

6.0 Resource Inventory

6.1 Natural Context of the Landscape

6.1.1 Geological History

The Swan River Landscape study area comprises two distinct geological zones separated by the Darling Fault, the Yilgarn Block to the east and the Perth Basin to the west. The Yilgarn Block is dominated by the ancient granitic rocks of the Western Shield which is a block of Precambrian crystalline rocks that forms the core of the continent and has remained basically stable for 570 million years. Phanerozoic sediments (younger than 570 million years) are rare in the Yilgarn Block and are confined to local depressions on the shield surface and to drainage channels.

The western margin of the Yilgarn Block is defined by the Darling Fault which is obscured by sediments but is now located approximately 1 to 3 km west of the Darling Scarp, which is its surface expression (DCE, 1980).

West of the Darling Fault and marginal to the Western Shield is the Perth Basin, a sedimentary trough filled with Phanerozoic rocks up to 15,000 m deep, which runs north and south slightly west of the Darling Scarp (Seddon, 1972). Mostly rocks of Cretaceous age (140-70 Ma B.P) or younger crop out in the Perth Basin although a portion of the Precambrian Western Shield has been preserved on the western side of the Basin and appears as the Leeuwin-Naturaliste Ridge.

At the beginning of the Phanerozoic (570 Ma B.P) Australia formed part of a single supercontinent, Gondwanaland, which subsequently broke up. The resulting land masses then became separated by the process of sea-floor spreading from mid-oceanic ridges. It is generally accepted that India and Antarctica were the land masses bordering Western Australia. As part of the breakaway from the Indian land mass, a rift- valley formed along the Perth Basin with the Darling Fault as its eastern margin. The floor of the rift-valley subsided deeply, so that sediments derived from erosion of both adjacent continents were deposited in it.

During the Permian (280-250 Ma B.P), Australia occupied a more polar position and widespread glaciation took place. The oldest rocks generally encountered in the Perth Basin are from this Permian age and there are thick glacial accumulations of similar age in India (Seddon, 1972). Separation of India from Australia is believed to have been completed during the Jurassic period. In the Perth Basin early in the Cretaceous (140 Ma B.P).

The Darling Fault was very active throughout the Jurassic (205-140 Ma B.P), fluvial sediments accumulated on the subsiding basin and are believed to be at least 4200 m thick (Playford *et al*, 1976). A period of uplift and erosion occurred believed to have been completed during the Jurassic period. The erosion was followed by a period of marine sedimentation to a thickness of as much as 12,000 m.

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At the end of the Cretaceous period (65 Ma B.P) the whole continent began to rise, marine sediments deposited in the Tertiary (65-2.5 Ma B.P) now make up a subsurface layer of shale, limestone and dolerite to a thickness of up to 600 m. During this time the Kings Park Formation was also deposited. It is a shallow-marine to estuarine deposit laid down in the drowned river valley or submarine canyon of the ancient Swan River estuary and consists mainly of shale and siltstone overlain by Quaternary deposits (Playford *et al*, 1976).

The soil types of the Swan River System are shown in Figure 2. During the past 2.5 million years fluctuating sea levels have resulted in the deposition of sediments of marine, aeolian and alluvial origin which blanket most of the Perth Basin. They consist of coastal deposits, coastal dunes, alluvium, laterite and associated sands (Playford *et al*, 1976).

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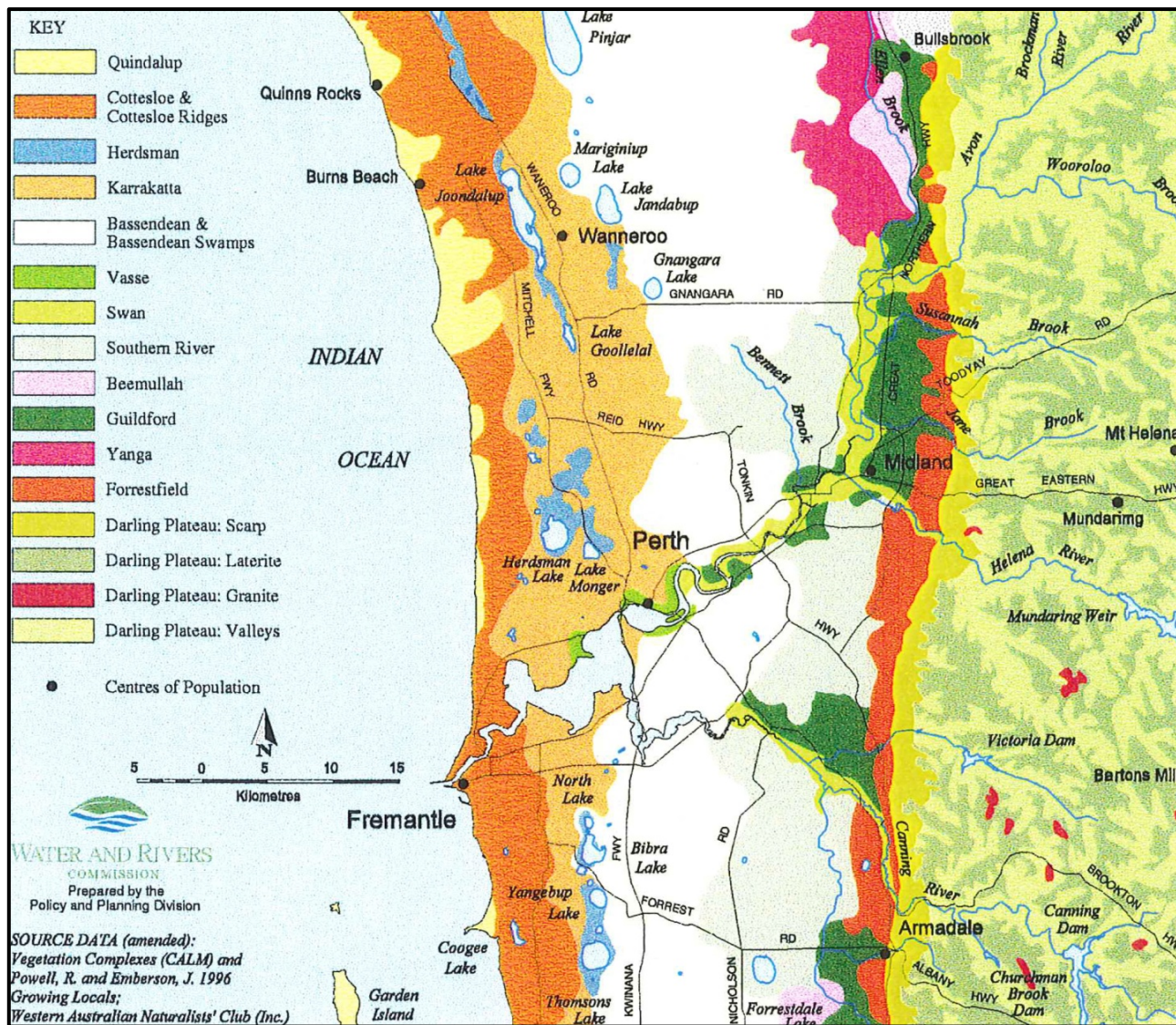
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Figure 2: Soil types of the Swan River system and surrounding areas



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6.1.2 Geomorphological Evolution

The Swan Coastal Plain consists of a large area within the Perth Basin bordered on the east by the Darling Scarp, on the west by the Indian Ocean, the Hill River Scarp to the north and Cape Naturaliste to the South. The Swan Coastal Plain has been built up by the accumulation of marine, aeolian and alluvial sediments over time.

