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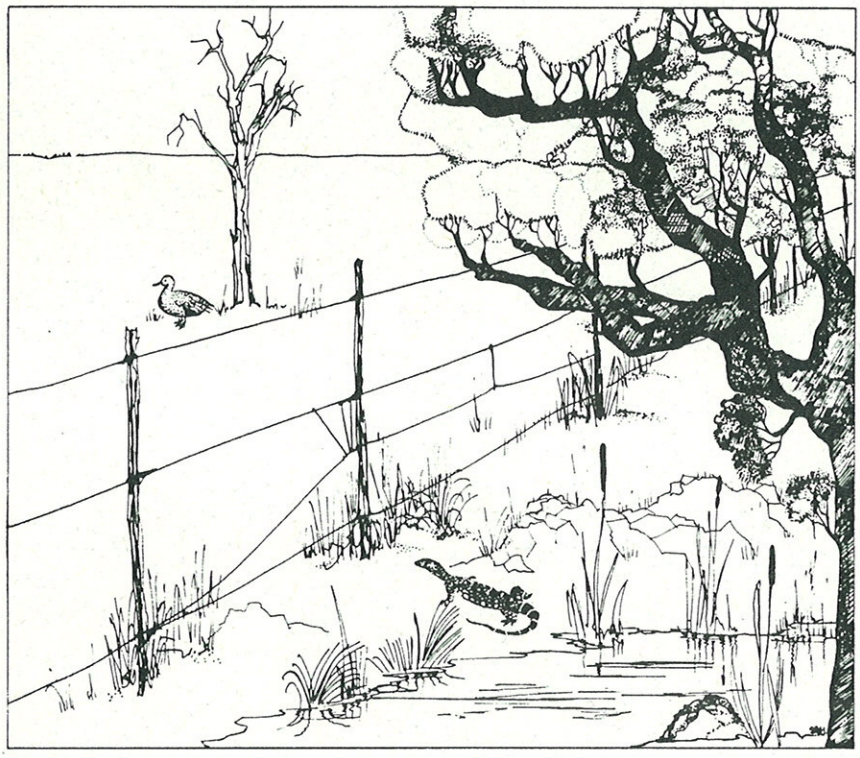
PEEL INLET MANAGEMENT AUTHORITY

Fringing vegetation of the Serpentine River in the Shire of Serpentine-Jarrahdale and City of Rockingham



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FRINGING VEGETATION OF THE SERPENTINE RIVER IN THE SHIRE OF SERPENTINE-JARRAHDALE AND CITY OF ROCKINGHAM

Report to the Peel Inlet Management Authority

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ABSTRACT

The Serpentine River is an integral landscape component of the Peel region. The Peel Inlet Management Authority (PIMA) believes that effective protection and appropriate management of the riverine environment is required if the community is to retain its benefit in the long term.

PIMA works in close cooperation with local and State government authorities, landowners and the general public to achieve a balance between conservation, recreation and development pressures.

Metroplan (Department of Planning and Urban Development 1990) identified parcels of land adjacent to the Serpentine River as suitable for future urban development. Population growth in this area will result in increased pressure on the river foreshores and there will be greater potential for nutrient export into an already eutrophic system.

The South West Corridor Plan Review (1993) proposes rural landscape protection zones for the northern section of the study area and identifies areas of high conservation / recreation value in the southern section.

PIMA commissioned this report as part of a series of studies to establish a better understanding of the Serpentine River system. Fringing vegetation is an important part of the river system and should be conserved and rehabilitated. The study will allow the Authority to be in a position to advise Government on suitable development setbacks and land use practices adjacent to the river.

TERMS OF REFERENCE

This report was prepared for the Peel Inlet Management Authority to provide baseline information on the vegetation adjacent to the Serpentine River immediately upstream of the existing Management Area and extending to the Serpentine Falls.

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1.0 INTRODUCTION

1.1 Aim

The vegetation survey was undertaken to provide baseline information for the Peel Inlet Management Authority (PIMA) on remnant vegetation adjacent to the Serpentine River. The Authority commissioned the survey in response to increased requests from local and State government to advise on appropriate river management strategies within the study area.

1.2 Background

The Peel Inlet Management Authority was constituted under the Waterways Conservation Act 1976 to conserve and manage the water and adjacent foreshores of the Peel-Harvey Estuarine System. Part of the Authority's role is to provide advice on developments and subdivisions which have the potential to impact on waterways within its Management Area. This advice may include recommendations regarding adequate reserves adjacent to the river. To define an appropriate foreshore reserve the Authority requires information on the existing vegetation, topographical features, flood prone areas and cadastre. This report provides a sound baseline study of the remnant vegetation of the Serpentine River.

Fringing vegetation is important in maintaining a healthy river system. Plant communities tend to be productive despite adverse growing conditions, and support a diverse and productive fauna.

Flora also interacts with the physical environment, stabilising sediments, contributing to the river's efficiency as a waterway and performing important functions in oxygen and nutrient dynamics in the system.

Fringing wetlands can trap heavy metals and various hydrocarbons before they reach estuarine and riverine waters. The organic peat which accumulates within these areas can bind pollutants and nutrients, regulating their passage into the river. This is particularly important in agricultural regions where nutrient loading tends to be high.

1.3 Study area

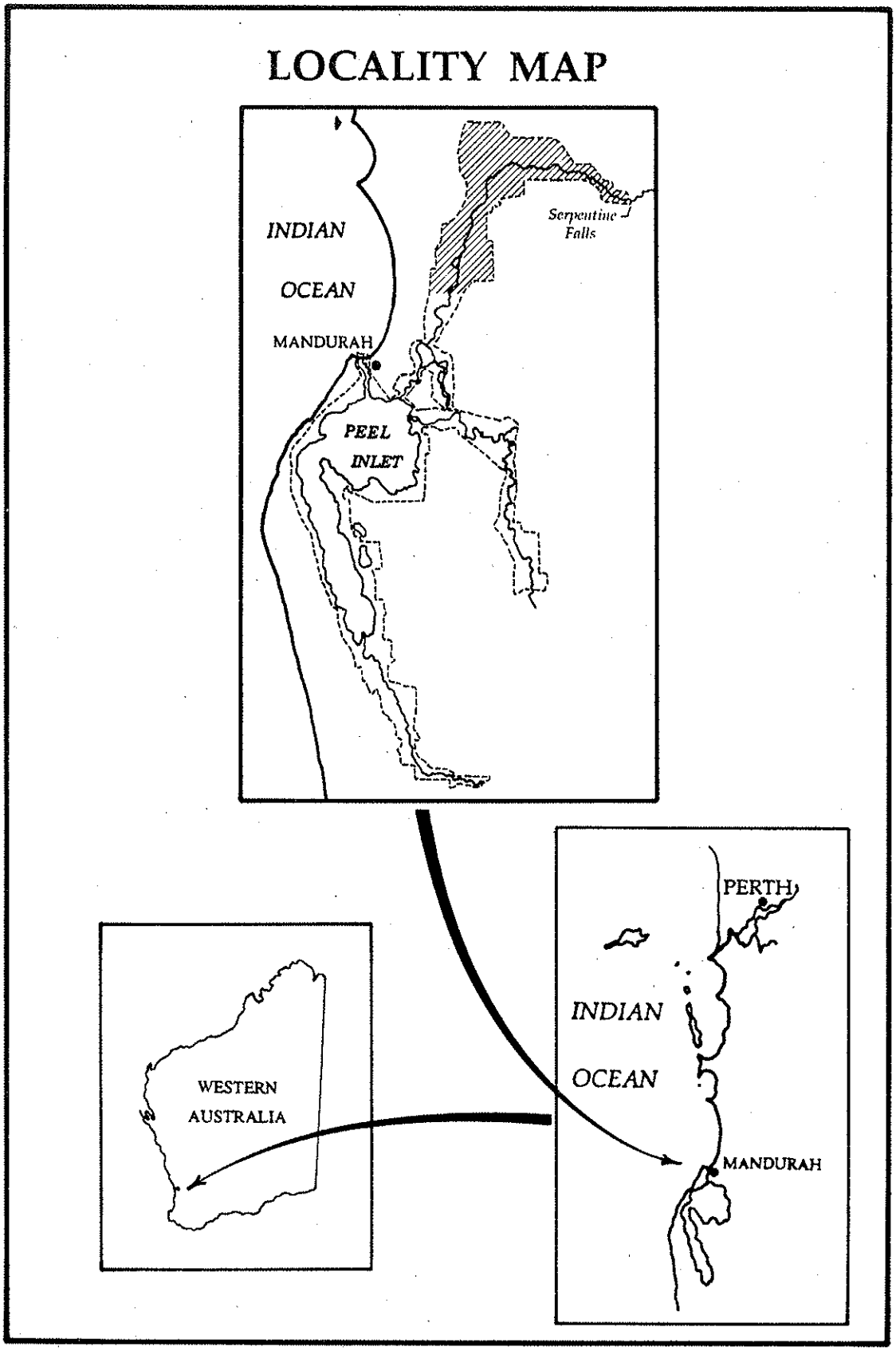
The Serpentine River is located between 32.27'11" and 32.23'00" south and 115.47'30" and 115.59'00" east. The river catchment includes an area to the east of the Darling Scarp and a section of the Swan Coastal Plain (Fig. 1). The southern boundary of the study area is defined by the current northern boundary of the Peel Inlet Management Area, while the eastern boundary is the Serpentine Falls. The northernmost section of the study area is bordered by Mundijong Road.

The majority of the study area is within the Shire of Serpentine - Jarrahdale. The remainder lies within the City of Rockingham.

The Serpentine River is a predominantly freshwater system from the Darling Scarp to approximately two kilometres below Karnup Road Bridge (Tom Rose pers. comm.). There are no accurate data to verify this, however the Water Authority deploy gauging stations above tidal influences and there is a station at Karnup Road. Tidal effects extend about two-thirds (approximately 4 km) of the way between Lake Road Bridge and Karnup Road Bridge.

The study area experiences a typical Mediterranean climate with an average rainfall of 884 mm (Trudgen 1991). During the winter months it is not uncommon for the river to overflow. In summer it may become dry in sections.

LOCALITY MAP



The study area's average maximum temperature varies from 17°C in July to 29°C in February. The average minimum temperature varies from 8°C in August to 17°C in the summer months (Trudgen 1991).

The Serpentine River flows through three primary geomorphic elements within the Swan Coastal Plain (McArthur & Bettenay 1960). For the majority of its course it flows through the Pinjarra Plain. This broad low-relief plain is composed mainly of Pleistocene fluvial sediments with some Holocene alluvium typically associated with major drainage systems. Some sections fall within the Bassendean Dune and Sandplain System, and the Vasse Estuarine and Lagoonal Deposits.

The dominant soil component is poorly drained clays that generally correspond with the Guildford Clay geologic formation. These soils are relatively fertile in comparison with the soils of the Swan Coastal Plain. The flat topography contributes to the formation of many small seasonal swamps.

2.0 METHODOLOGY

2.1 Vegetation sampling

Botanical assessments of the study area were conducted on two separate occasions (January 1993 and February 1993) and included description and mapping of the vegetation communities and collection of qualitative (presence / absence) data within each community type. Once a species list has been compiled, composition data can be established for a number of sites. Subsequently communities occurring within a sample are determined. This data form facilitates rapid and accurate description of vegetation complexes in the field.

Qualitative data is sufficient for descriptive and mapping purposes, however quantitative data collection is essential if baseline information is required to monitor and determine changes over time.

The quality of the vegetation was assigned a subjective value according to the level of disturbance, density of foliage and height of the dominant tree species.

The vegetation classification system employed is consistent with that established by Pen (1981). This system classifies vegetation as communities on the basis of common species from which community types are derived. It is important to note however, that the system used in this study deviates slightly from that of Pen (1981) in terms of the specific floristic characteristics of some community types.

According to Pen (1992), fringing vegetation can be broken up into six major categories: salt-marsh, estuarine fringing forest, fringing vegetation, sandy rise vegetation, freshwater vegetation and disturbance-related plant species assemblages.

2.2. Vegetation mapping

Vegetation associations were mapped from aerial photographs (Appendix 1) and subsequent field verification.

Sketch maps were traced from 1992 aerial photographs of the region at a scale of 1 : 20 000. The sketch maps showing the river and peripheral vegetation were digitised and used in a geographic information system [Arc/Info (ESRI)] to create coverages. The basic coverages were then transferred to a Microstation 4 environment to produce the final maps. The symbols were drawn manually in each vegetation polygon.

Vegetation that fringed the river, any wetland in the immediate vicinity and remnant vegetation associated with the river were recorded. These broad patterns were then ground truthed to ascertain the specific floristics of each dominant vegetation type. Species identifications were established from Marchant et al. (1987).

Environmental management issues were identified and documented. They included fire hazards, weed infestations and mosquito breeding areas, vehicle access tracks, associated erosion and areas degraded due to uncontrolled stock access to the river.

2.2.1 Limitations of the vegetation survey

Differences in geological and environmental ranges were not considered in this study.

