pterostylis nana			x
Restionaceae			
Alexgeorgea nitens	x		
Hypolaena exsulca			x
Loxocarya flexuosa	x		
Loxocarya pubescens	x		
Lyginia barbata	x		
Restio sp.	x		
Xanthorrhoeaceae			
Xanthorrhoea preissii		x	x
DICOTYLEDONAE			
Apiaceae			
Trachymene pilosa	x		
Asteraceae			
Podotheca chrysantha	x		
Cotula coronopifolia			x
Lagenifera huegelii	x	x	
Millotia myosotidifolia	x		
Podotheca gnaphalioides	x		
Quinetia urvillei	x		
Casuarinaceae			
Allocasuarina fraseriana	x		
Allocasuarina humilis	x		
Crassulaceae			
Crassula colorata	x		
Dilleniaceae			
Hibbertia aurea	x		
Hibbertia huegelii	x		
Hibbertia hypericoides	x		
Hibbertia subvaginata	x		x
Hibbertia vaginata	x		
Hibbertia perfoliata			x

Species	Dry	Transitional	Wet
Droseraceae			
Drosera erythrorhiza	x		x
Drosera gigantea			x
Drosera macrantha			x
Drosera menziesii	x		
Drosera pulchella			x
Drosera sp			x
Epacridaceae			
Astroloma xerophyllum			
Brachyloma preissii	x		
Conostephium minus	x		
Conostephium pendulum	x		
Leucopogon australis		x	x
Leucopogon conostephioides	x		
Leucopogon gibbosus	x		
Leucopogon racemulosus	x		
Leucopogan sprengelioides	x		
Goodeniaceae			
Dampiera linearis	x		x
Lechenaultia floribunda	x		
Scaevola paludosa	x		
Verrauxia reinwardtii	x		
Lamiaceae			
Hemiandra pungens	x		
Lauraceae			
Cassytha racemosa			x
Cassytha glabella	x		
Lentibulariaceae			
Polypompholyx multifida			x
Lobeliaceae			
Lobelia tenuior		x	
Loranthaceae			
Nuytsia floribunda	x		x
Menyanthaceae			
Villarsia albiflora			x
Mimosaceae			
Acacia saligna		x	
Acacia sessilis	x		
Acacia huegelii	x		
Acacia pulchella	x		
Molluginaceae			
Macarthuria australis	x		

Species	Dry	Transitional	Wet
Myrtaceae			
Agonis linearifolia			x
Astartea fascicularis	x		x
Beaufortia elegans	x		
Calothamnus lateralis			x
Calythrix angulata	x		
Calythrix fraseri	x		
Eremaea pauciflora	x		
Eucalyptus calophylla		x	
Eucalyptus marginata	x	x	x
Eucalyptus rudis			x
Eucalyptus todtiana	x		
Hypocalymma angustifolium		x	x
Melaleuca preissiana		x	x
Melaleuca rhaphiophylla			x
Pericalymma ellipticum			x
Regelia inops	x		
Scholtzia involucrata			x
Verticordia nitens	x		
Papilionaceae			
Aotus cordifolius			x
Bossiaea eriocarpa	x		
Burtonia conferta	x		
Daviesia preissii	x		
Daviesia divaricata	x		
Daviesia triphylla	x		
Euchilopsis linearis			x
Eutaxia virgata			x
Gompholobium aristatum	x		
Gompholobium tomentosum	x		
Hovea pungens	x		
Hovea trisperma	x		
Jacksonia densiflora	x		
Jacksonia furcellata	x		
Jacksonia sternbergiana		x	
Kennedia prostrata		x	
Nemcia reticulata		x	
Oxylobium lineare			x
Pultenaea reticulara	x	x	
Sphaerolobium medium			x
Viminaria juncea			x
Polygalaceae			
Comesperma virgatum			x
Proteaceae			
Adenanthos cygnorum	x	x	
Banksia attenuata	x		
Banksia grandis		x	
Banksia ilicifolium		x	
Banksia littoralis			x
Banksia menziesii	x		
Conospermum stoechadis	x		
Persoonia saccata	x		

Species	Dry	Transitional	Wet
Petrophile linearis	x		
Stirlingia latifolia	x		
Synaphaea spinulosa	x		
Rubiaceae			
Opercularia hispidula			x
Rutaceae			
Eriostemon spicatus	x		
Boronia ramosa			x
Stylidiaceae			
Stylidium aff. piliferum	x		
Stylidium brunonianum	x		
Stylidium calcaratum	x		
Stylidium diuroides	x		
Stylidium junceum			x
Stylidium macrocarpum	x		
Stylidium repens	x		
Stylidium schoenoides	x		
Thymeleaceae			
Pimelea leucantha	x		
Violaceae			
Hybanthus calycinus	x		
Stackhousiaceae			
Stackhousia huegelii			x