Five main geomorphic units have been identified on the Swan Coastal Plain, the Ridge Hill Shelf, the Pinjarra Plain and the Bassendean, Spearwood and Quindalup Dune systems (Seddon, 1972). These deposits generally show a progressive decrease in age and elevation passing from east to west and their locations are shown in Figure 3.

The easternmost unit of the Swan Coastal Plain is the Ridge Hill Shelf which forms the foothills of the Darling Scarp and consists of a series of laterite-covered spurs which are the remnants of a once continuous feature that has been eroded eastward over time (Pilgrim, 1979). The Ridge Hill Shelf slopes gently westward and is dissected by many microscale channels. The soils generally have a high iron and alumina content and have good drainage capabilities. The slope and drainage of the shelf does not allow the ponding of water and therefore swamps are rare.

The Pinjarra Plain is an alluvial plain at the foot of the Darling Scarp. The Pinjarra Plain has been built up by the deposition of alluvial sediments brought down by the streams of the plateau. Deposition began with the retreat of the sea during the Riss glacial period about 240,000 years ago (McArthur and Bettenay, 1974). The plain is surfaced mainly by clays and loams in the valley flats and by poorly sorted clayey sands and gravels in the piedmont zone (Playford et al, 1976).

These soils are relatively fertile, in comparison with other soils of the Swan Coastal Plain. The plain is dominated by various sized channels and although the soils are tolerably well drained the flatness of the plain results in the formation of small seasonal swamps (Seddon, 1972).

The Bassendean Dune System is the oldest of the dune systems of marine origin and today consists of a series of low hills varying from 20 m to almost flat which rise to 110 m above sea level. They were formed as a belt of coastal dunes and associated shoreline deposits which accumulated mostly during a period of high sea level, about 115,000 years ago during the Riss-Wurm interglacial period (McArthur and Bettenay, 1974). The dunes were probably largely calcareous with a smaller proportion of quartz sand but over time the soluble calcium carbonate has been leached out leaving the infertile grey quartz sand found today (Seddon, 1972). The present shape of the dunes is largely inherited from the original coastal dunes but the relief has been much diminished as a result of the leaching (Playford *et al*, 1976). The excessive permeability of the sands leads to a characteristic lack of drainage channels but the dunes lie over an almost impermeable organic hard pan which is close to the surface in many of the interdunal depressions, so while the sand ridges are excessively drained the swales become saturated with water, creating seasonally inundated basins (Semenuik, 1988).

Following the formation of the Bassendean Dunes there was a considerable break before the accumulation of the relatively youthful Spearwood Dunes began in the Wurm I interstadial about 80,000 years ago (McArthur and Bettenay, 1974). The topography and composition of the Spearwood Dunes differ markedly from the Bassendean Dune System. The hills are higher and the soils are less leached, the yellow colour shows that there are still appreciable amounts of iron in the soil. The surface soils are leached and the carbonate has been precipitated below to form layers and columns of hard, compact limestone deposited from solution by percolating waters (Seddon, 1972). Along the western fringes of the Spearwood Dunes the limestone has been extensively exposed by wind action with the material removed being deposited to the east. The dunes form linear, continuous parallel ridges and intervening narrow and steep-sided depressions (Semenuik, 1988). The contact between the eastern margin of the Spearwood Dunes and the Bassendean Dunes is marked by a line of swamps and lakes which may represent old lagoons cut off by foredunes from a prograding shoreline.

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The Spearwood Dunes are characterised by an absence of drainage channels and the wetlands tend to be irregular to elongate basins forming linear chains due to the strong inheritance in the lithified, parallel dune sets (Semenuik, 1988).

The Quindalup Dunes occur as a series of elongated dunes generally running parallel to the current coastline and are associated with a falling sea level over the past 5000 years. The dunes are restricted to a narrow coastal strip and are often separated from the Spearwood System by a line of lakes or inlets (McArthur and Bettenay, 1974). They consist of calcareous sands which are high in lime but low in soluble salts; the sands are mostly unconsolidated although there is some cementing in lower layers as lime dissolved from surface layers is redeposited at depth (Seddon, 1972).

The lakes, inlets and estuaries of the Swan Coastal Plain show a distinct lineation parallel to the coastline in relation to the three dune systems (Seddon, 1972). That they generally occur along the boundaries between adjacent dune systems shows that each dune system formed independently (McArthur and Bettenay, 1974). The estuarine reaches of the Swan and Canning Rivers show this relationship to the dune topography. The broadwaters of the Swan at Freshwater Bay and Melville Water and all of the lower Canning estuary to Bull Creek are north-south lake-like elongations that occupy interdunal depressions (Seddon, 1972).

The many small streams running off the Scarp flow in narrow, deep, steep-sided valleys. As the streams flow into the permeable sediments of the plain much of their water is lost, hence sediments are dropped and alluvial fans are formed. The formation of the alluvial fans which have coalesced with time has resulted in the gently undulating surface that we see on the Pinjarra Plain today (Seddon, 1972). A feature of the streams entering the Pinjarra Plain is that they are diverted either north or south and enter the ocean at a few select points. In some cases the dunes have diverted the streams, but McArthur and Bettenay (1974) believe that headward erosion and river capture is a more likely explanation.

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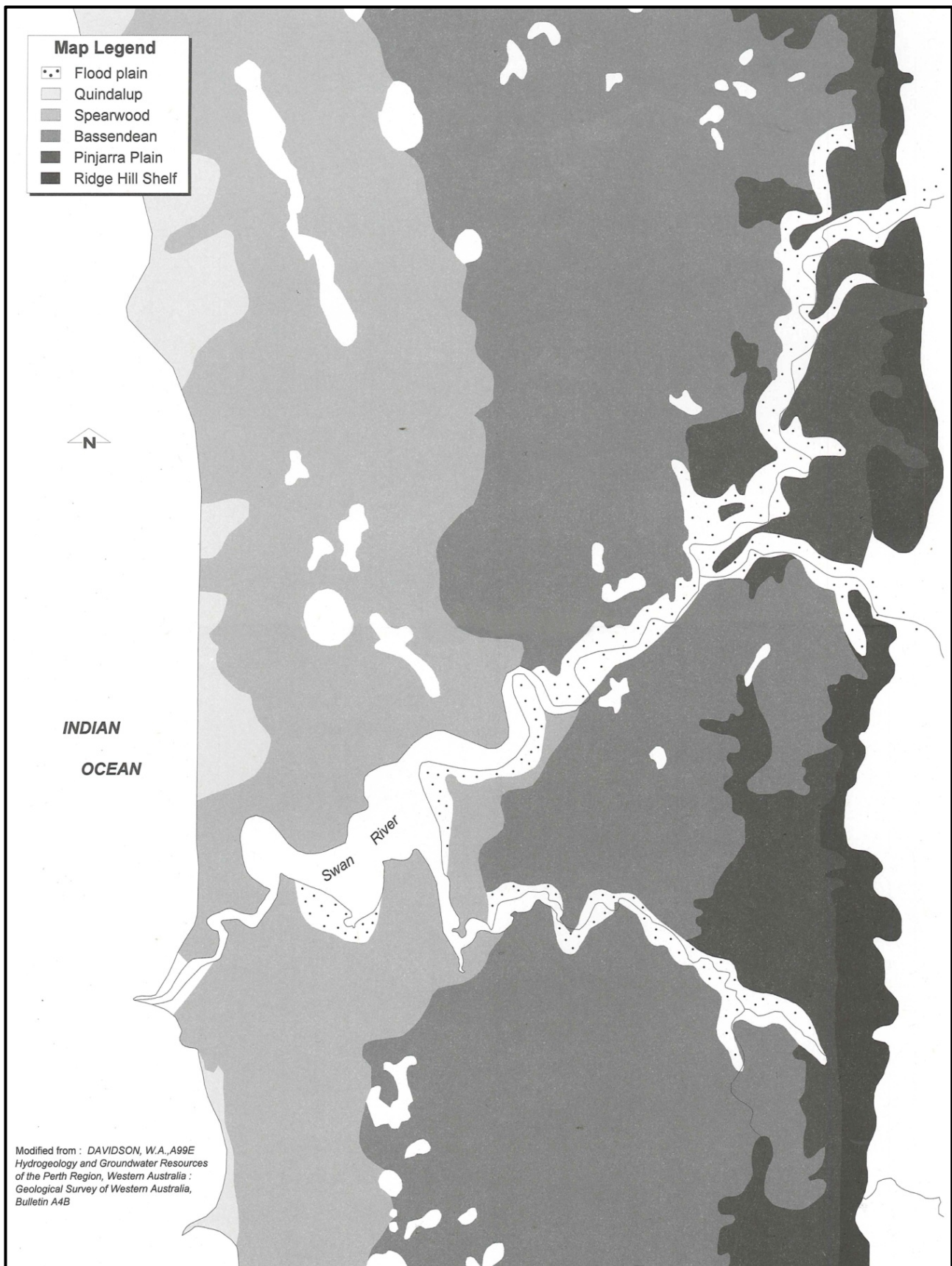
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6.1.3 Changing Climate