The study was also limited by:

1. Restricted access on private property,
2. Inaccessible terrain,
3. Some minor difficulties with plant identification to species level. Unknown taxa were submitted to the WA Herbarium for identification.
4. Certain annuals may have been overlooked because of their seasonal habits and the time frame of the study.
5. Time constraints which limited comprehensive qualitative studies being carried out to establish rigorous community compositions.

3.0 VEGETATION OF THE STUDY AREA

3.1 Background

As stated in 2.1, fringing vegetation is broken into six major categories.

1. Salt-marsh

   These develop in areas which are saline either through direct tidal inundation or as a result of tidal inundation followed by evaporation of water trapped on the marsh by a shoreline levee. It is believed that the latter effect is prevalent where peripheral sediment deposition is greater.

2. Estuarine fringing forest

   This vegetation type is typically dominated by the small saltwater sheoak (*Casuarina obesa*), saltwater paperbark (*Melaleuca cuticularis*), paperbark (*M. viminea*) and swamp paperbark (*M. rhaphiophylla*), occurs as the ground level increases and if salinity levels are not extreme.

3. Fringing vegetation

   This consists of those emergent species which live more or less permanently in shallow water. These shallow water bodies may be seasonal.

4. Sandy rise vegetation

   This category is composed of vegetation occuring on remnant coastal dunes and raised margins of water bodies.

5. Freshwater fringing vegetation

This vegetation occurs in areas receiving substantial freshwater input, either from surface inputs (i.e. creeks or drains) or from groundwater seepage which typically occurs at the base of a ridge or sand dune (Pen 1992).

6. Disturbance-related plant assemblages

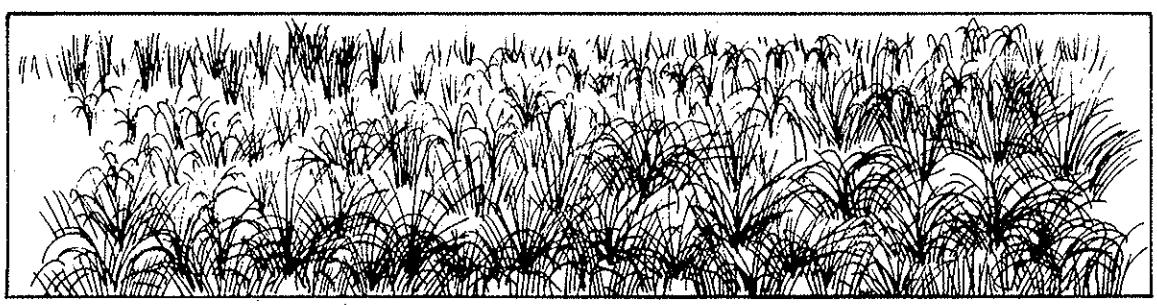
Plant assemblages may develop in areas subject to frequent disturbance. Such assemblages are characterised by either a lack of native plant regeneration or a high degree of weed infestation and heterogeneity. Pen (1992) provided examples of these areas. Relic trees over pasture are largely prevented from regenerating because of continuous physical disturbance including grazing and therefore the population becomes increasingly aged. Another example of a disturbance-related plant assemblage is in areas which have been subject to changing land use over many years and conditions have not yet established equilibrium. In this case, some native plant species are undergoing decline while others are becoming established or are expanding their extent. At the same time ephemeral weeds exploit opportunities for invasion, which may in the long term retard the regeneration of native species. Such assemblages appear chaotic and contrast greatly with the homogeneity of native plant communities and the continuums which exist between them.

The environmental relationships of the various freshwater communities have been investigated for most river systems in the Perth region. The plant communities of the Serpentine River are very similar, and their distribution in relation to environmental factors, such as salinity and freshwater flushing, can be inferred from observations of local conditions. However, further studies are required to gain an understanding of the environmental parameters which affect the distribution of the communities identified.

3.2 Salt-marsh vegetation

Juncus kraussii closed sedgeland

The eastern flood plain of the property (known as Amarillo), immediately south-east of the bend in Amarillo Drive, in the southern section of the study area (Maps 1 and 2), is covered by extensive areas of this vegetation complex.



This seasonally inundated area is characterised by continuous dense homogeneous bands of both shore rush (*Juncus kraussii*) and the rush *J. pauciflorus* (reaching 2 m) which alternate with dense matrices of shore rush (*Juncus kraussii*) and jointleaf sedge (*Juncus holoschoenus*). There are occasional isolated moonah (*Melaleuca preissiana*) and flooded gum (*E. rudis*),

which suggests that the structure of the vegetation of the flood plain has been altered by clearing with only understorey species (in this case *Juncus* spp.) regenerating.

There are some minor infestations of weed species such as *Mentha pulegium*. The *Juncus kraussii* community has maintained its integrity through intense grazing pressure, and persistent extensive stands form a mosaic with severely degraded grazed areas.

The river bank has been heavily degraded by livestock movements, however some areas of *Juncus kraussii* have persisted beneath a moonah (*Melaleuca preissiana*) and swamp paperbark (*Melaleuca rhaphiophylla*) overstorey. The extent of this community east of the limits of Maps 1 and 2 has not been mapped. This area is of regional significance in terms of the extent of the sedgeland. The conservation value of this area is extremely high.

Sarcocornia quinqueflora closed herbland

This community is restricted to a single small patch in the lower reaches of the study area (on the Amarillo property) and consists of small homogeneous patches of samphire (Map 2). This area of low decumbent samphire herb *S. quinqueflora* is on the peripheral accretion banks of the Serpentine River at the downstream end of Amarillo Lake. The only associated species is the small herb *Samolus repens*. The presence of this community reflects the saline conditions of the estuary, indicating tidal influence.

3.3 Fringing vegetation

Schoenoplectus validus closed sedgeland

This community type is characterised by monospecific stands of this tall weeping sedge. *Schoenoplectus validus* is an emergent lake club-rush often found growing in shallow waters. This species can reach up to 2 m, and can be found in three regions of the study area. The first homogeneous stand is located to the south-east of Amarillo Lake (Map 2), and is subject to grazing pressure. A narrow stand of *Schoenoplectus validus* occurs along the south-western fringe of a hypersaline lake on the corner of Baldivis Road and Stakehill Road (Map 4). The third stand is located in the northern portion of a wetland immediately north-east of the intersection between Karnup Road and Jarrah Road (Map 5).

Small stands of this sedge also occur throughout the study area in conjunction with other species.

3.4 Fringing forest vegetation

Melaleuca cuticularis low open-closed forest

Saline soils bordering estuaries generally support the small saltwater paperbark *Melaleuca cuticularis* (Marchant et al. 1987). This complex usually lies landward of occasional fringing shoreline rushes.

Extensive bands of low open forest are present on the western bank of Amarillo Lake, north to approximately one kilometre south of where the river has been trained (Maps 2 and 3). Additionally, two saline seasonal wetlands, located immediately south and north-east of the intersection of Karnup Road and Jarrah Road, are dominated by this species (Map 5). The last stand of this species was located in a small wetland adjacent to the *Eucalyptus-Banksia* species matrix of the Lowlands property (Map 8). The distribution of this species is restricted by rural activities.

There is considerable variation in the distribution of understorey species, with some communities retaining understorey integrity and others progressively experiencing weed invasion and maintaining few native species. The understorey is usually characterised by introduced monocot species including *Agrostis avenacea* (blown grass), *Rumex obtusifolius* (broad-leaf dock), *Watsonia* species. *Zantedeschia aethiopica* (arum lilies) are common in lower lying regions. A number of less disturbed communities have an understorey dominated by *Baumea articulata* (jointed twig-rush), *Isolepis nodosa* and a number of unidentified sedges.

The wetlands in the vicinity of the intersection of Karnup Road and Jarrah Road (Map 5) are characterised by dense monospecific *Melaleuca cuticularis* (3-5 m) stands lying immediately north of a *Melaleuca* spp. complex which fringes an area of open water. High density *Schoenoplectus validus* is present in some depressed areas. The introduced shrub *Diosma* is a conspicuous component of grazed areas.

In other areas dominated by this complex there are occasional *Eucalyptus rudis* (15 m). There are also sporadic interspersed *Eucalyptus calophylla* (marri) and *Nuytsia floribunda* (Christmas bush). In inundated areas, the understorey is dominated by *Baumea articulata* (jointed twig-rush), with *Isolepis nodosa* (knotted club-rush) and a number of introduced monocots prevalent in drier regions. Scattered *Xanthorrhoea preissii* (blackboy) occur in these communities (Maps 2, 3 and 8).

Melaleuca rhaphiophylla - M. cuticularis low open forest

In a number of locations in the study area, the overstorey consists of the *Melaleuca rhaphiophylla* (small freshwater paperbark) and the *M. cuticularis* (saltwater paperbark), which together form a low open forest between shore rush communities (*Juncus kraussii*) and landward pasture (Maps 1, 3, 4 and 6). The dominant understorey species are essentially the same as those typified by the *M. cuticularis* low open-closed forest but includes the native grass *Schoenus elegans.*

Melaleuca viminea low open - closed forest

Two stands of this community occur on the raised sandy areas adjacent to the trained regions of the Serpentine River (Map 4). In these locations the small (2 -3 m) paperbark *Melaleuca viminea* is the dominant overstorey species (Map 4). Occasional scattered *M. teretifolia* and planted *E. rudis* (flooded gum) characterise the elevated sides of the drain. In this disturbed community, the understorey is dominated by weed species such as *Stenotaphrum secundatum* (buffalo grass), *Avena fatua* (wild oats), *Rumex obtusifolius* (dock), *Watsonia* sp. and the large weed *Ricinus communis* (castor oil trees). *Juncus microcephalus* and an unidentified *Juncus* species are scattered throughout this community.

Melaleuca spp. open - closed thicket

A continuous matrix of dense monospecific continuous thickets of a variety of *Melaleuca* species prevails landward of the *Melaleuca cuticularis* (saltwater paperbark) low open forest (Map 2) along the western foreshore of the lake immediately east of Amarillo Drive. The dominant taxa include *M. viminea, M. rhaphiophylla, M. hamulosa* and *M. lateritia* (red robin) and an unidentified *Melaleuca* species with purple flowers. The specific combination of prevalent *Melaleuca* species varied with location (Maps 1-6). This matrix is characterised by a lack of understorey species, however, *Juncus* species, the club-rush *Bolboschoenus caldwellii*, both the introduced and native bulrushes

(*Typha orientalis* and *T. domingensis* respectively) and the waterbutton *Cotula coronopifolia* are occasionally associated with these thickets. *Aster subulatus* (wild aster) occurs in the understorey.

3.5 Freshwater vegetation

Baumea juncea sedgeland

Landward of the *Eucalyptus* spp.-*Juncus* spp. open woodland, which fringes extensive regions between Amarillo and South Western Highway, bare twig-rush (*B. juncea*) can be found between the stands of rush and the landward pasture grasses. It seldom forms a sufficiently substantial stand to enable its recognition as a separate community. Unlike knotted club-rush (*Isolepis nodosa*) which is associated with sandy rises, twig-rush (*B. juncea*) is found in low lying areas apparently prone to freshwater flushing (Pen 1992). Such areas were probably favoured for clearing and development in the past, and as a consequence little *B. juncea* closed sedgeland remains today.

Melaleuca rhaphiophylla low open - closed forest

This low open-closed forest occurs in a number of regions throughout the study area (Maps 2-6, 8 and 10). It generally exists in conjunction with *M. lateritia* (red robin) and persists landward of the *E. rudis* (flooded gum) and *Juncus* spp. complexes. *Allocasuarina obesa* (saltwater sheoak) is regularly dispersed throughout this community. The understorey consists predominantly of introduced monocots such as blowfly grass (*Briza maxima*) and couch (*Cynodon dactylon*), with occasional persistent native grasses including *Lepidobolus* sp. and *Schoenus elegans.*

Melaleuca spp. - *Baeckea* sp. low open - closed forest

This complex is characterised by extremely dense under and middle storeys. The predominant species is *M. preissiana*, with occasional *M. lateritia* and an unidentified *Melaleuca* species with purple flowers, with a high proportion of interspersed *Baeckea*. The understorey is dominated by a number of *Juncus* species with few, if any, weed species present. Weed pockets are dominated by couch, blowfly grass and pennyroyal (*Mentha pulegium*). Although there was evidence of stock movement through this community, the extent of damage was minimal.

3.6 Sandy rise vegetation

Eucalyptus rudis - Melaleuca rhaphiophylla woodland

This community occurs intermittently throughout the study area, most commonly fringing the river but also occurring on the flood plain and in wet depressions (Maps 1-12). The overstorey consists of remnant flooded gum (*E. rudis*) which forms a woodland with the swamp paperbark (*Melaleuca rhaphiophylla*). *E. calophylla* and *E. haematoxylon* are present throughout, but are not common in any location. The understorey has generally been depleted of native species, as a result of clearing and grazing. A large amount of local variation in dominant understorey components exists. The predominant understorey species are *Ehrharta calycina* (perennial veldt), buffalo grass, *Digitaria sanguinalis* (crab grass), blown grass, *Pennisetum clandestinum* (kikuyu) and *Taraxacum officinale* (dandelion) along with a plethora of other weeds. Some native species persist in pockets. Such species include jointed twig-rush (*Baumea articulata*), common sword sedge

(*Lepidosperma longitudinale*), shore rush (*Juncus kraussii*), the small rush *J. microcephalus* and the knotted club-rush (*Isolepis nodosa*). The small native ground cover *Centella cordifolia* occurs in damper areas.