APPENDIX 4

LIST OF VEGETATION ASSOCIATIONS RECORDED AT EGERTON

EGERTON VEGETATION TYPES

BaBm	*Banksia attenuata/B. menziesii* Low Woodland
EcBa	*Eucalyptus calophylla/Banksia attenuata* Woodland
BmBaBi	*Banksia menziesii/B. attenuata/B. ilicifolium* Low Woodland
Ac	*Adenanthos cygnorum* Open Scrub
EcMp	*Eucalyptus calophylla* Woodland over *Melaleuca preissiana* Low Woodland
MpJp	*Melaleuca preissiana* Low Woodland over *Juncus pallidus* Sedgeland
Jp	*Juncus pallidus* Sedgeland
Pe	*Pericalymma ellipticum* Closed Heath
Al	*Agonis linearifolia* Open Heath over *Juncus pallidus* Sedgeland
MpAl	*Melaleuca preissiana* Low Open to Low Woodland over *Agonis linearifolia* Closed Heath
AfHa	*Astartea fascicularis/Hypocalymma ellipticum* Closed Heath
MpErBl	*Melaleuca preissiana/Eucalyptus rudis* Closed Forest with *Banksia littoralis*
ErMp	*Eucalyptus rudis* Open Forest over *Melaleuca preissiana* Low Woodland
MrEr	*Melaleuca rhaphiophylla/Eucalyptus rudis* Low Closed Forest
MpPe	*Melaleuca preissiana* Low Open Woodland over *Pericalymma angustifolium* Closed Heath
Er	*Eucalyptus rudis* Open Forest
Bar	*Baumea articulata* Closed Sedgeland
Mr	*Melaleuca rhaphiophylla* Low Closed Forest
As	*Acacia saligna* Low Woodland over *Agonis linearifolia* Open Heath
Em	*Eucalyptus marginata* Woodland
Mp	*Melaleuca preissiana* Low Woodland
Ha	*Hypocalymma angustifolium* Closed Heath
MpAf	*Melaleuca preissiana* Low Open Woodland over *Astartea fascicularis* Closed Heath
Ec	*Eucalyptus calophylla* Woodland

APPENDIX 5

LIST OF VERTEBRATE FAUNA RECORDED AT EGERTON, ELLENBROOK & WHITEMAN PARK

Amphibian and reptile species recorded on the coastal plain between the Swan and Moore Rivers, indicating those species known (+) at Ellenbrook, Whiteman and Melaleuca Parks and Egerton.

Species present on the northern Swan Coastal Plain	Species present at: Ellenbrook Park	Whiteman Park	Melaleuca Park	Egerton
FROGS				
Leptodactylidae (Ground Frogs)				
Crinia georgiana	+	+	+	+
Heleioporus albopunctatus				
Heleioporus barycragus				
Heleioporus eyrei	+	+	+	+
Heleioporus inornatus				+
Heleiporus psammophilus				
Limnodynastes dorsalis	+	+		+
Myobatrachus gouldii	+	+		
Neobatrachus pelobatoides				
Pseudophryne guentheri	+	+	+	
Ranidella glauerti	+		+	+
Ranidella insignifera	+	+	+	+
Hylidae (Tree Frogs)				
Litoria adelaidensis	+		+	
Litoria moorei	+			
TORTOISES				
Chelidae (Side-neck Tortoises)				
Chelodina oblonga	+	+	+	
Pseudemydura umbrina				
LIZARDS				
Gekkonidae (Geckoes)				
Crenadactulus ocellatus				
Diplodactylus alboguttatus		+		
Diplodactylus polyopthalmus				
Diplodactylus spinigerus	+		+	+
Gehyra variegata				
Heteronotia binoei				
Phyllodactylus marmoratus		+		
Underwoodisaurus milii				