South West Australia has not been glaciated since the Permian (260 Ma B.P) when the continents were merged as one land mass. During the Cretaceous period the continents of Gondwana separated and moved apart. Although Australia occupied a polar position the temperature gradient across latitudes was much less marked than today and the climatic conditions of Australia would have been broadly similar to those at present (Summerfield, 1991). Toward the end of the Cretaceous there is evidence of a slight cooling but this trend was reversed during the early Tertiary.

Figure 3: Geomorphology of the Swan River System and surrounding areas

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At the beginning of the Tertiary (65 Ma B.P) Australia was still connected to Antarctica but the seas of the high latitudes would have been much warmer than today and there is no evidence of an icecap on Antarctica at that time (Barlow, 1981). The final separation of Australia from Antarctica approximately 40 Ma B.P initiated circumpolar oceanic currents, reducing heat transfer from equator to the pole and increasing the temperature gradient across latitudes. This resulted in an expansion of the Arctic ice sheet and in parts of Australia the levels of precipitation would have fallen with progressive aridity and the establishment of a Mediterranean climate as Australia drifted northwards (Hopper, 1993). In the early Pliocene (5 Ma B.P) there is evidence of an ice-surge which would have resulted in a lowering of temperatures in Australia and an increase in dry anticyclonic circulation. This was followed by a Pliocene warming and then a second cooling in the late Pliocene (Barlow, 1981). Glacial-interglacial cycles resulting in large scale oscillations in temperature had now become established with the warm interglacials being wetter than the cool glacials (Kershaw, 1981). The fluctuations in ice sheet volume during glacial- interglacial cycles have been the primary control of global sea level change for at least the past 2 Ma. As discussed in the previous section these sea level changes resulted in the formation of the dune systems of the Swan Coastal Plain. Sea level and temperature changes are also major factors controlling precipitation levels. Lower sea levels caused by the expansion of the ice sheets expose the continental shelf. This combined with lower sea surface temperatures causes a reduction in the warm shallow water available to form atmospheric moisture which decreases precipitation (Kershaw, 1981).

Approximately 6500 Ma B.P. there was a warm, wet phase that was favourable for plant expansion and diversification. Since about 5000 BP there has been a recession of precipitation to present levels which are considered intermediately favourable to vegetation communities. Around 1800-1200 B.P. the climate was quite arid resulting in the building of the Quindalup Dune System and the regression of vegetation (Beard, 1981).

The south-west region which contains the study area has a current climate that is distinguished by its succession of abundant winter rains and intense summer drought which characterise the 'Mediterranean' climate. A subtropical belt of high pressure breaks down into anticyclonic cells which move south in the summer and north in the winter. The prevailing air circulation over the south west region is anticlockwise with a dominant westerly component in the winter and an easterly component in the summer (Gentilli, 1972). Relief from the hot, dry easterly winds in summer comes from the south-westerly afternoon Seabreeze.

Summer temperatures average 29°C maximum and 17°C minimum. In the winter the average maximum temperature is 18°C with a 9°C minimum. The average annual rainfall recorded at the Perth Airport is 801 mm with the majority of the rain falling between May and August inclusive (Bureau of Meteorology, 1995). The combination of hot dry summers with afternoon south-westerly winds averaging about 20-40 km per hour creates an environment in which forest and bush fires are liable to occur (Rippey & Rowland, 1995).

Table 6: Climate averages from Perth Airport data collected from 1944-1993 (Bureau of Meteorology, 1995)

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean monthly rainfall (mm)	7	17	15	45	107	176	162	118	69	47	26	12	801
Mean daily max (°C)	31.5	31.6	29.4	25.2	21.4	18.7	17.7	18.2	20	22.3	25.4	28.5	24.2
Mean daily min (°C)	16.8	17.4	15.8	12.8	10.3	9	8	8	8	10.1	12.4	14.7	12.0

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6.1.4 Plant Communities

The vegetation of a landscape is an essential element in defining local character and location. Dominant species are important key elements enabling the viewer to recognise the locality of the viewed scene. Many people, even if they do not know the names of plants, will recognise the difference between the low coastal species' and open woodlands and scrub of the sandy coastal plain.

Vegetation can be classified according to the taxonomic classification; or by groups or classes according to characteristics such as main growth form, vegetation species dominance or structural dominance.

There is no single correct way to classify plants and the type of classification used in this document has been chosen as it was considered the most useful for landscape interpretation. This document has used the Department of Conservation and Environment vegetation classification (1980). This system is based on the types of vegetation communities and how they relate to the landforms, soils and rainfall (Hedde, 1979; DCE 1980). The location of vegetation complexes is shown on Figure 4 and they are described in brief in Table 7.