In some areas the understorey has been completely replaced by introduced monocots with the only native component of the vegetation being relic *E. rudis* (flooded gum). Dock, wild oats (*Avena barbata*) and pennyroyal are obvious components of the understorey throughout areas dominated by this complex or variations of this complex (Maps 9-12).

Other areas dominated by *Melaleuca rhaphiophylla* (freshwater paperbark) (15 m) and *Eucalyptus rudis* (flooded gum) (15 m - 30 m) are fringed on the landward side by *E. calophylla* (marri) (25 m). Isolated stands of *Agonis linearifolia* (swamp peppermint) occur. Restricted areas of this complex are associated with *Acacia saligna* (golden-wreath wattle) and *A. alata* (winged wattle), *Baumea articulata* (jointed twig-rush) and *B. juncea* (bare twig-rush) (1.5 m), *Hovea* sp., *E. haematoxylon* (mountain marri), *Daviesia* sp. and *Darwinia citriodora* (lemon-scented Darwinia) (Maps 1-4, 6 and 8).

In some areas *Watsonia* sp. are very widespread and highly abundant (Maps 5 and 6). Other weeds commonly present in this community include an unidentified purple spiky cats tail, wild oats, *Lupinus* sp., *Cyperus eragrostis* (umbrella sedge) and couch.

In some locations where the river has been trained and has a steep bank (Map 8), weed, tree and herbaceous species predominate. Species present include castor oil trees, *Solanum sodomeum* (apple of sodom) and the introduced shrub *Diosma*.

Kunzea spp. closed thicket

Closed thickets dominated by *Kunzea* spp. (Maps 3-7) are typically associated with stinkwoods particularly *Jacksonia sternbergiana* (green stinkwood). The thickets fall beneath a sparse *E. calophylla* (marri), *Banksia attenuata* (candle banksia) and *B. ilicifolia* dominated overstorey. Associated understorey and middlestorey species include *Schoenoplectus validus* (lake club-rush) in depressions surrounded by a purple-flowered *Melaleuca* sp., *Dasypogon bromeliifolius* (pineapple bush) and *Macrozamia riedlei* (zamia). Dominant introduced monocots include wild oats, rye grass (*Lolium* sp.) and an unidentified wiry grass.

Banksia spp. open - closed woodland

Banksia woodlands characterise the landscape on the raised sandy soils on both sides of the Serpentine River (Maps 1, 2 4, 5, 7 and 8). *Banksia grandis* (bull banksia), *B. attenuata* (candle banksia), *B. ilicifolia* and *B. menziesii* (firewood banksia) are the dominant species, with the canopy ranging from open to closed. The estimated average height of the tree species within this community is between 8-10 m. The lower lying areas are characterised by *B. littoralis* (swamp banksia).

Banksia attenuata (candle banksia) (8 m) and *B. menziesii* (firewood banksia) are typically consistently distributed with occasional *B. ilicifolia* (10 m). *Nuytsia floribunda* (Christmas tree) and *E. marginata* (jarrah) (15 m) are widely distributed but not particularly common in any locations characterised by this community.

Associated species include *Allocasuarina* spp., woody pears (*Xylomelum occidentale*), marri (*Eucalyptus calophylla*), jarrah (*E. marginata*), *Allocasuarina fraseriana*, occasional *Nuytsia floribunda* (Christmas tree) and a variety of woolly bushes (*Adenanthos* spp. including *A. cygnorum*). *Dryandra sessilis* (parrot bush) and *Jacksonia furcellata* (grey stinkwood) and *J. sternbergiana* (green stinkwood) are interspersed throughout areas dominated by this community.

This complex is vigorous and has high species richness. Extreme diversity in the understorey also characterises this community. The understorey is predominantly native, with considerable variation in the specific composition. Species recorded included *Xanthorrhoea preissii* (blackboy), *Macrozamia riedlei* (zamia), *Kunzea ericifolia*, *Hovea* sp., the native sedge *Baumea articulata* (jointed twig-rush), *Dasypogon bromeliifolius* (pineapple bush), Mangles kangaroo paw (*Anigozanthos manglesii*), *Stipa* sp. and *Lepidobolus* sp. A number of additional monocots recorded however could not be identified.

There is comparatively little weed invasion in these areas, with the road verge and fencing providing a buffer and reducing opportunities for invasion of weeds from cleared rural properties. Prevalent weed species include the shrub *Diosma* and blowfly grass.

3.7 Other plant communities and vegetation types

Melaleuca rhaphiophylla low closed (swamp) forest

The swamp paperbark *Melaleuca rhaphiophylla* forms dense low stands (3-4 m) of closed forest over small lakes within the study area (Maps 1, 2, 3, 5 and 7). The introduced parasite golden dodder (*Cassytha flava*) is extremely common on the paperbarks. This community is characterised by an absence of understorey species as a result of limited light penetration and permanent water, although pennyroyal and dock persist in this community.

Eucalyptus spp. - *Banksia* spp. closed woodland

A variety of overstorey species characterise this community type. The dominant eucalypts include *E. calophylla* (marri) and *E. marginata* (jarrah) and occur in association with *Banksia ilicifolia*, *B. menziesii* (firewood banksia) and *B. grandis* (bull banksia) (Maps 8 and 9). *Dryandra sessilis* (parrot bush), *Jacksonia sternbergiana* (green stinkwood), *Kunzea ericifolia*, *Kingia* sp., *Adenanthos cygnorum* (woolly bush) and *Macrozamia riedlei* (zamia) form a patchy middlestorey. The understorey is typified by very dense leaf litter, and a high proportion of regeneration of the dominant tree species. Understorey species are sparse, although a few homogeneous clumps of *Juncus microcephalus* persist.

This community also extends across the western boundary of the property known as the Lowlands. As well as the species listed above, tree species present include *Allocasuarina fraseriana* and *Xylomelum occidentale* (woody pear) (both species range in height between 8 -10 m). The understorey in this area is substantially more dense as the landholders have restricted stock access to this area for a number of decades. Assorted native grasses such as *Lepidobolus* sp. and creepers including *Hovea* sp. prevail.

The bracken fern *Pteridium esculentum* is distributed throughout this community, occurring as an extensive monospecific stand in the *Eucalyptus-Banksia* woodland (Map 9). In this context this native species is behaving as a weed. Prickly pear (*Opuntia stricta*) is present in this community and represents a potential threat to the persistance of the natural value of these areas.

This community has maintained its integrity well in this rural environment and has high conservation value.

Eucalyptus calophylla - E. marginata open - closed forest

These two species co-occur in a single stand in a cleared area (Map 9). This stand is associated with *Banksia ilicifolia* and *B. grandis* (bull banksia) in low numbers. The understorey is predominantly pasture grass species with relic *Juncus* species forming clumps.

The occurrence of these two species in dense, co-dominant stands, within an agricultural area, suggests that these trees once prevailed throughout the adjacent community and that agricultural activities and burning practices may have accelerated the transition to the *Eucalyptus* spp. - *Banksia* spp. dominated community, which surrounds this remnant.

Eucalyptus spp. - *Juncus* spp. open forest

This community fringes the river for several hundred metres within the property known as the Lowlands (Map 8). This is the largest continuous stand of this community in the study area. In other areas, dense populations of *E. rudis* form communities with extensive stands of *Juncus kraussii* (shore rush) and *J. microcephalus* in seasonally inundated regions with knotted club-rush (*Isolepis nodosa*) on sandy rises (Map 1). *E. rudis* (flooded gum) (20 - 30 m) is the only tree species in this community, with no other associations except in the vicinity of the Scarp. The Darling Range ghost gum (*Eucalyptus laeliae*) occurs in small numbers between South Western Highway east to the Serpentine Falls. These areas are particularly characterised by a lack of *Melaleuca* in significant quantities. The understorey in depressions is dominated by *Schoenoplectus validus* (lake club-rush) and the native bulrush *Typha domingensis*, with *Bolboschoenus caldwellii* (marsh club-rush) forming monospecific stands in, and adjacent to, disturbed regions such as tracks (Maps 1, 8 and 9). Interspersed species include *Baumea articulata* (jointed twig-rush), *Carpobrotus* spp. (pigface), *Acacia rostellifera* and *Jacksonia furcellata* (grey stinkwood). The introduced shrub *Diosma* sp. occurs in isolated patches in the understorey, and *Trisetaria cristata* (cat's tail grass), buffalo grass and *Trifolium* spp. (clovers) are present. The understorey is generally very dense.

Weeds including couch and *Watsonia* spp. occur consistently through this community. Adjacent to the Scarp, the dominant weed components include the native bracken fern and *Rubus fructicosa* (blackberry).

Baeckea spp. low open - closed scrubland

Homogeneous continuous dense stands of *Baeckea* sp. occur in three locations in the study area (Maps 5 and 6). This scrubland is occasionally associated with sparse *Melaleuca preissiana* (moonah) and *M. lateritia* (red robin), and the understorey is typically composed of introduced grasses and herbs, including cat's tail grass, couch and pennyroyal. In some locations, *Juncus pauciflorus* and *Baumea articulata* (jointed twig-rush) persist (Map 5).

Pastured woodlands

The majority of the study area is characterised by cleared agricultural land with relic trees from past stands of forest and woodland communities remaining over pasture grasses. Stands of eucalypts including *Eucalyptus marginata* (marri), *E. gomphocephala* (tuart), *E. calophylla* (jarrah) and *E. rudis* (flooded gum) of varying densities occur throughout the study area.

Baeckea sp., *Kunzea ericifolia, Kingia* sp., *Schoenoplectus validus* (lake club-rush), and other native grasses and sedges have persisted in some areas.

Most of the native species are likely to have disappeared or declined substantially in abundance as a result of pastoral activities. Scattered native trees and some relic native shrub and sedge species have persisted amongst diverse and abundant weed species.

Agricultural - open

Extensively cleared areas (Maps 1-12) are characterised by occasional relic shade trees, particularly *E. marginata* (jarrah), *E. gomphocephala* (tuart) (both 40 m and greater) and *E. calophylla* (marri), with *E. rudis* (flooded gum) increasingly prevalent in the vicinity of the Serpentine River and its tributaries. In some areas which appear to have little stock access there are dense but discontinuous stands of *Jacksonia sternbergiana* (green stinkwood) (Map 2). Some paperbarks occur in cleared areas, particularly *Melaleuca preissiana* (moonah) and occasional *M. cuticularis* (saltwater paperbark).

Drainage channels in some areas are visually defined by the presence of dense *Juncus pauciflorus*.

The most prevalent weed is pennyroyal although some areas retain substantial areas of apple of sodom.

A number of grass species characterise these regions including common barley grass (*Hordeum leporinum*).

4.0 WEED INFESTATION

Progressive weed invasion threatens stands of native vegetation and thus the conservation value of areas of remnant vegetation. Agricultural activity is characterised by high levels of disturbance to the natural environment and such activities typify the Serpentine study area. Introduced species can displace less competitive native species and thus alter the ecological integrity and aesthetic appeal of the Serpentine region.

The degree of weed invasion in the vicinity of the Serpentine River appears to be partially dependent upon the influence of grazing stock. The physical nature of the area, location and number of tracks and the distance from built areas are also important determinants (Trudgen 1991).

Some weeds are more successful than others. Monocots including couch, buffalo grass, crab grass, veldt grass, blowfly grass and wild oats species occur consistently throughout the area.

Close to the town of Serpentine the predominant weed species include *Lantana* sp., bamboo (*Arundo donax*), apple of sodom and blackberry.

Specific concerns are associated with the species listed below. These species are extensively distributed throughout the study area.

Solanum sodomeum

Apple of Sodom is a declared noxious weed, introduced from South Africa. This poisonous weed favours coastal limestone soils. It is a woody perennial which spreads by seed.

Cassytha flava

Golden dodder is an introduced parasitic weed. This species typically invades and destroys *Melaleuca* stands and it is a point of concern that dodder is prevalent through the study area. Seed distribution and fragmentation of the leaf material by birds etc. enhance the distribution of this weed.

Diosma

This shrub, from the family Rutaceae, originated in the Eastern States and is a common garden plant throughout WA. The plant produces pink or white flowers with acrid smelling small leaves. This plant is widespread throughout the study area.

Mentha pulegium (pennyroyal)

This noxious weed is widespread throughout the south section of the Swan Coastal Plain. It is an aromatic perennial herb which spreads both vegetatively from rhizomes and by seeds.

Rubus fructicosa

Blackberry brambles are a serious nuisance in the Perth Metropolitan Region and are prevalent along both the Swan and Canning Rivers. A similar pattern is apparent along the river banks in the vicinity of the Town of Serpentine, heavily infested by this weed. The distribution of the brambles is believed to be restricted to approximately three kilometres of the river.