Species present on the northern Swan Coastal Plain	Species present at: Ellenbrook Park	Whiteman Park	Melaleuca Park	Egerton
Pygopodidae (Legless Lizards)				
Aclys concinna				
Aprasia pulchella				
Aprasia repens	+	+	+	
Delma fraseri	+		+	
Delma grayii				
Lialis burtonis	+	+	+	
Pletholax gracilis	+	+		
Pygopus lepidopodus		+	+	
Agamidae (Dragons)				
Ctenophorus ornatus				
Pogona minor	+	+	+	+
Tympanocryptis adelaidensis	+	+	+	
Varanidae (Monitors or Goannas)				
Varanus gouldii	+	+		
Varanus rosenbergi		+		
Varanus tristis				
Scincidae (Skinks)				
Bassiana trilineata	+	+	+	
Cryptoblepharus plagiocephalus	+	+	+	+
Ctenotus delli				
Ctenotus fallens	+	+	+	
Ctenotus gemmula	+	+	+	
Ctenotus impar		+		
Ctenotus labillardieri				
Ctenotus lesueurii	+	+	+	
Cyclodomorphus branchialis				
Egernia kingii				
Egernia luctuosa				
Hemiergis initialis				
Egernia napoleonis	+	+	+	+
Hemiergis quadrilineata	+			+
Lerista christinae	+			
Lerista distinguenda				
Lerista elegans	+	+	+	+
Lerista lineata				
Lerista lineopunctulata				
Lerista praepedita	+		+	+
Menetia greyii	+	+	+	+
Morethia lineoocellata	+	+	+	
Morethia obscura	+	+	+	
Tiliqua occipitalis	+	+		

Tiliqua rugosa	+	+	+	
SNAKES				
Typhlopidae (Blind Snakes)				
Ramphotyphlops australias	+	+		
Ramphotyphlops bituberculata				
Ramphotyphlops pinguis				
Ramphotyphlops waitii				
Boidae (Pythons)				
Morelia spilota				
Morelia stimsoni				
Elapidae (Front-fanged Snakes)				
Acanthophis antarcticus				
Demansia psammophis				
Demansia reticulata				
Notechis coronatus				
Notechis curtus				
Notechis scutatus	+	+		+
Pseudechis australis				
Pseudonaja affinis	+	+	+	
Pseudonaja modesta				
Pseudonaja nuchalis				
Rhinoplocephalus gouldii	+	+	+	
Rhinoplocephalus nigriceps				
Vermicella bertholdi	+		+	
Vermicella bimaculata			+	
Vermicella calonotus	+	+	+	
Vermicella fasciolata		+		
Vermicella semifasciata	+			

Totals	North Swan Coastal Plain (WA Museum, 1978)	Species positively identified at: Ellenbrook	Whiteman Park	Melaleuca Park	Egerton
Frogs	14	9	6	7	6
Tortoises	2	1	1	1	
Geckoes	8	1	2	1	1
Pygopods	8	4	4	3	
Dragons	3	2	2	2	1
Varanids	3	1	2		
Skinks	25	15	13	12	6
Snakes	23	7	6	5	1
TOTAL	86	40	36	31	15

Species of birds present at Ellenbrook (RAOU) and Whiteman Park (Arnold et al, 1991) Compared to those confirmed at Egerton.

Species	Ellenbrook and/or Whiteman Park	Confirmed at Egerton
Emu/*Dromaius novaehollandiae*	+	+
Australasian Grebe/*Tachybaptus novaehollandiae*		+
Pacific Heron/*Ardea pacifica*	+	
Little Pied Cormorant/*Phalacrocorax melanoleucos*		+
Sacred Ibis/*Threskiornis aethiopica*		+
Australian Shelduck/*Tadorna tadornoides*		+
Pacific Black Duck/*Anas superciliosa*		+
Black-shouldered Kite/*Elanus notatus*	+	+
Brown Goshawk/*Accipiter fasciatus*	+	
Collared Sparrowhawk/*Accipiter cirrhocephalus*	+	
Wedge-tailed Eagle/*Aquila audax*	+	+
Australian Hobby/*Falco longipennis*	+	
Brown Falcon/*Falco berigora*	+	
Australian Kestrel/*Falco cenchroides*	+	
Unidentified Quail/*Coturnix sp.*	+	
Eurasian Coot/*Fulica atra*		+
Swamp Hen/*Porphyrio porphyrio*		+
Laughing Turtle-Dove/*Streptopelia senegalensis* (i)		+
Common Bronzewing/*Phaps chalcoptera*	+	
Little Corella *Cacatua pastinator*		+
Pink & Grey Galah/*Cacatua roseicapilla*		+
Red-capped Parrot/*Purpureicephalus spurius*	+	
Ringnecked Parrot '28'/*Barnardius zonarius*	+	+
Elegant Parrot/*Neophema elegans*	+	
Fan-tailed Cuckoo/*Cuculus pyrrhophanus*	+	+
Shining Bronze-Cuckoo/*Chrysococcyx lucidus*		+
Southern Boobook Owl/*Ninox novaeseelandiae*	+	
Barn Owl/*Tyto alba*	+	
Tawny Frogmouth/*Podargus strigoides*	+	
Australian Owlet-nightjar/*Aegotheles cristatus*	+	
Fork-tailed Swift/*Apus pacificus*	+	
Laughing Kookaburra/*Dacelo novaeguineae*		+
Sacred Kingfisher/*Halcyon sancta*	+	+