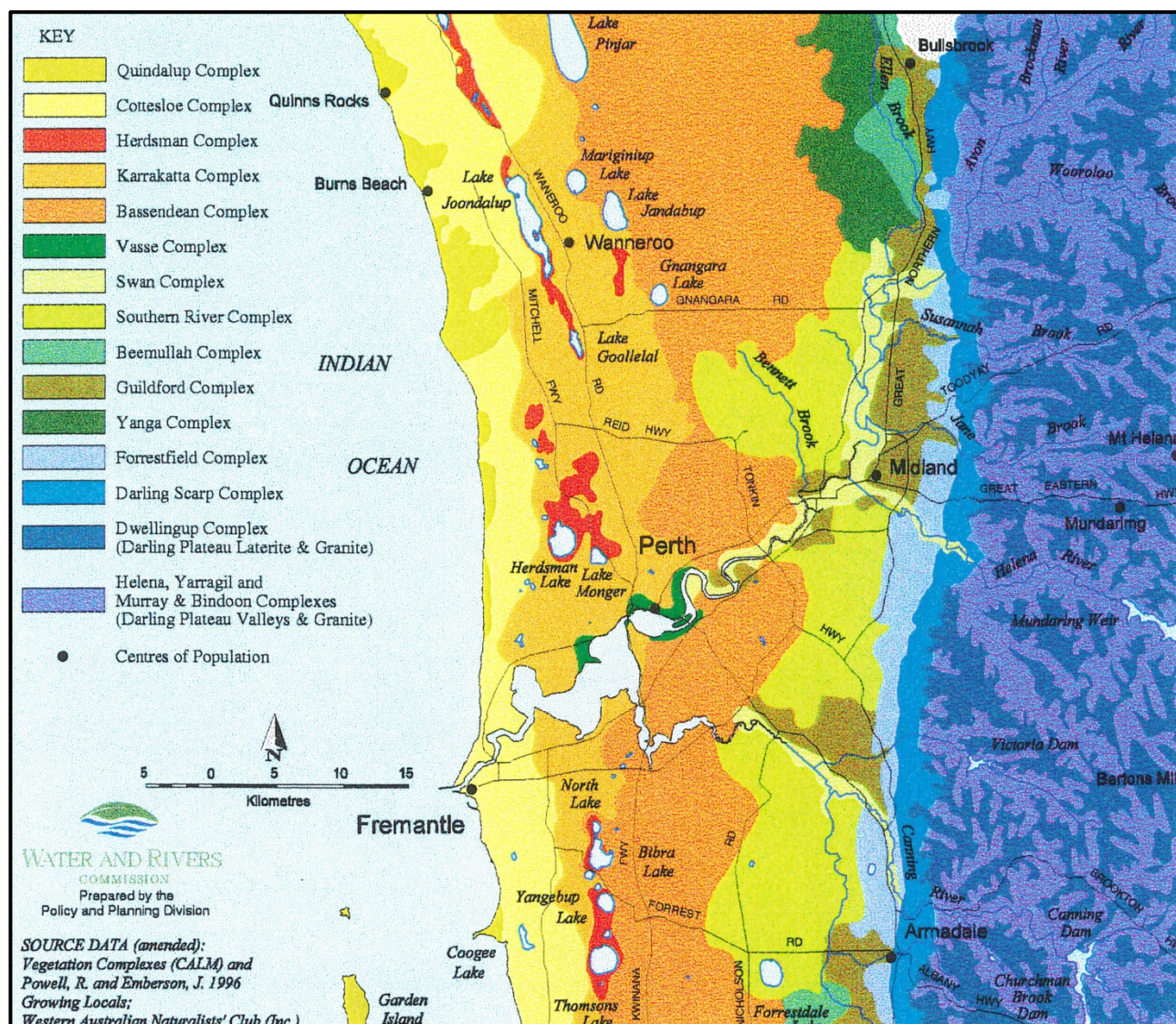
Table 7: Vegetation complexes of the Swan River landscape study area. Modified from Department of Conservation and Environment (1980)

Bassendean Complex	Vegetation ranges from woodland of <i>Eucalyptus marginata</i> - <i>Allocasuarina fraseriana</i> - <i>Banksia</i> species to low woodland of <i>Melaleuca</i> species, and sedgelands on the moister sites. This area includes the transition of <i>Eucalyptus marginata</i> to <i>Eucalyptus tottiana</i> in the vicinity of Perth. Occurs on the aeolian deposits of the Swan Coastal Plain.
Beemullah Complex	Mixture of low open forest of <i>Casuarina obesa</i> and open woodland of <i>Eucalyptus calophylla</i> - <i>Eucalyptus wandoo</i> - <i>Eucalyptus marginata</i> . Minor components include closed scrub of <i>Melaleuca</i> species and occasional occurrence of swamp Cyprus (<i>Actinostrobus pyramidalis</i>)
Bindoon Complex	Woodlands of <i>Eucalyptus loxophleba</i> with <i>Eucalyptus wandoo</i> - <i>Eucalyptus accedens</i> on the upper slopes and breakaways. Found on the major valley floors and scarps of the Darling Plateau.

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Cottesloe Complex	Mosaic of woodland of <i>Eucalyptus gomphocephala</i> and open forest of <i>Eucalyptus gomphocephala</i> - <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> -, closed heath on the limestone outcrops. The complex is found on the aeolian deposits of the Swan Coastal Plain.
Darling Scarp Complex	Vegetation ranges from low open woodland to lichens according to depth of soils. Woodland components chiefly <i>Eucalyptus wandoo</i> with <i>Eucalyptus laeliae</i> in the north, <i>Eucalyptus haematoxylon</i> in the south and <i>Eucalyptus calophylla</i> throughout the Darling Plateau region. Found on the major valley floors and scarps of the Darling Plateau.
Dwellingup Complex	Open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> found on the lateritic uplands of the Darling Plateau. Understorey includes <i>Grevillea diversifolia</i> and <i>Adenanthos barbigerus</i> .
Forrestfield Complex	Vegetation ranges from open forest of <i>Eucalyptus calophylla</i> - <i>Eucalyptus wandoo</i> - <i>Eucalyptus marginata</i> to open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> - <i>Casuarina fraseriana</i> - <i>Banksia species</i> . Fringing woodland of <i>Eucalyptus rudis</i> in the gullies that dissect the Ridge Hill Shelf.
Guildford Complex	A mixture of open forest to tall open forest of <i>Eucalyptus calophylla</i> - <i>Eucalyptus wandoo</i> - <i>Eucalyptus marginata</i> and woodland of <i>Eucalyptus wandoo</i> (with rare occurrences of <i>Eucalyptus lane-poolei</i>). Minor components include <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> . Occurs on fluvial deposits of the Swan Coastal Plain.
Helena Complex	Vegetation ranges from open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> - <i>Eucalyptus patens</i> through to heath and herbland to lichens on granite rock. Found in major valleys combining slopes and floors of the Darling Plateau.
Herdsmen Complex	Sedgeland and fringing woodlands of <i>Eucalyptus rudis</i> - <i>Melaleuca species</i> . Found on the aeolian deposits of the Swan Coastal Plain.
Karrakatta Complex	Predominantly open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> and woodland of <i>Eucalyptus marginata</i> - <i>Banksia species</i> . Found on aeolian deposits of the Swan Coastal Plain.
Murray Complex	Vegetation ranges from open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> with <i>Eucalyptus patens</i> on the slopes to fringing woodland of <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> on the valley floors. It is found on the major valleys and slopes of the Darling Plateau.
Quindalup Complex	Coastal Dune Complex consisting mainly of two alliances - the strand and foredune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of <i>Melaleuca lanceolata</i> - <i>Callitris preissii</i> and the closed scrub of <i>Acacia saligna</i> .
Southern River Complex	Open woodland of <i>Eucalyptus calophylla</i> - <i>Eucalyptus marginata</i> - <i>Banksia species</i> with fringing woodland of <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> along creek beds. This complex is found on aeolian deposits of the Swan Coastal Plain.
Swan Complex	Fringing woodland of <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> with localised occurrence of low open forest of <i>Casuarina obesa</i> and <i>Melaleuca cuticularis</i> . Found on the alluvial deposits of the Swan Coastal Plain.
Vasse Complex	Mixture of the closed scrub of <i>Melaleuca species</i> ; fringing woodland of <i>Eucalyptus rudis</i> - <i>Melaleuca species</i> and open forest of <i>Eucalyptus gomphocephala</i> - <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> . Found on marine origin deposits of the Swan Coastal Plain.
Yanga Complex	Predominantly closed scrub of <i>Melaleuca species</i> and low open forest of <i>Casuarina obesa</i> on the flats subject to inundation. On drier sites the vegetation reflects the adjacent to the Bassendean Complex.
Yarragil Complex	Open forest of <i>Eucalyptus marginata</i> - <i>Eucalyptus calophylla</i> . Typically found in the minor valleys of the Darling Plateau.