Rumex spp. including *R. obtusifolius*

Dock species are declared noxious weeds. This genera is a major problem in areas with high rainfall. Broad-leaf dock is a common weed throughout the study area. Dock species are prolific seeders and produce seed which can germinate any time during the growing season. Vegetative reproduction by fragmentation also occurs.

Zantedeschia aethiopica

Arum lilies are well established within creeks and damp lands. They persist within the vegetation communities fringing the Serpentine River. This species spreads by regeneration from root fragments and by seeds. It is declared noxious by some local authorities. Anecdotal evidence suggests that the distribution of arum lilies is increasing rapidly.

5.0 DISCUSSION

5.1 Loss of understorey species

A pattern of vegetation loss similar to that observed by Pen (in press) in the vicinity of the Collie and Brunswick Rivers is occurring along the Serpentine River. Much of the native fringing forest which once occupied the Serpentine River has been lost th14rough the clearing of land for agriculture. The remaining vegetation is largely represented by native tree species such as *E. rudis* (flooded gum), *Allocasuarina* spp. (sheoak) and *Melaleuca rhaphiophylla* (freshwater paperbark). Most of the understorey has been replaced by introduced weeds, mostly grasses. The sequence of events involved the replacement of native shrubs, sedges, grasses and herbs slowly through clearing, livestock grazing and trampling and an increase in the frequency of fire, which favours species with short life cycles, most of which are introduced. In the study area today, all of the forest or woodland with largely intact understorey resides in the lower and middle sections of the Serpentine River. Upstream, closer to the Town of Serpentine, the native understorey becomes progressively sparse as a result of higher density living.

5.2 Common native understorey species

Despite the abundance of weeds and severe disturbance from livestock and fire, a few native species persist in the understorey of forest and woodland communities in the exclusively agricultural regions dominating the eastern part of the study area. These species include the shrubs *Jacksonia sternbergiana* (green stinkwood), *J. furcellata* (grey stinkwood), *Baeckea* sp., the sedge *Schoenoplectus validus* and the rushes *Juncus pauciflorus* and *J. kraussii*. These species are present throughout the study area, and in some locations are extending their distribution. In conditions of severe disturbance these species are often found growing along the immediate periphery of the rivers.

5.3 Erosion

Erosion of the river bank is a serious problem in certain sections of the study area. This problem has arisen partially as a result of clearing and grazing, with livestock having unrestricted access to most sections of the river.

The area with the greatest potential for severe erosion in the long term lies between the Lowlands property and South Western Highway. Here, a very steep sandy rise flanks the river on the western bank. It supports sandy rise vegetation of *Eucalyptus calophylla* - *Banksia* spp. woodland. Four wheel drive vehicles, livestock and frequent fires have thinned out the vegetation and undermined trees in places, leading to a major subsidence in one area which requires physical attention to prevent further serious erosion.

The Serpentine River cuts mostly through agricultural land used for the grazing of livestock. During the course of this study only two sections of the river in the study area were observed to be entirely fenced off to prevent livestock from trampling the foreshore. Some old fence lines remain in places, but these were all in disrepair. It would appear that the river represents de facto fences on most properties. Undermining of trees is a common sight east of the Lowlands property. In these sections, riverbank undercutting is most severe and sandy sediment deposits of eroded material are common on the bends of the rivers. In some sections native shrubs and sedges and/or weeds protect the river margins, but in others there is only muddy or sandy foreshore.

5.4 Protection of fringing vegetation

The regions within the study area which presently support the most natural stands of fringing vegetation are the Lowlands property, the region known as Amarillo, the lake on the corner of Baldivis Road and Stakehill Road, and the State Forest. These areas require the highest level of protection from:

(a) livestock trampling;

(b) frequent fire (i.e. greater than 5 years);

(c) weed invasion (see Section 4.);

(d) vehicle damage; and

(e) development pressures.

All of the remnant vegetation fringing the river may be enhanced by the prevention of livestock access. Regeneration of understorey and middle storey species can result as a consequence of defining livestock access points. This in turn may decrease the current success of introduced weed species and achieve a stable equilibrium centred around a predominantly native complex.

5.5 Management of remnant vegetation

There are significant stands of remnant vegetation requiring management if they are to be maintained for wildlife habitat and corridors, riverbank stabilisation and nutrient uptake.

There are two System Six areas located within the study area, M105 (Lowlands) and M108 (Geogrup Lake). The significant areas of remnant vegetation occurring in both areas contribute to their high conservation value. The Lowlands area is in private ownership. The owners maintain the remnant vegetation on the property as part of their overall management regime. Unless necessitated by a change in circumstances (e.g. ownership, fire) this management regime is considered appropriate.

The area contained within the System Six recommendation M108 is partly within the Peel Inlet Management Authority's (PIMA) management area. This allows for some control over land use activities which may impact on the remnant vegetation. Extension of PIMA's Management Area to include at least the remainder of this area is appropriate. Implementation of the System Six recommendations is supported.

Management plans prepared in consultation with the landowners would provide a basis for the long-term management of both areas. Various agencies (e.g. CALM, PIMA, the local government authority) have the expertise to prepare these plans).

There are many other areas of remnant native vegetation within the study area which require management for their long-term protection.

Landholders should be encouraged, by means of joint funding, to fence off the native vegetation on their properties. Local and State government agencies should assist with funding. Stock access points to the river should be defined to restrict uncontrolled access. Overgrazing river banks prevents regrowth and causes erosion.

Forms of financial compensation should be considered for those landowners who exclude land from production to protect remnant vegetation.

Landscape Protection Zones should be encouraged within the local authority town planning schemes to protect native vegetation. If at some stage in the future land adjacent to the river is required for urban development, suitable foreshore reserves should be acquired by the Crown.

Other issues which need consideration include fire management, disease control (e.g. dieback), maintenance of genetic variation, replanting from the existing gene pool and rehabilitation. Protection of native fauna will facilitate continued seed dispersal by this means, and the associated mixing of neighbouring gene pools.

6. SUMMARY

Livestock grazing, commercial hay production and a few dairies are the predominant land use activities within the study area. Most of the agricultural properties have been extensively cleared and for the most part only scattered trees remain to represent the native vegetation. Stock generally have free access to the river and, as a consequence, livestock have caused severe erosion of the river banks and denuded the banks of native vegetation. The vegetation fringing the river is characterised by sparsity of the understorey and trees which are being undermined through erosion.

Twenty-one communities were identified in the study area, some of which are of regional significance. The best examples of undisturbed complexes being the *Eucalyptus-Banksia* woodland, *Melaleuca* spp. open-closed thicket, *Juncus kraussii* closed sedgeland, *Kunzea* spp. closed thicket and *Baeckea* spp. scrubland. The conservation value of these areas is high, however without appropriate management their value will diminish.

Some communities were floristically distinct, however more complex woodland and scrub communities were less readily classified. This is due to considerable floristic variation within the communities. This variation relates to differences in community structure and spacing of plants as a result of habitat variation and human impact. Differences in species quantities rather than in floristic composition were observed.

The fringing vegetation of the rivers has been highly degraded through certain land use practices which have facilitated weed invasion within much of the study area. Some relic communities have persisted. This study, like Pen (in press), has shown however that the long-term viability of these communities adjacent to developed or developing areas, is threatened by the presence and spread of a large number of exotic weeds. Weeds can hinder regeneration. Ultimately, the landscape and habitat values of the river will diminish if these relic communities are not protected and extensive weed control programmes are not developed and implemented.

One recognised means of riverbank regeneration is by the exclusion of livestock. This is best achieved through fencing. The erosion problems apparent in the agricultural areas may be minimised by allowing revegetation of the banks.

The study area also supports rich and diverse fauna. Loss of native vegetation threatens to displace this fauna, some of which is rare and endangered.

The majority of native vegetation which existed in the Serpentine River catchment has been lost since agricultural development commenced. Without effective management the remaining native vegetation is under serious threat. Local and State government authorities must develop long-term strategies to ensure the ecological integrity of the study area.

7.0 REFERENCES

Department of Planning and Urban Development (1990) Metroplan. Perth, Western Australia.

Department of Planning and Urban Development (1993) South West Corridor Structure Plan Review (from Rockingham to North Mandurah. Perth, Western Australia.

Marchant, N J, Wheeler, J R, Rye, B L, Bennett, E M, Lander, N S and MacFarlane, T D (1987) Flora of the Perth Region. Part One and Part Two. Western Australian Herbarium, Department of Agriculture, Western Australia.

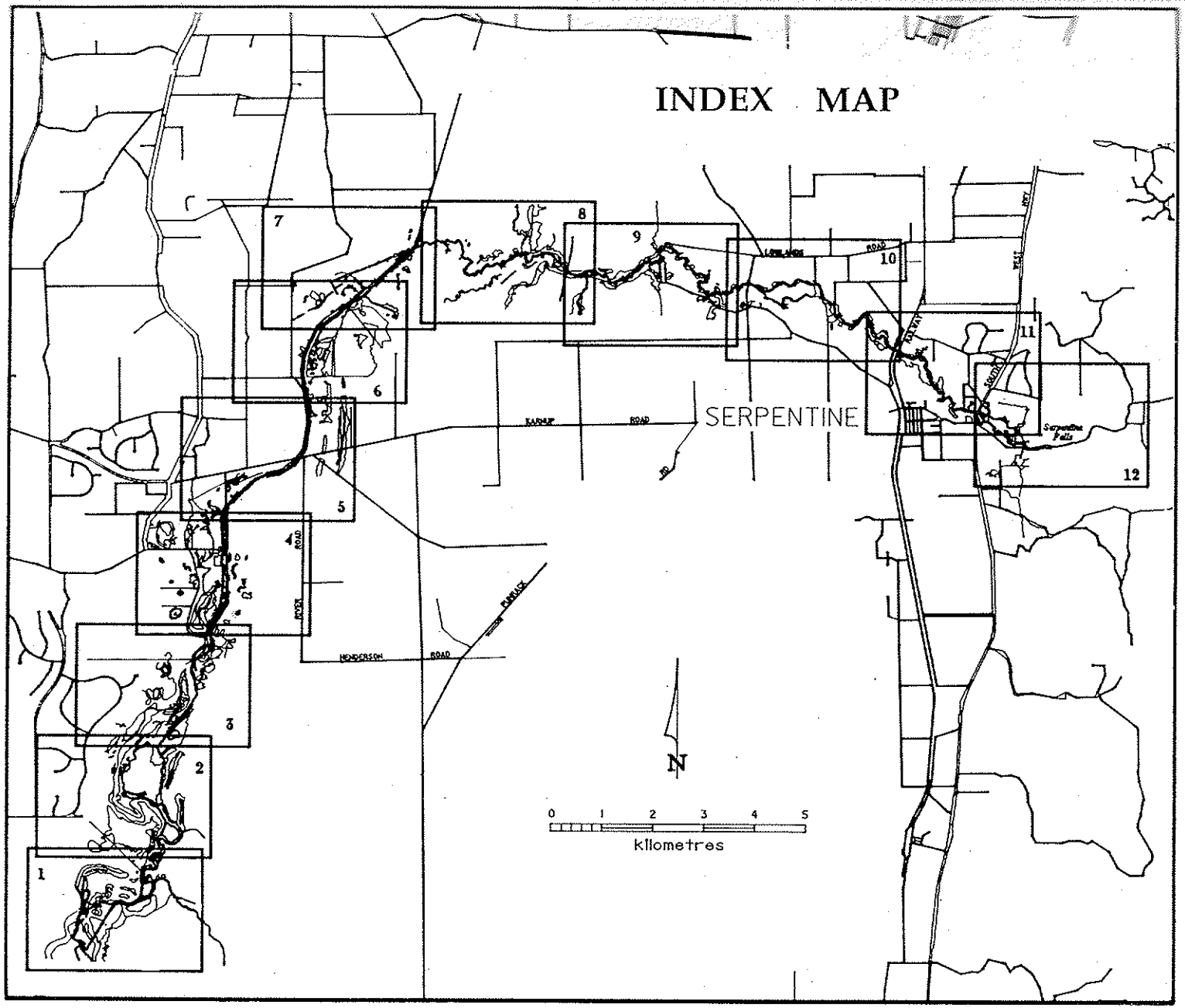
McArthur, W M and Bettenay E (1960) Development and Distribution of Soils of the Swan Coastal Plain, Western Australia. CSIRO Soil Publication No. 16.

Pen, L J (1981) Peripheral vegetation of the Swan and Canning Estuaries 1981. Unpubl. Hons. Thesis, Murdoch University.

Pen, L J (1992). Fringing estuarine vegetation of the Leschenault Estuary 1941 - 1991. Waterways Commission Report No. 31.

Pen, L J (In press) Freshwater fringing vegetation of the Canning, Southern and Wungong Rivers on the Swan Coastal Plain. Swan River Trust Report No. 7.

Trudgen, M (1991) A flora and vegetation survey of the coast of the City of Mandurah. Department of Planning and Urban Development, Perth.