Rainbow Bee-eater/*Merops ornatus*	+	+
Welcome Swallow/*Hirundo noexena*	+	
Tree Martin/*Cecropis nigricans*	+	
Black-faced Cuckoo-shrike/*Coracina novaehollandiae*	+	+
Scarlet Robin/*Petroica multicolor*	+	
Hooded Robin/*Melandryas cucullata*	+	
Rufous Whistler/*Pachycephala rufiventris*	+	+
Golden Whistler/*Pachycephala pectoralis*	+	
Grey Shrike-thrush/*Collurcincla harmonica*	+	+
Grey Fantail/*Rhipidura fuliginosa*	+	+
Willie Wagtail/*Rhipidura leucophrys*	+	+
Australian Reed Warbler/*Acrocephalus australis*	+	+
Splendid Wren/*Malurus splendens*		+
Weebill/*Smicrornis brevirostris*	+	
Western Warbler/*Gerygone fusca*	+	+
Brown Thornbill/*Acanthiza apicalis*	+	+
Western Thornbill/*Acanthiza inornata*	+	
Yellow-rumped Thornbill/*Acanthiza chrysorrhoa*	+	
Varied Sittella/*Daphoenositta chrysoptera*	+	
Red Wattlebird/*Anthochaera carunculata*	+	+
Little Wattlebird/*Anthochaera chrysoptera*	+	+
Yellow-throated Miner/*Manorina flavigula*	+	
Singing Honeyeater/*Lichenostomus virescens*	+	
Brown-headed Honeyeater/*Melithreptus brevirostris*	+	
Brown Honeyeater/*Lichmera indistincta*		+
New Holland Honeyeater/*Phylidonyris*	+	
novaehollandiae	+	+
White-cheeked Honeyeater/*Phylidonyris nigra*	+	
Tawny-crowned Honeyeater/*Phylodonyris melanops*	+	+
Western Spinebill/*Acanthorhynchus superciliosus*	+	
Mistletoebird/*Dicaeum hirundinaceum*	+	
Spotted Pardalote/*Pardalotus punctatus*	+	
Striated Pardalote/*Pardalotus striatus*	+	+
Red-eared Firetail/*Emblema oculata*	+	+
Australian Magpie-lark/*Grallina cyanoleuca*	+	
Masked Woodswallow/*Artamus personatus*	+	
Grey Butcherbird/*Cracticus torquatus*	+	
Magpie *Gymnorhina tibicen*	+	+
Australian Raven *Corvus coronoides*		
Total present	57	36

KEY: (+) Present (i) Introduced Species

Mammal Species Confirmed at Ellenbrook, Whiteman Park (Arnold et al, 1991) and Egerton.

Species Found on the Swan Coastal Plain	Species confirmed at: Ellenbrook	Whiteman Park	Egerton
Tachyglossidae (Echidnas)			
Tachyglossus aculeatus/Echidna		+	
Dasyuridae			
Sminthopsis griseoventer/Dunnart			
Dasyurus geoffroii/Chuditch			
Peramelidae (Bandicoots)			
Isoodon obesulus/Southern Brown Bandicoot	+	+	+
Phalangeridae (Possums)			
Trichosurus vulpecula/Brush-tailed Possum			
Burramyidae (Pygmy Possums)			
Cercartetus concinnus/Western Pygmy Possum			
Tarsipedidae (Honey Possums)			
Tarsipes rostratus/Honey Possum		+	+
Macropodidae (Kangaroos and Wallabies)			
Macropus fuliginosus/Western Grey Kangaroo	+	+	+
Macropus irma/Western Brush Wallaby	+	+	
Mollosidae (Mastiff Bats)			
Tadarida australis/White-striped Bat			
Mormopterus planiceps			
Vespertilionidae (Vesper Bats)			
Chalinolobus gouldii/Gould's Wattled Bat			
Chalinolobus morio/Chocolate Wattled Bat			
Eptesicus regulus			
Nyctophilus geoffroyi/Lesser Long-eared Bat			
Nyctophilus major/Greater Long-eared Bat			
Muridae (Rats and Mice)			
Hydromys chrysogaster/Water Rat		+	
Mus musculus/House Mouse (i)		+	+
Pseudomys albocinereus/Ash-grey Mouse		+	
Rattus fuscipes/Southern Bush-Rat			
Rattus rattus/Black Rat (i)		+	+

Leporidae (Rabbits and Hares)			
Oryctolagus cuniculus/Rabbit (i)	+	+	+
Canidae (Foxes and Dogs)			
xVulpes vulpes/European Red Fox (i)	+	+	+
Felidae (Cats)			
Felis catus/Feral Cat (i)			
Number of species confirmed:			
Native	3	7	3
Introduced	2	4	4