Figure 4: Vegetation complexes of the Swan River system and surrounding areas



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For the landscape description, it was considered that a classification which took soils and landform into consideration would be useful in areas where there has been dramatic modification of plant communities. If rehabilitation were to be considered, the soil and landform alone would be sufficient guide to which species would be appropriate to an area. The main plants associated with soil types of the Swan Coastal Plain are listed in Section 9. This list is not intended to be comprehensive; rather it provides a starting point for people considering establishing indigenous plants. As a background description, the types of plant communities found in the study area are outlined below.

Background

The composition and structure of south-west Western Australia is dependent on several factors. The importance of climate as a controlling influence on the vegetation type is quite evident and the seasonality of the Mediterranean climate has resulted in a uniquely adapted flora. The different landforms and the generally nutrient-poor soils are also important factors in determining plant types and distribution. In evolutionary terms, this area is the product of highly leached nutrient-poor soils, cool to warm Mediterranean climate, and physical isolation, and many of the species and complexes are unique to the region. Recognisable features of this area include the predominance of sclerophyllous trees and shrubs, the unique floristic diversity of these shrub communities, the paucity of herbaceous plants and the high degree of endemism or uniqueness to this region (Beard, 1990). The plant communities and complexes on the Swan Coastal Plain and Darling Ranges are clearly associated with soil types which in turn are associated with the geomorphic elements, distance from the coast, and elevation. The dominant flora is mainly Banksia low woodland on leached sands with Melaleuca swamps where the land is poorly drained. Woodlands of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Eucalyptus calophylla*) occur on less leached soils (Beard, 1990).

The Quindalup Dune System is composed of generally unconsolidated calcareous sand, and supports several plant communities in a landward progression from the shoreline. Indigenous species include the grasses *Spinifex hirsutus* and *S. longifolius* (Erickson *et al*, 1988). Two species which commonly colonise the beaches are sea rocket (**Cakile maritima*) and **Arctotheca populifolia*, which are both introduced and are able to withstand the windy, alkaline and saline conditions of the beach environment, and so contribute to the formation of sand mounds and ridges.

The dune heath may consist of grasses, succulents, sedges or shrubs, and some typical species are *Spinifex hirsutus*-, sea spinach (*Tetragonia decumbens*)-, *Lipidosperma gladiatum*; and coastal daisy (*Olearia axillaris*). On the windward slopes of the stable dunes low dense thicket vegetation occurs and is dominated by *Acacia lasiocarpa* and *Melaleuca acerosa*.

Underlying the Spearwood Dune System is the Tamala Limestone that is the parent rock of the Cottesloe and Karrakatta Soil Associations. Beard (1990) has described the plant formations for the tuart-jarrah-marri tall open forest, and closed heath. The closed heath formation is found in the shallow soils and limestone outcrop areas of western Spearwood Dunes and is characterised by dense shrubs, with some of the more common species being cockies tongues (*Templetonia retusa*), chenille honeymyrtle (*Melaleuca huegelii*) and woolly bush (*Adenanthos sericeus*). Sedges may also be present. The tall open forest forms a belt approximately 10 - 12 km wide and the shallow, yellow and brown Cottesloe Soils in the west generally support tuart- dominant forest. This formation exhibits a small-tree layer, including peppermint (*Agonis flexuosa*), slender banksia (*Banksia attenuata*) and sheoak (*Allocasuarina fraseriana*). A tall-shrub layer, a low-shrub layer, and ground flora such as orchids and lilies comprise species such as blackboy (*Xanthorrhoea preissii*), slender myoporum (*Myoporum caprarioides*) and the zamia (*Macrozamia reidleyi*) (Beard, 1990). The deeper sands of the Karrakatta Soil Association in the eastern part of the Spearwood Dunes allow species such as jarrah (*Eucalyptus marginata*) and marri (*Eucalyptus calophylla*). A woodland formation of jarrah-banksia is also found over the Karrakatta Soils, and is very similar in structure to the tall open forest of the Cottesloe Soils.

However, the small-tree layer is very well developed with *Banksia* species being equally dominant with jarrah. The tall shrub-layer of the woodland is less prominent than that of the tuart-jarrah-marri forest, but includes similar common species such as *Jacksonia furcellata* and *Acacia saligna*.

The leached, grey quartz sands of the Bassendean System form low hills up to 50 - 60 m high with interdunal swamps, and support a low open forest formation (Seddon, 1972). The understorey layers are very diverse, and the dominant tree species are *Banksia attenuata*, *B. 'menziesii'*, *Allocasuarina fraseriana* and *Eucalyptus todtiana*. A formation confined to the Bassendean System is the marri-jarrah-banksia open woodland, in which the small tree and tall shrub strata are similar to those found in other formations. Jarrah is generally found on the higher slopes with marri occurring on lower slopes.

In the interdunal depressions there are many small swamps, and these occur within Spearwood and Bassendean geomorphic elements. There may be fringing woodland of flooded gum (*Eucalyptus rudis*) or swamp and low closed forest of paperbark. The common freshwater swamp paperbark (*Melaleuca raphiophylla*) is the dominant tree, and the saltwater paperbark (*Melaleuca cuticularis*) is also common, especially around salt and brackish water bodies. The moonah (*Melaleuca preissiana*) may occur on the drier swamp margins, in an open formation with an understorey of shrubs such as holly leaf banksia (*Banksia ilicifolia*). Belts of sedges and/or bulrushes extend into the water bodies and may include *Gahnia* sp, *Baumea articulata*, and the introduced **Typha orientalis*.

The Pinjarra Plain is composed of alluvial sediments that have been transported off the adjacent Darling Plateau by many small streams. Tall open forest of marri-wandoo-jarrah is restricted to certain soil types of the Pinjarra Plain and the geomorphic element known as the Ridge Hill Shelf. The relatively fertile soil associated with this vegetation formation has determined that most of the original forest formation has been cleared to some extent, with stands of marri and wandoo remaining amongst pasture.

The Darling Scarp is the western edge of the Darling Plateau. Where erosion on the slopes of the Scarp has exposed granite and laterite, shallow soils around the outcrops support communities of shrubs and herbs. The Darling Scarp receives almost the highest rainfall in the Perth Metropolitan Region. Where the soil is deep there are woodlands of marri (*Eucalyptus calophylla*), wandoo (*Eucalyptus wandoo*), flooded gum (*Eucalyptus rudis*) and jarrah (*Eucalyptus marginata*).

The Darling Plateau can be broadly classified into uplands, major valleys and minor valleys (Powell, 1990). The uplands are gently undulating and the soil surface is gravelly and supports jarrah dominated forest. Some marri (*Eucalyptus calophylla*), bull banksia (*Banksia grandis*), sheoak (*Allocasuarina fraseriana*) are found in this forest. Major valleys of the plateau are deep and broad and support marri, jarrah and wandoo on the higher sections and flooded gum and freshwater paperbark (*Melaleuca raphiophylla*) on the valley floor. In the study area, there are a number of granite outcrops that support the types of shrubs and herbs typically found in the lower storeys of the surrounding vegetation complexes. The minor valleys of the Plateau are made up of tributary streams that support a forest of jarrah, marri and Swan River blackbutt (*Eucalyptus patens*) on the higher sections, while the valley floors support swamp peppermint (*Agonis linearifolia*) and shrubs and woodlands of *Melaleuca preissiana* and swamp banksia (*Banksia littoralis*).