INDEX MAP
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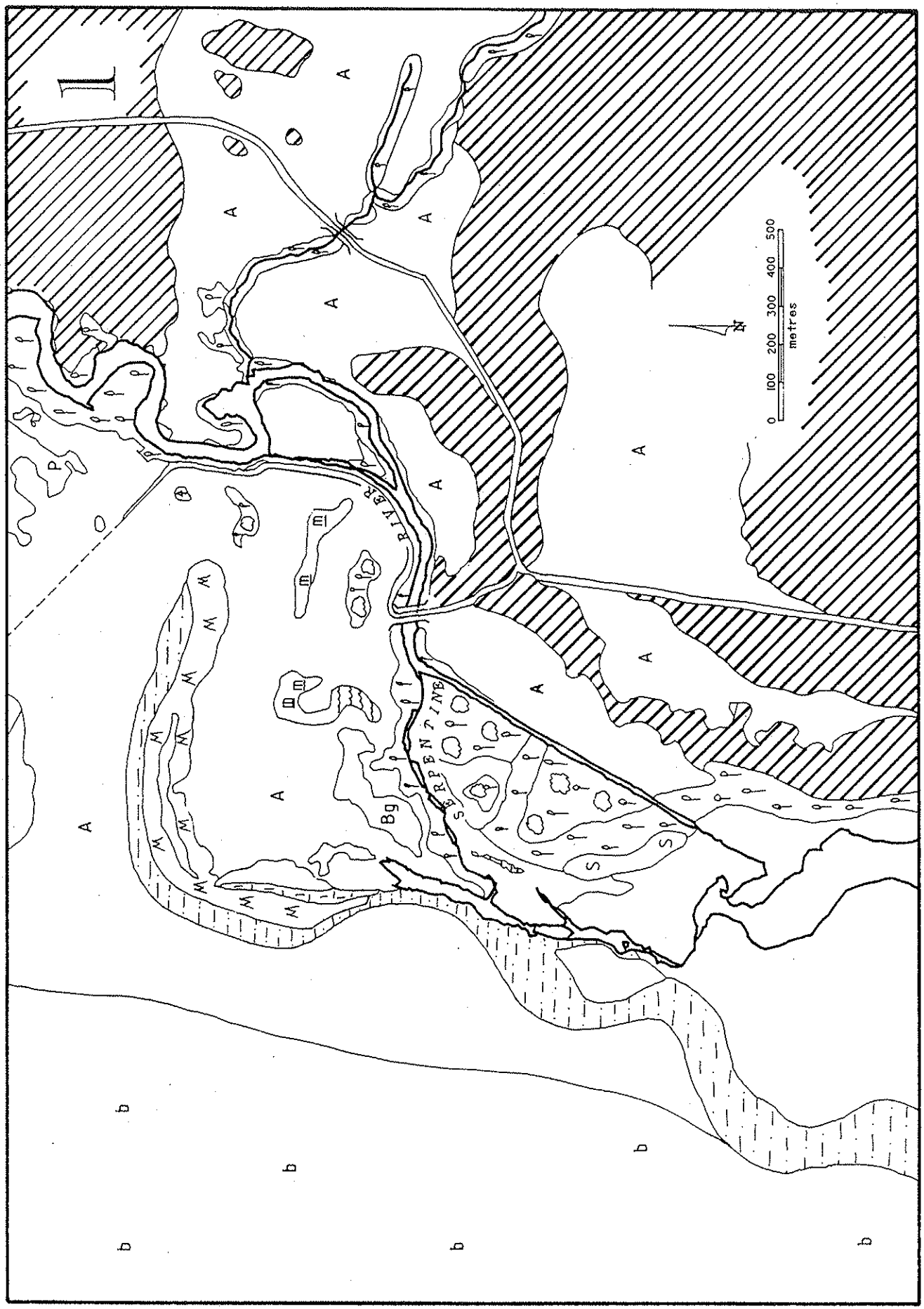
A
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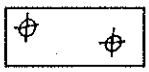
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

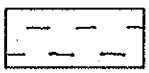
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

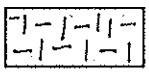


Schoenoplectus validus
closed sedgeland

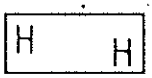
FRINGING ESTUARINE FOREST VEGETATION



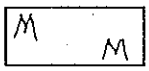
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

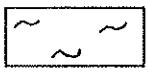


Melaleuca viminea
low open - closed forest



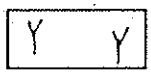
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



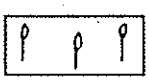
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

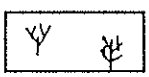


Melaleuca spp. - Baeckea spp.
low open - closed forest

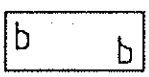
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



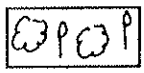
Kunzea spp.
closed thicket



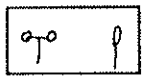
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

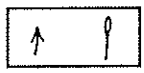
Melaleuca rhaphiophylla
low closed (swamp) forest



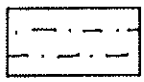
Eucalyptus rudis
pastured woodland



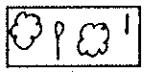
Eucalyptus spp. - Banksia spp.
closed woodland



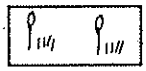
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

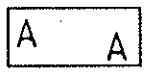


E. gomphocephala - E. rudis
pastured woodland

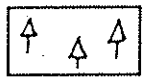


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

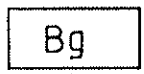


Cleared agricultural land

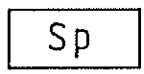


Pinus pinaster - P. radiata
pine plantation

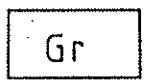
Pasture



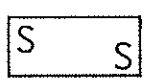
Bare ground



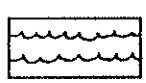
Salt pan



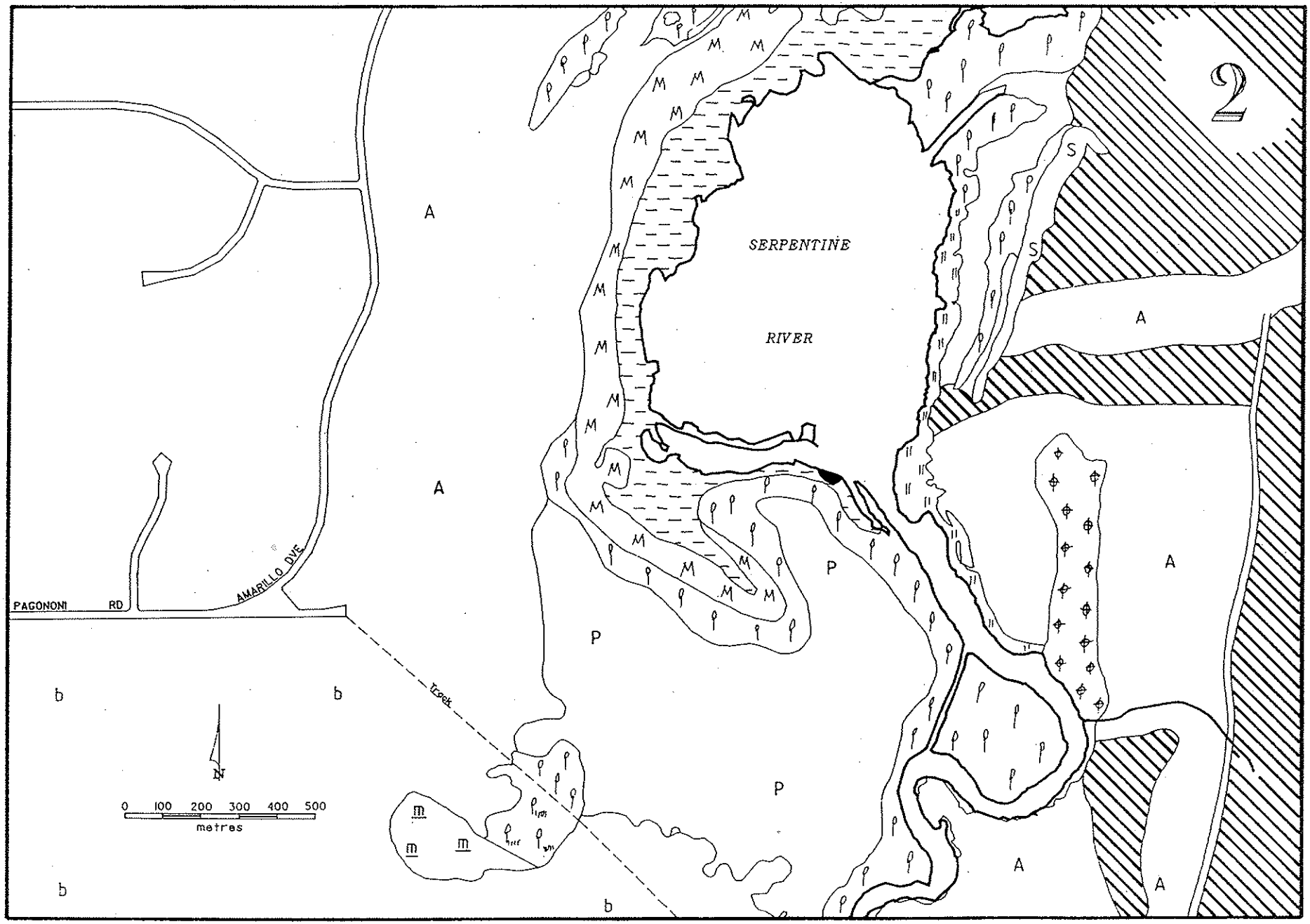
Scattered grasses



Sand



Standing water


2
SERPENTINE
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PAGONONI RD
AMARILLO DVE
Track
b
b
b
b
N
0 100 200 300 400 500
metres

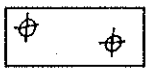
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

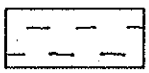
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

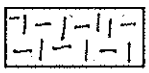


Schoenoplectus validus
closed sedgeland

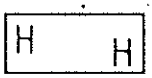
FRINGING ESTUARINE FOREST VEGETATION



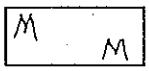
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

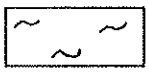


Melaleuca viminea
low open - closed forest



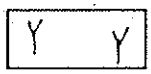
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



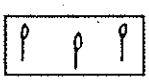
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

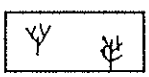


Melaleuca spp. - Baeckea spp.
low open - closed forest

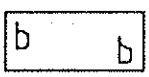
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



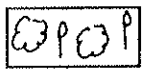
Kunzea spp.
closed thicket



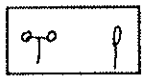
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

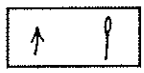
Melaleuca rhaphiophylla
low closed (swamp) forest



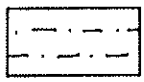
Eucalyptus rudis
pastured woodland



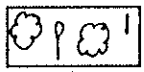
Eucalyptus spp. - Banksia spp.
closed woodland



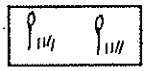
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