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6.2 Cultural Context

6.2.1 The Nyungar Landscape

The *Swan River System Landscape Description* includes a brief literature review of places of significance to Nyungars (indigenous people of the south-west of Western Australia) in the *Derbal Yarragan* or Swan River area. It is not a comprehensive account of Nyungar significance "of the area and mainly focuses on Nyungar use of the river prior to and immediately after colonisation. It is recognised that, as a part of the Swan River Trust's public consultation phase when developing landscape policies, further studies into Nyungar contemporary use of the river will be necessary. Today, many Nyungars continue to access the river for sustenance, knowledge, and spiritual renewal and to practise distinctly Nyungar cultural forms (Collard, pers com, 1997).

It is important to note that the records made by historians and early colonists reflected their own personal interpretation of Nyungar lifestyle, culture and language (Green, 1984). Few reports are reliable, most are lacking in detail, and often contradictory, and all are by non-Aboriginals (Green, 1984). The colonists were writing of customs that they often understood little about and these were explained in a language that was foreign to them. In addition, the colonists' own opinions and views were strongly reflected in the writings. When Nyungar accounts were documented, it is certain that they were strongly mediated by the non-Aboriginal writers.

It is also important to note that the spelling of the Nyungar words in this document may vary from other sources. This reflects the fact that Nyungar has only recently been put in written form. Due to the lack of uniform system of spelling many early documenters have interpreted Nyungar speech differently.

Len Collard (pers com, 1997) notes that non- Aboriginal cartographical conventions and systems of boundary making are not directly nor easily transferable into Nyungar systems of naming and land use. By placing a Nyungar name on a map, it tends to imply that places have fixed names over time, that there is only one 'true' name for a place and that all Nyungars have a shared consensus of meaning around that one name. On the contrary, Nyungar names depend on the context of use, and who uses them. All names are equally correct. For example Len Collard (pers comm, 1997) notes that he has heard different Nyungars refer to- 'Kings Park' as *Karrakatta* (hill of the crabs); *Yongarinyup* (place for catching kangaroos); *Geenungin Bo* (the place for looking a long way) and *Karlkarniny* (fire place).

In accepting non-Aboriginal mapping conventions, it must be recognised that there is the risk of making our understanding of Nyungar sites too simple and open to possible misinterpretation.

Background

Indigenous people whose country lies in the south- west corner of Western Australia are collectively known as Nyungars. Indigenous people with familial ties to this country share a common culture, language, history and affiliation with land (Green, 1984). Most refer to themselves as Nyungars (Green, 1962). When in 1940, Norman Tindale developed a schema for setting out indigenous 'tribal' boundaries he claimed that there were 14 different Nyungar groups based on social and linguistic characteristics and location (Bindon and Walley, 1993) as shown in Figure 5. Whadjuk Nyungars consider their *boodjar* or territory to be the land south of the Swan River, while Juet Nyungar land is to the north of the Swan River according to Lyon (O'Connor *et al*, 1989). Juet boodjar or land immediately north of the Swan River at the time of settlement was known as Mooro, the territory of Yellagonga. Green (1984) claims that Yellagonga's people moved their hunting and gathering area further north to the Lake Monger area when Stirling arrived to colonise the present site of the City of Perth.

Whadjuk land south of the Swan River and between the Canning River and the coast is called Beeliar. According to Lyon (1833), at the time of colonial settlement the land was the territory of Midgegooroo, who was the father of Yagan. Both of these men and their extended families offered much resistance to the white colonists. According to Lyon land between the Swan and Canning Rivers was known as Beeloo or river dwellers, the territory of Munday's people. Munday also gave strong resistance to the colonisation of the Beeloo lands.

Figure 5: Nyungar tribal boundaries of the southwest of WA (after Tindale 1940)

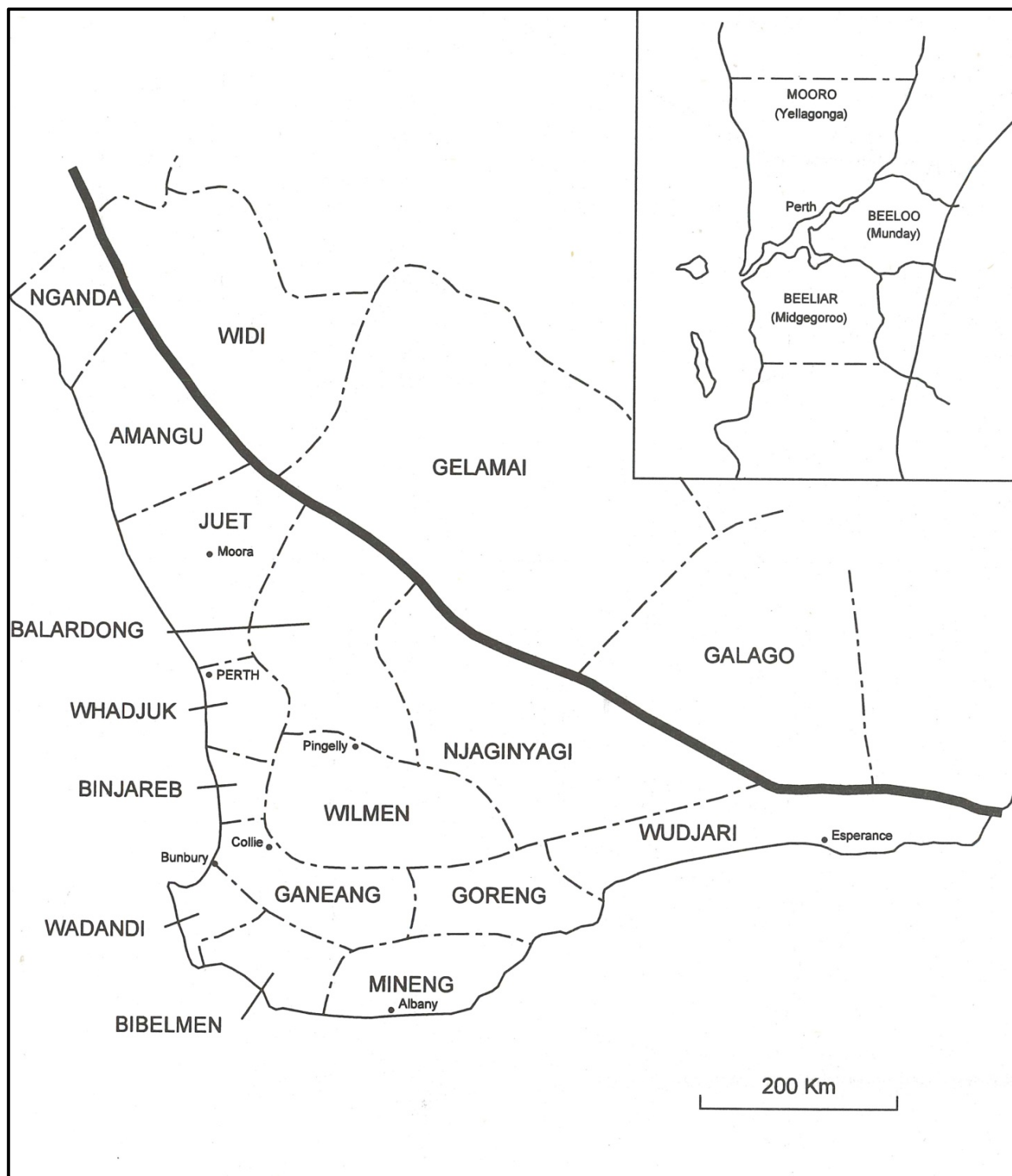


Table 7: Nyungar seasons and activities which relate to the seasonal changes in the environment. After Bindoon and Walley (1993), and Green (1984).