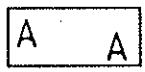


E. gomphocephala - E. rudis
pastured woodland

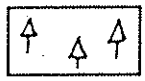


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

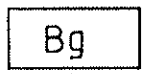


Cleared agricultural land

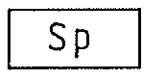


Pinus pinaster - P. radiata
pine plantation

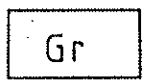
Pasture



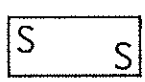
Bare ground



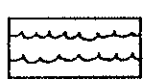
Salt pan



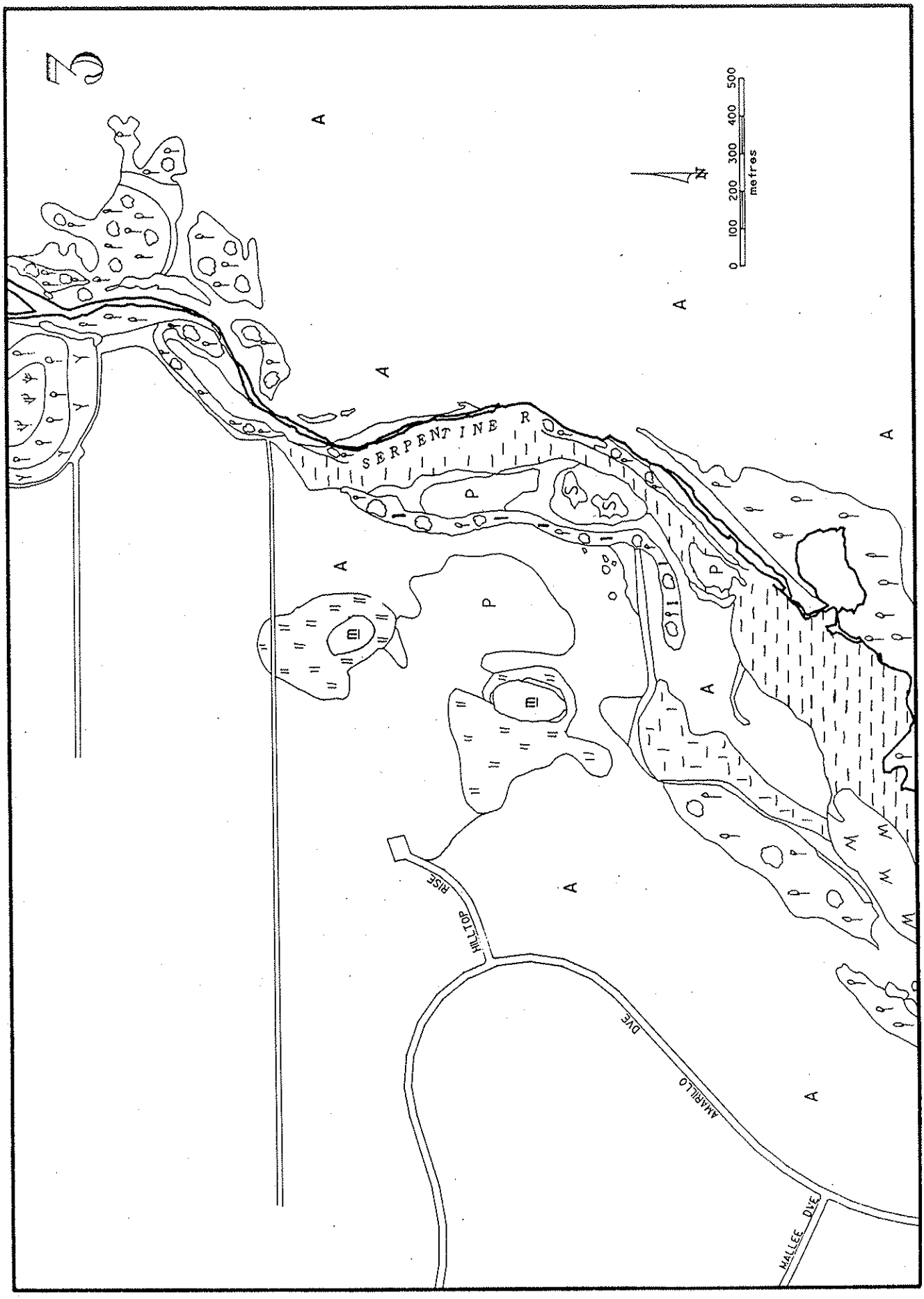
Scattered grasses



Sand



Standing water


SERPENTINE R
HILLTOP RISE
AMARILLO DVE
MALLEE DVE
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metres
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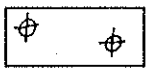
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

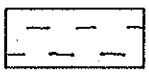
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

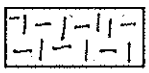


Schoenoplectus validus
closed sedgeland

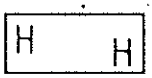
FRINGING ESTUARINE FOREST VEGETATION



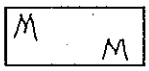
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

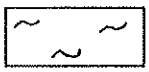


Melaleuca viminea
low open - closed forest



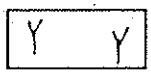
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



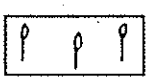
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

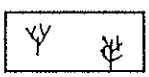


Melaleuca spp. - Baeckea spp.
low open - closed forest

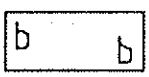
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



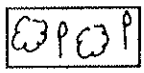
Kunzea spp.
closed thicket



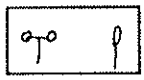
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

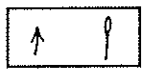
Melaleuca rhaphiophylla
low closed (swamp) forest



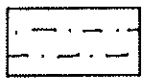
Eucalyptus rudis
pastured woodland



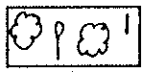
Eucalyptus spp. - Banksia spp.
closed woodland



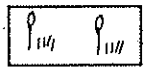
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

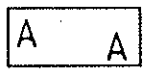


E. gomphocephala - E. rudis
pastured woodland

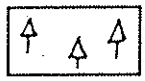


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

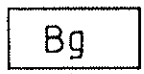


Cleared agricultural land

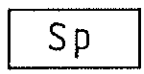


Pinus pinaster - P. radiata
pine plantation

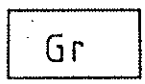
Pasture



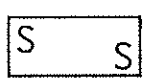
Bare ground



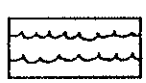
Salt pan



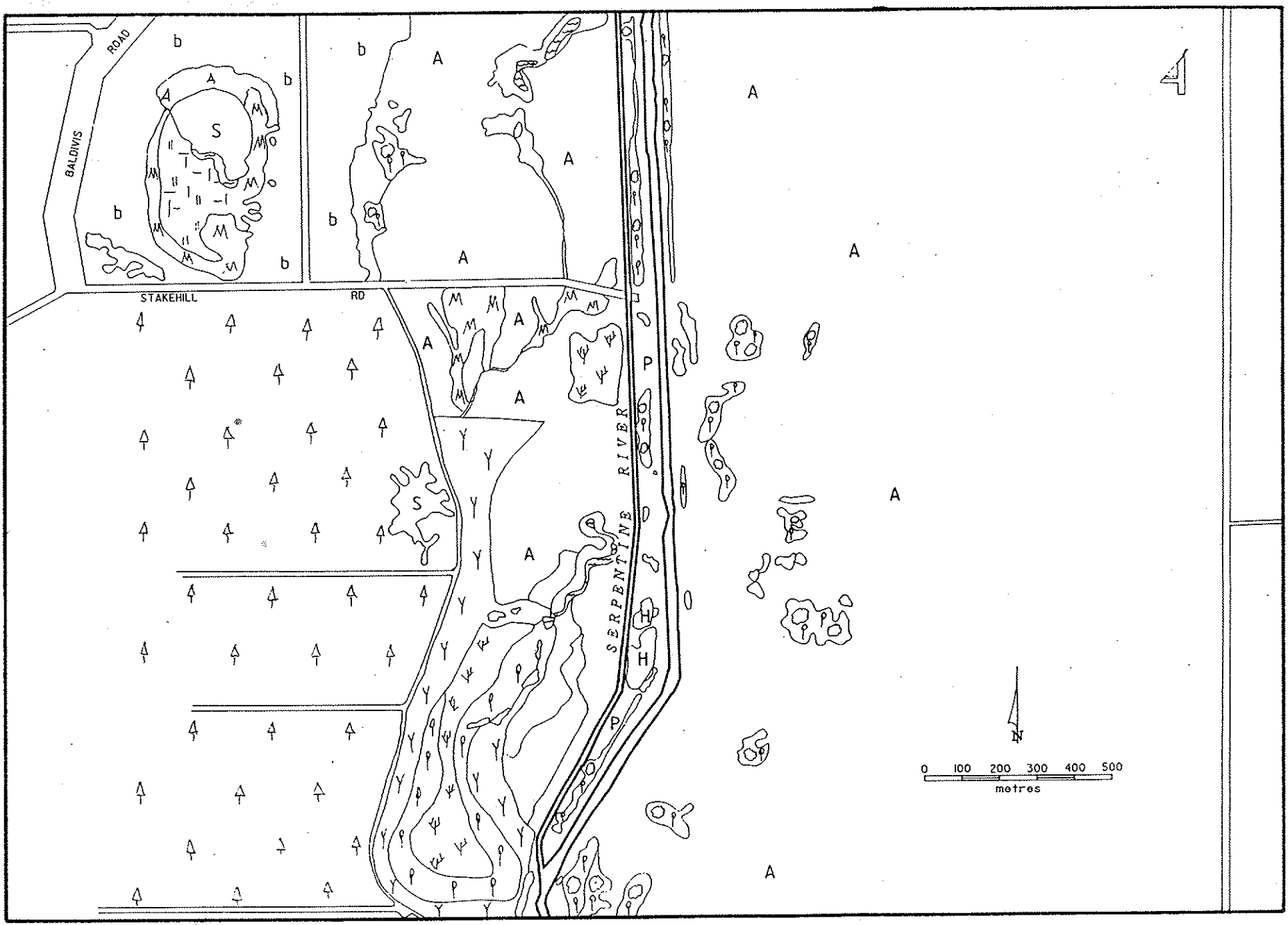
Scattered grasses



Sand



Standing water


BALDIVIS ROAD
STAKEHILL RD
SERPENTINE RIVER
0 100 200 300 400 500
metres

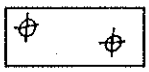
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

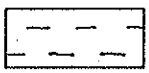
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

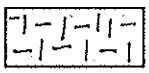


Schoenoplectus validus
closed sedgeland

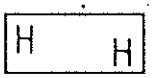
FRINGING ESTUARINE FOREST VEGETATION



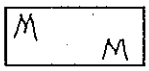
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

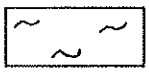


Melaleuca viminea
low open - closed forest



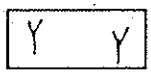
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



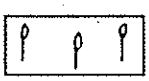
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

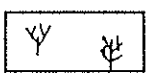


Melaleuca spp. - Baeckea spp.
low open - closed forest

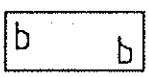
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



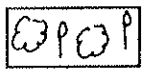
Kunzea spp.
closed thicket



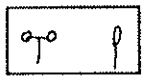
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

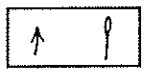
Melaleuca rhaphiophylla
low closed (swamp) forest



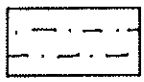
Eucalyptus rudis
pastured woodland



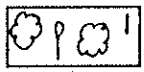
Eucalyptus spp. - Banksia spp.
closed woodland



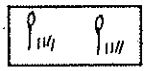
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

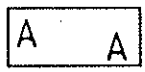


E. gomphocephala - E. rudis
pastured woodland

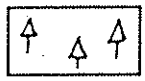


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

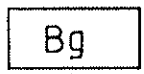


Cleared agricultural land

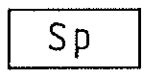


Pinus pinaster - P. radiata
pine plantation

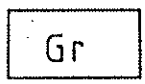
Pasture



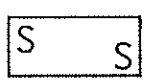
Bare ground



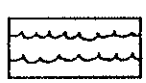
Salt pan



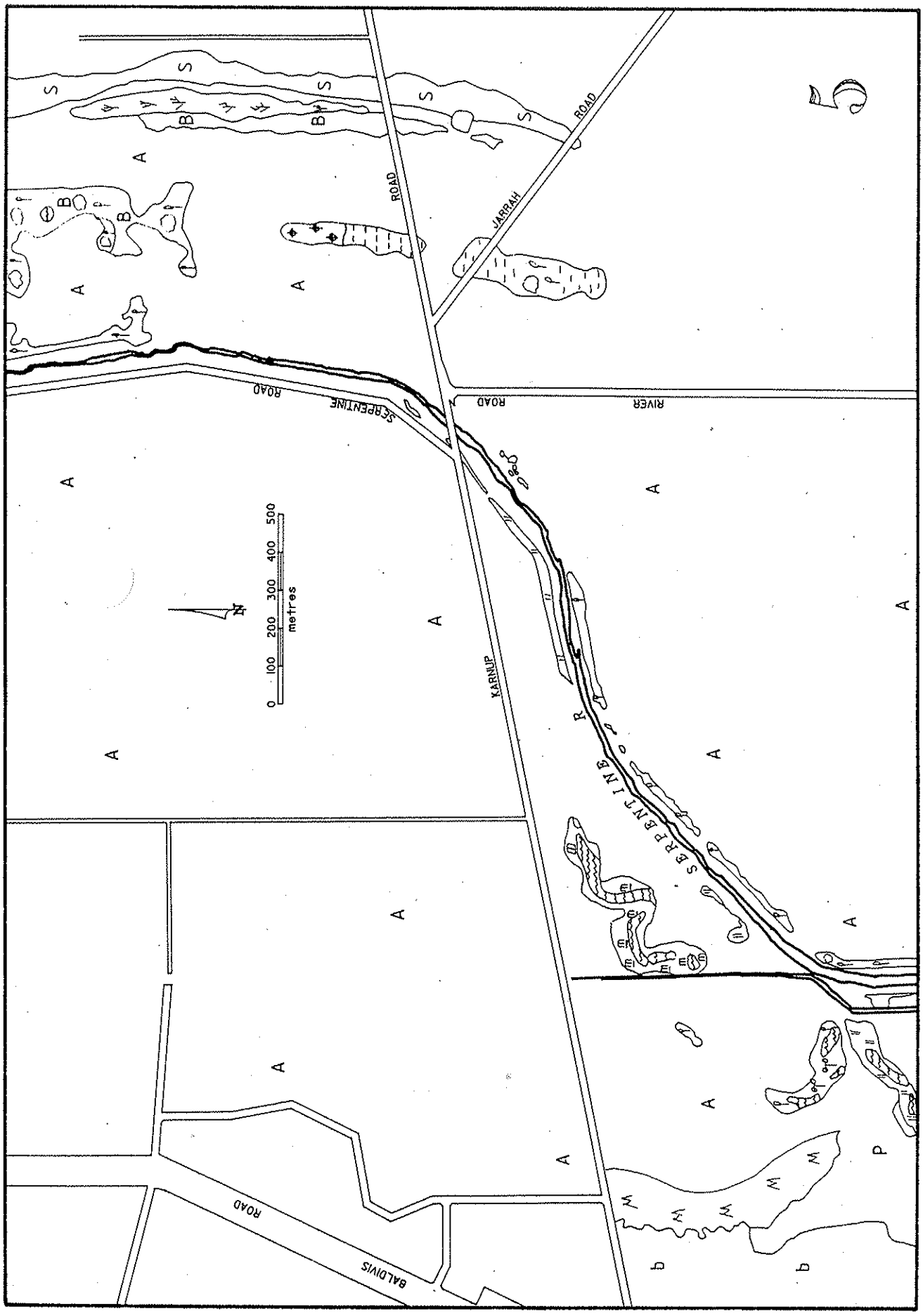
Scattered grasses



Sand



Standing water


ROAD
JARRAH
ROAD
SERPENTINE
ROAD
RIVER
KARNUP
SERPENTINE
RIVER
ROAD
BALDIVIS
0 100 200 300 400 500
metres
N

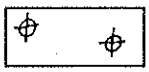
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