Nyungar seasons	Time of year	Activities and significance
Bunuru Hot easterly and north winds	February to March	- The dry conditions meant that Nyungars moved to the coast and estuaries, where fish constituted a large proportion of the diet of this season. Fish, such as tailor and mullet were trapped in shallow water and easily caught. Marron, gilgies, <i>kooyal</i> (frogs) and tortoises were collected from wetlands. - The fruits of the zamia, <i>Macrozamia riedlei</i>, were collected and the toxin removed. The horizontal rhizomes of the bulrush, <i>Typha domingensis</i>, were pounded to a flattened cake and roasted. <i>Haemodorum spicatum</i> (a bulb) was collected and roasted for use as a spice. Wattle, banksia blossom and various roots were collected. - Climbing trees for <i>koormul</i> (possums) took place.
Djeran Becoming cooler with winds from the south-west	April to May	- Fishing of the estuaries and other waters continued. - Bulbs and seeds were collected for food. - Group fishing in inland lakes and at weirs took place.
Makuru Cold and wet with westerly gales	June to July	- Nyungars moved to inland hunting areas once the rains had replenished inland water resources. <i>Tribonanthes</i> sp (tuberous plants) were collected. <i>Kuljak</i> (swans) began moulting making them unable to fly and easy to catch. - By holding a smouldering bull banksia branch (<i>Banksia grandis</i>) beneath their skin cloaks (<i>bookas</i>) Nyungars were able to keep warm.
Djilba Becoming warmer	August to September	- The tubers of <i>Platysace cirrosa</i> were dug from beneath wandoo. <i>Waitch</i> (emus), quenda, <i>koormul</i> (possums) and <i>yonga</i> (kangaroos) were hunted. <i>Meen</i> and <i>djakat</i> (roots) were collected.
Kambarang Rain decreasing	October to November	- Families moved towards the coast. - The moodjar or Christmas Tree <i>Nuytsia floribunda</i> provided sweet gum when the bark was removed. - The <i>Astroloma</i> sp and <i>Santalum acumiatum</i> were in fruit and the yam <i>Dioscorea hastifolia</i> and <i>Platysacea cirrosa</i> were collected. - Waterfowl and other bird eggs were connected. <i>Kooyal</i> (frogs), <i>yaarkin</i> (tortoises) and <i>gilgie</i> (freshwater crayfish) were caught. - Pits and traps were used to collect possums and kangaroos.
Birak Hot and dry with easterly winds during the day and south- west sea breezes in the late afternoon	December to January	- Nyungar burnt sections of scrubland to force kangaroos, wallabies, goannas and small marsupials into the open. The fires were lit until Bunuru to reduce undergrowth and encourage the lush growth of grasses and young plants in <i>Djilba</i>. - Banksia flowers were gathered for the honey. - Bronze wing pigeons caught.

Boodjar or land is important to Nyungars because of its economic, social and spiritual significance. The south-west of the State prior to colonisation was a plentiful area being well watered, with a mild climate and abundant natural foods. The Swan River and its freshwater tributaries were surrounded by the lightly wooded plains abundant in food and water to those who knew plants, birds and seasonal fluctuations. Each Nyungar group had their *kaleep* or favoured camping locality that held for them a special significance. Beyond this there was a more extensive area over which they foraged and hunted (Green, 1984). Bindon and Walley (1993) discuss how local Nyungar relied on seasonal changes shown in the landscape as indicators for the collection of food and provision of shelter. The Nyungar year is divided into six seasons. These and the key activities for the season are shown in Table 7 below. Table 7 shows Whadjuk Nyungar (or Perth) words for the seasons. Other Nyungars have different words. It is important to remember when planning for the landscape and natural resource management that many Nyungar continue to use the natural resources mentioned in the table and that continuity of access to these resources is important to Nyungars. The spiritual significance of the landscape is also important for specific Nyungar stories about landscape.

Nyungars have a sense of respect and kinship with the biota and environment and regard themselves as inseparable from the eternal process of nature (Green, 1984). Various sites which have Waugal and other beliefs associated with the Swan River are described in each precinct. Nyungar attitudes and minimal impact on the river environment resulted in a *Beeloo* or river ecology that was in a relatively undisturbed state of equilibrium until colonial settlement.

Nyungar Native Title Claims

Native Title is the name of the law given to the traditional ownership of land and waters that have always belonged to Aboriginal people and Torres Strait Islanders according to their traditions, laws and customs (National Native Title Tribunal, pers com, 1997). Native Title may be found to exist where it has not already been extinguished by an inconsistent government grant to a third party. It may also be found to exist where the Native Title claimants have maintained their connection over the land. The information on the National Native Title Tribunal Register only reflects the information provided by the applicants and a determination will only be made if all the parties to the application agree. Where the registrar of the tribunal 'accepts' a native title application, this does not mean that Native Title has been granted, rather that it has been accepted for mediation.

Native Title cannot displace existing interests in land and waters that have been validly granted. It is possible for Native Title rights to coexist with other interests over the land or waters. Existing interests, such as pastoral leases, other leases, licences and permits will continue to apply even if there is a determination of Native Title. The tribunal does not accept applications over present freehold. The exception to this is where the freehold is held either by the Crown or Aboriginal people.

Presently, there are several Native Title claims in the Swan and Canning Rivers areas, some of which overlap. Some of the accepted claims fall within the Swan River Management Area and are described below. It is important that the most up to date information is collected from the National Native Title Tribunal when planners make land use decisions.

The Swan Valley Nyungah Community and other Nyungah Peoples have registered claim to Native Title pursuant to the Native Title Act 1993 over an area of land including the Swan River and its foreshores. The area of interest is almost 3 000 square kilometres. The claim is number WC95/81 and is registered by Mr Robert Bropho. It follows the Swan and Canning River foreshores, from the Fremantle Port Authority boundary, to just north of Heirisson Island and the Canning River to Salter Point, excluding Bullsbrook confluence. The claim includes the right to protect the area from activities inconsistent with Native Title interests in this area. The applicants note that they have had and continue to have an interest in occupying, using and enjoying the land and water claimed. They want to protect from injury, desecration, excavation, damage, destruction or alteration, sites and areas which are significant to the applicants in accordance with Aboriginal tradition within the interest area (National Native Title Tribunal records, 1997).

The claim WC95/85 has been registered by Mr Terry Cornwall on behalf of Nyungars. The claim covers an area over 700 square kilometres. It includes a broad area from Wanneroo through to Geographe Bay and the mouth of the Donnelly River. The claim covers the Swan and Canning Rivers in a line from east of Perth City. The applicants have stated that they do not claim any areas of freehold title within the claim area granted prior to 1 January 1994. The Native Title rights include the use and enjoyment of the land and waters including the protection of Aboriginal sites (National Native Title Tribunal records, 1997).

Mr Corrie Bodney has registered claim WC95/86 for the Bodney Family Group Ballaruks. The area includes the land, islands and ocean generally within a 60 mile radius of Perth being the Whadjuk territorial boundary.

6.0 Resource Inventory

The land includes South Port Kennedy, Jarrahdale, Mount Cook, Balladon, and Clackline to the confluence of Moore River and Gingin Brook to Guilderton. It includes the ocean and islands from 3 nautical miles west of Rottnest Island excluding all private freehold and residential leases and special leases. The living descendants of the Ballaruk people of the Whadjuk Territory claim the rights and interests of the Ballaruks pursuant to their traditional laws and customs based on mythological, spiritual, social and economic association and ties to relevant estates and ranges. The applicants retain substantive ritual and other cultural knowledge of the region and the people have maintained regular visits to relevant areas for purposes including travelling, cultural maintenance and development and use the land and water tracts (National Native Title Tribunal records, 1997).

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6.2.2 The Swan River Colony and a new cultural landscape

The development of Perth has been strongly influenced by the Swan and Canning Rivers since the time of the settlement of the Swan River Colony in 1829. Perth was founded in August 1829 by Captain James Stirling (Stannage, 1979). With the unexpected arrival of settlers on 5 August 1829, Stirling felt compelled to make a decision on a site for the capital and he chose the northern bank of what is now known as Perth Water. His reasoning varies in his reports but included the attractiveness of the site, fresh water and the availability of building materials. He wrote of delaying his survey of the general coast and country *for the purpose of laying out the town of Fremantle at the entrance to Melville Water as a landing port and also the town of Perth near the island of the Swan River, with a view to its being in the neighbourhood of those who may wish to cultivate the rich lands immediately above it on the river*' (in Markey, 1979). The decision to have the Swan River Colony on the northern side of Perth Water has been a key factor in development patterns of Perth.

By the 1860s the physical and social shape of Perth had been largely determined. In the early years of colonial settlement, the Swan and Canning Rivers dictated the development of the area by playing an important transport role, both for communication links and as a means of conveyance. Riverfront properties were essential for successful communication and trade. As a result these properties were rationed to allow an average river frontage of approximately 800 metres to maximise the number of owners who could utilise the river (Markey, 1979). The properties were generally long and narrow, which is reflected in the present day road layouts of the inner suburbs. Details of the first landowners are described in the precinct sections and the subdivisions are shown in Figure 6. The original landowners' influence on the nature of today's land use ranges from minimal to quite substantial. For example, the time of subdivision of their properties dictated urban expansion.

The Swan River Colony administrative, political, business and military centres were in the immediate vicinity of the Barrack Street and St Georges Terrace, Perth (Stephenson, 1975).

Hay Street developed as a lesser commercial and shopping precinct, while north of Wellington Street were workshops, cottages and stockyards. Perth Port was built at the foot of William Street. Due to the shallow waters shipping and industry were restricted to the Fremantle and Perth Ports and adjoining areas.

The small ports of Fremantle, Perth and Guildford provided these first isolated settlements with vital communication and trading links.

By the 1860s, Perth was also becoming more accessible by overland routes which were being built by the convicts, the first of which arrived in 1850 (Stannage, 1979). Many of the notable public buildings of Perth were constructed in the convict era including the Town Hall, Cloisters, Trinity Church and Government House. The convicts provided much needed labour for a struggling colony; however their arrival meant that the free people had to learn to live with the presence of convicts and the social effects of the system including fear and often violence. During this time Queen Victoria proclaimed Perth as a city (1856), however the population of the colony was quite small and development was hardly flourishing (Stannage, 1979).

The most of the land around Perth was used for agriculture with varied success. The upper reaches of the Swan and Canning Rivers were more favourable to agriculture having richer alluvial soils. The lower reaches, particularly of the Swan River, were favoured for residential development due to poor soils, and gradually, as transport improvements were made, the original large rural blocks were subdivided.

In the 1880s, the railroad between Fremantle-Perth- Guildford was constructed expediting business and allowing suburban development along the lines north of the Swan River. During the same decade, river infilling along the Esplanade was to shape the linear foreshore in front of the city which has dominated the city landscape ever since.

It was not until the western gold rush of the 1890s that Perth started to expand with the increased population and money. Great social and structural changes were undertaken as a result of the increased population and the considerable effort to increase development on the part of Sir John Forrest's Government. A colony-wide railway system centred on Perth was built, and drainage, sewerage, lighting and road construction increased. The newly found wealth allowed the construction of lavish buildings such as His Majesty's Theatre and the Fremantle Railway Station (Apperly *et al*, 1989). At this time, the Perth city area began to lose its residential character and localised suburban communities were forming.

Ferries allowed suburban developments on the southern side of Perth to expand during the early 1900s. By the 1920s, horse drawn carriages had almost been replaced by buses, trams and the occasional motor car. Along with an increasing population, there was an increased demand for access to the river and for riverside developments and amenities. As a result in 1928, planning legislation was put in place to counteract the previous decades of uncontrolled and uncoordinated development (Webb, 1979).

With the rest of the world, Perth suffered the Depression of the 1930s. Many people became homeless and unemployed. The Government initiated public works to create employment. Sections of the foreshore including Riverside Drive, Langley Park and Mounts Bay Road were infilled and walled using unemployed labour (Stannage, 1981).

During and immediately after World War II, there were very few major building developments in the city or surrounding suburbs. Increasing numbers of city users were travelling to work in motor cars and public transport use began to decline.

The 1955 *Stephenson-Hepburn Plan for Perth* and Fremantle recognised the need to balance urban development, public open space, recreation, communications and industry. The plan was used as the major guide in the Metropolitan Region Scheme in 1963. In 1959 with the opening of the Narrows Bridge and Kwinana Freeway, the pace of land subdivision and suburban development increased and Perth began to stretch in a north-south direction along the coastline.

The *Corridor Plan for Perth*, prepared by the Metropolitan Region Planning Authority (1970), set the direction and shape of the metropolitan area till the turn of the century. Its objectives were to maximise economic efficiency in the future development of Perth, enhance the urban environment and preserve the essential character of non urban areas. In 1990, Department of Planning and Urban Development prepared the *Metroplan - Strategic Metropolitan Growth to the Year 2021*. It indicates the general location and extent of major land uses in the region including future urban growth areas, major transport corridors, location of activity centres, rural areas and regional open space. It is supported by policy statements and structure plans.

On a more detailed scale, local government authorities in collaboration with the Swan River Trust are responsible for developing the policies which shaping the land use of the Swan River System.

Differences in planning policies have resulted in a range of cultural and natural landscapes along the river system which are outlined in more detail in the precinct descriptions.

Values and the Swan River System Landscape

The present day Swan River System Landscape strongly reflects the community's past and present values. The natural landform and vegetation that help give a 'sense of place' and regional identity has been altered dramatically by urban development.

Despite these dramatic changes it is river's waterform among the low undulating plains and the relative rise of the Darling Plateau as a linear backdrop which are the features that help us associate the surrounding landscape as being Perth. Retaining and enhancing the physical landscape features would be one way to improve the visual amenity and ecological integrity of the Swan River System.

For most of the Swan and Canning River the built form contributes little to creating regional identity as Perth's suburban residences and amenities are indistinguishable from most parts of suburban Australia. There has been little use of identifiably local building materials in our modern environment and in particular the Perth city landscape is dominated by international styles and building materials from external sources. Hough (1990) claimed that a city constructed from materials which have no connection with local site is an expression of wealth and denial of regionalism. It may be indicative, of our society's values or priorities, that the city sky-rise is dominated by the conservative highrise offices of financial institutions and multinational companies. These past decisions on land use amenity should guide planners to not shy away from new built design ideas which take into consideration the natural advantages of the Swan River and will give some local identity.

The Swan River System landscape will continue to be reflective of the values of our community and the Swan River Landscape Program will provide an opportunity to guide the implementation of values such as local identity, ecological integrity, land use diversity and adequate public access to the river environment.

6.0 Resource Inventory

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