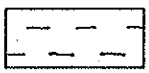
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

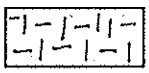


Schoenoplectus validus
closed sedgeland

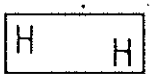
FRINGING ESTUARINE FOREST VEGETATION



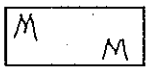
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

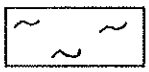


Melaleuca viminea
low open - closed forest



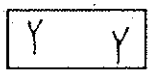
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



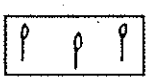
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

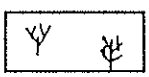


Melaleuca spp. - Baeckea spp.
low open - closed forest

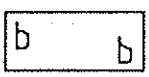
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



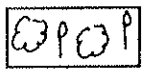
Kunzea spp.
closed thicket



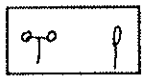
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

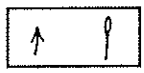
Melaleuca rhaphiophylla
low closed (swamp) forest



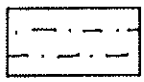
Eucalyptus rudis
pastured woodland



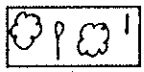
Eucalyptus spp. - Banksia spp.
closed woodland



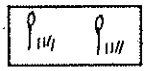
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

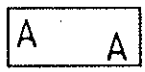


E. gomphocephala - E. rudis
pastured woodland

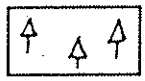


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

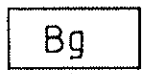


Cleared agricultural land

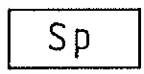


Pinus pinaster - P. radiata
pine plantation

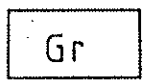
Pasture



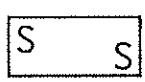
Bare ground



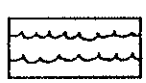
Salt pan



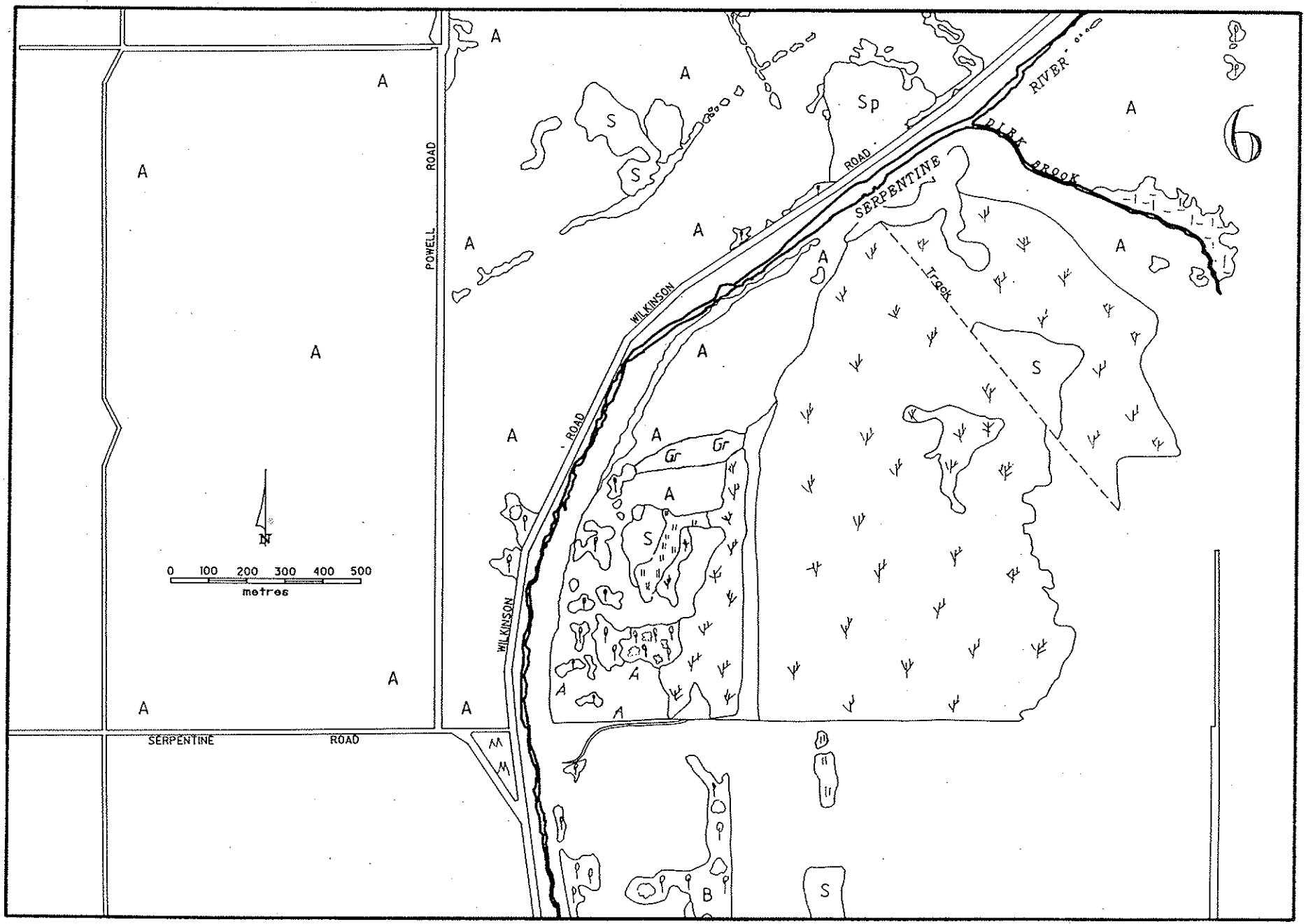
Scattered grasses



Sand



Standing water


A
S
Sp
Gr
B
M
ROAD
POWELL ROAD
WILKINSON ROAD
SERPENTINE ROAD
SERPENTINE
RIVER
PIRK BROOK
Trail
6
N
0 100 200 300 400 500
metres

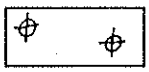
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

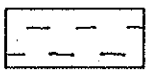
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

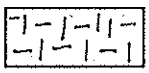


Schoenoplectus validus
closed sedgeland

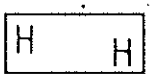
FRINGING ESTUARINE FOREST VEGETATION



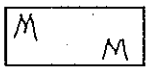
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

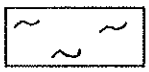


Melaleuca viminea
low open - closed forest



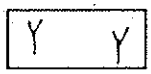
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



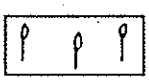
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

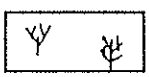


Melaleuca spp. - Baeckea spp.
low open - closed forest

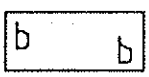
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



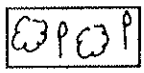
Kunzea spp.
closed thicket



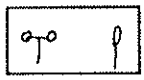
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

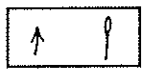
Melaleuca rhaphiophylla
low closed (swamp) forest



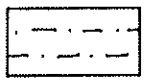
Eucalyptus rudis
pastured woodland



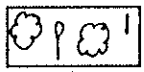
Eucalyptus spp. - Banksia spp.
closed woodland



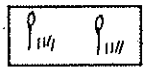
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

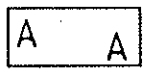


E. gomphocephala - E. rudis
pastured woodland

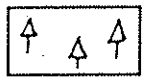


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

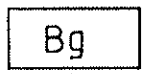


Cleared agricultural land

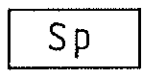


Pinus pinaster - P. radiata
pine plantation

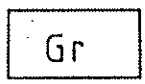
Pasture



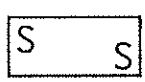
Bare ground



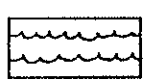
Salt pan



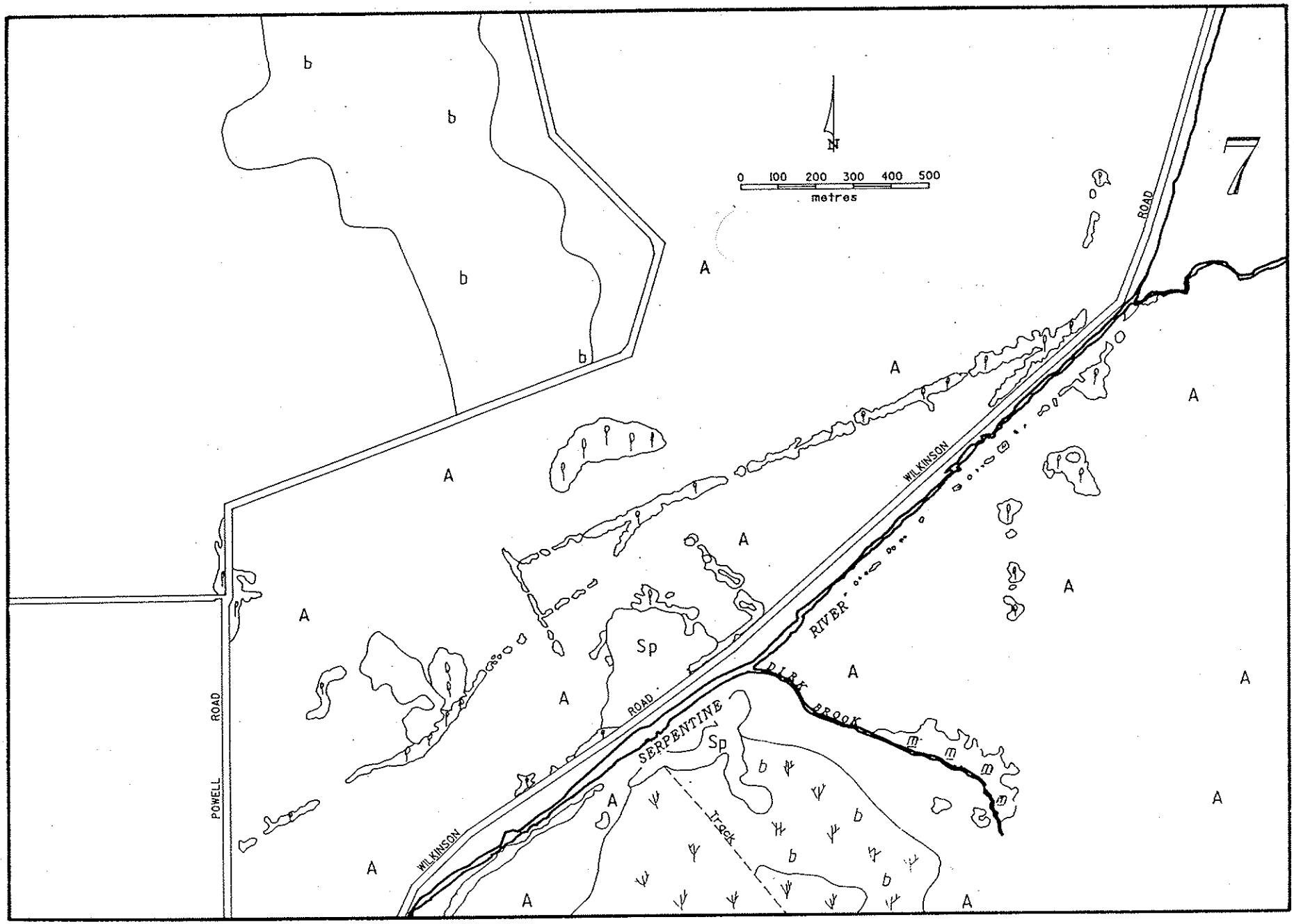
Scattered grasses



Sand



Standing water


7
N
0 100 200 300 400 500
metres
ROAD
WILKINSON
RIVER
DIRK BROOK
SERPENTINE
ROAD
POWELL ROAD
WILKINSON
Track
A
b
Sp
m

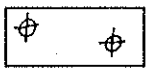
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

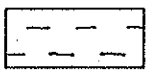
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

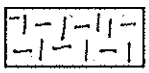


Schoenoplectus validus
closed sedgeland

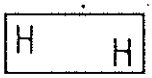
FRINGING ESTUARINE FOREST VEGETATION



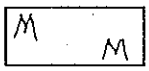
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

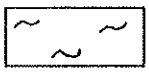


Melaleuca viminea
low open - closed forest



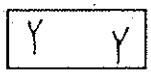
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



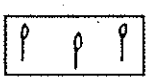
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

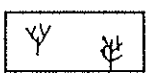


Melaleuca spp. - Baeckea spp.
low open - closed forest

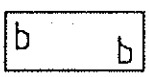
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



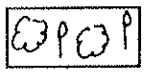
Kunzea spp.
closed thicket



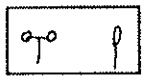
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

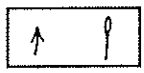
Melaleuca rhaphiophylla
low closed (swamp) forest



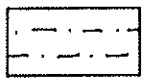
Eucalyptus rudis
pastured woodland



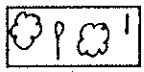
Eucalyptus spp. - Banksia spp.
closed woodland



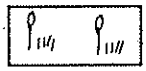
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

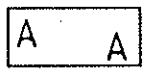


E. gomphocephala - E. rudis
pastured woodland

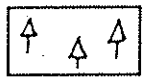


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

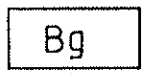


Cleared agricultural land

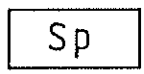


Pinus pinaster - P. radiata
pine plantation

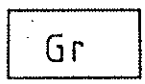
Pasture



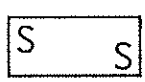
Bare ground



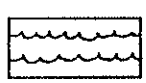
Salt pan



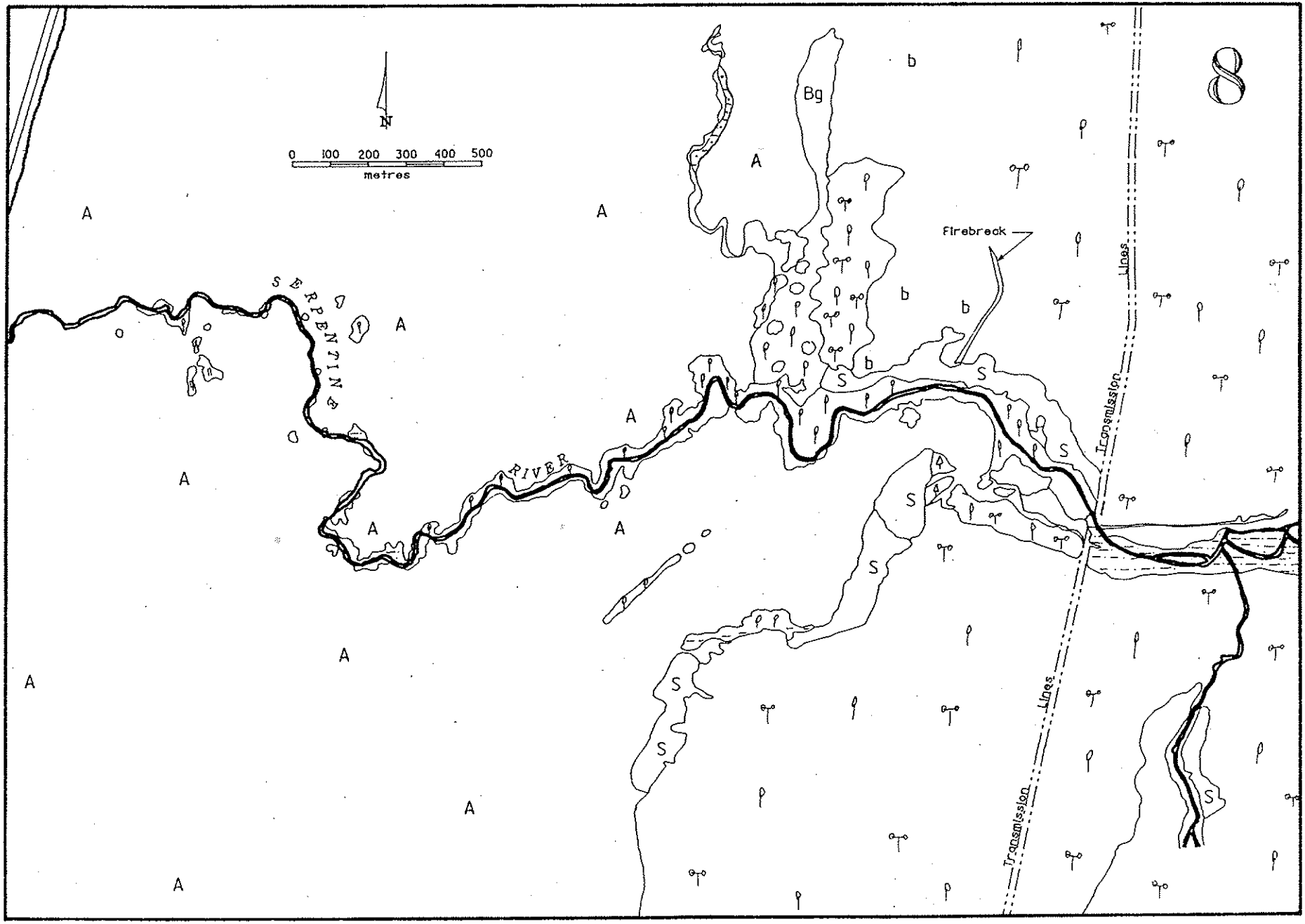
Scattered grasses



Sand



Standing water


8
N
0 100 200 300 400 500
metres
SERPENTINE
RIVER
Firebreak
Transmission Lines
Transmission Lines
Bg
A
b
S

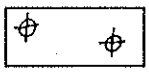
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

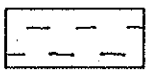
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

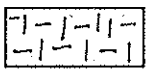


Schoenoplectus validus
closed sedgeland

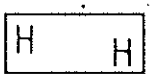
FRINGING ESTUARINE FOREST VEGETATION



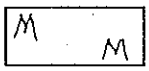
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

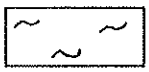


Melaleuca viminea
low open - closed forest



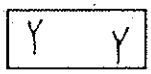
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



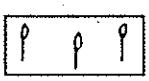
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

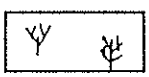


Melaleuca spp. - Baeckea spp.
low open - closed forest

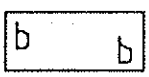
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



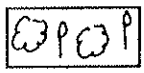
Kunzea spp.
closed thicket



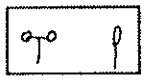
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

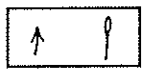
Melaleuca rhaphiophylla
low closed (swamp) forest



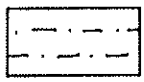
Eucalyptus rudis
pastured woodland



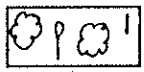
Eucalyptus spp. - Banksia spp.
closed woodland



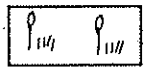
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

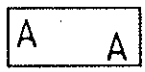


E. gomphocephala - E. rudis
pastured woodland

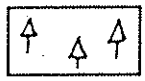


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

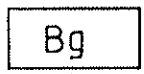


Cleared agricultural land

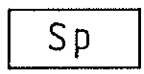


Pinus pinaster - P. radiata
pine plantation

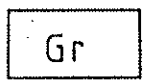
Pasture



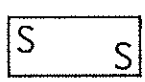
Bare ground



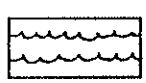
Salt pan



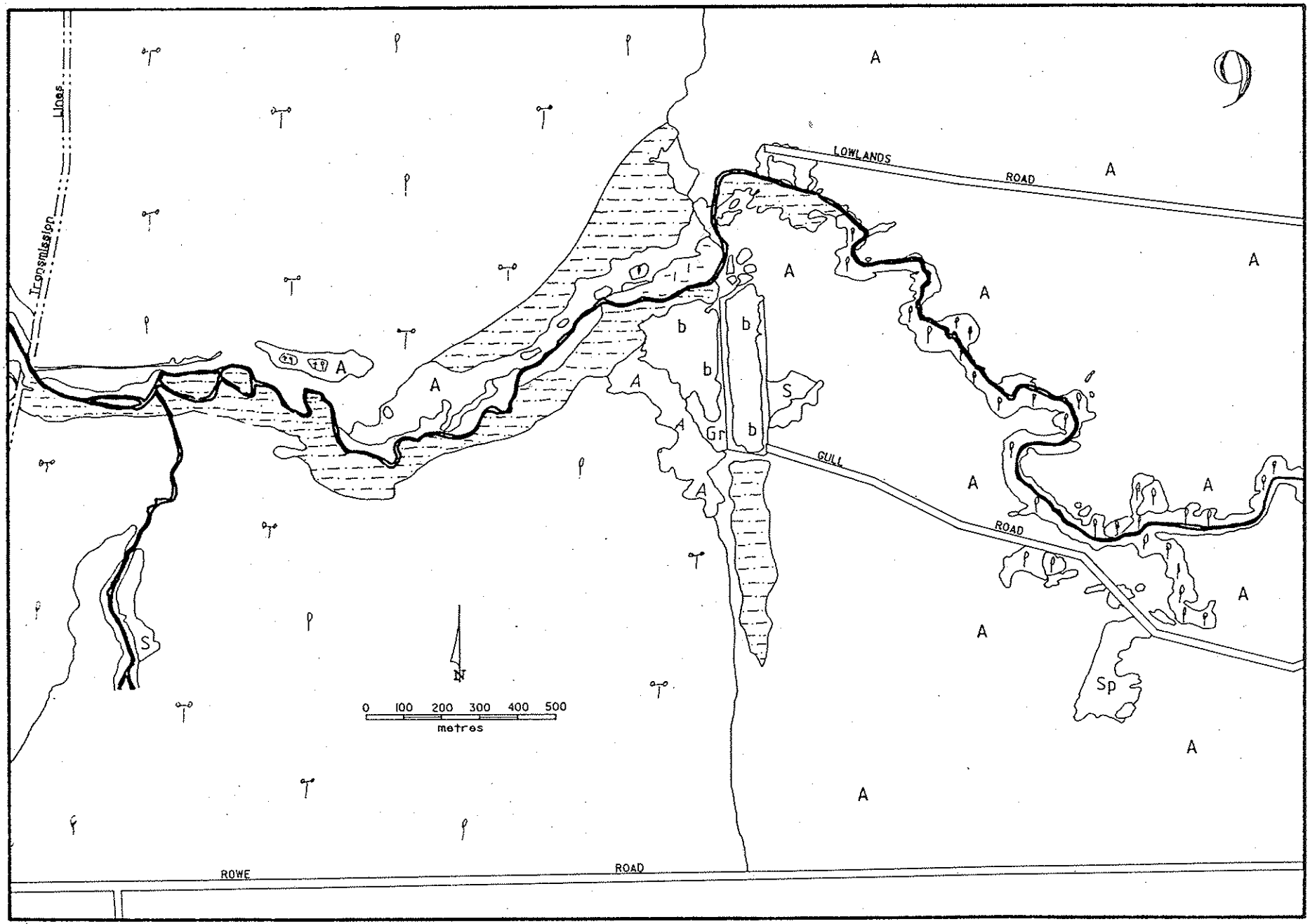
Scattered grasses



Sand



Standing water


9
Transmission Lines
LOWLANDS ROAD
GULL ROAD
ROWE ROAD
A
b
S
Gr
Sp
N
0 100 200 300 400 500
metres

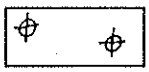
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

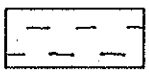
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

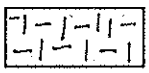


Schoenoplectus validus
closed sedgeland

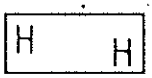
FRINGING ESTUARINE FOREST VEGETATION



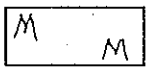
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

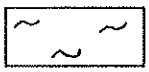


Melaleuca viminea
low open - closed forest



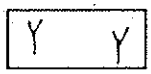
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



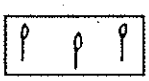
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

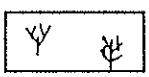


Melaleuca spp. - Baeckea spp.
low open - closed forest

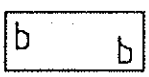
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



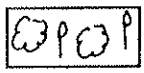
Kunzea spp.
closed thicket



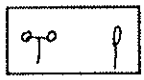
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

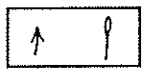
Melaleuca rhaphiophylla
low closed (swamp) forest



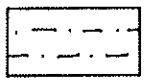
Eucalyptus rudis
pastured woodland



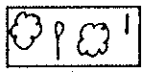
Eucalyptus spp. - Banksia spp.
closed woodland



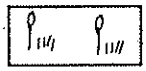
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

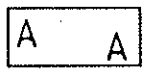


E. gomphocephala - E. rudis
pastured woodland

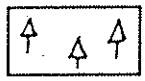


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

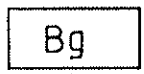


Cleared agricultural land

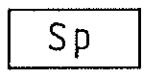


Pinus pinaster - P. radiata
pine plantation

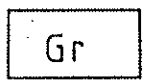
Pasture



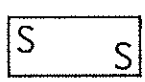
Bare ground



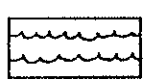
Salt pan



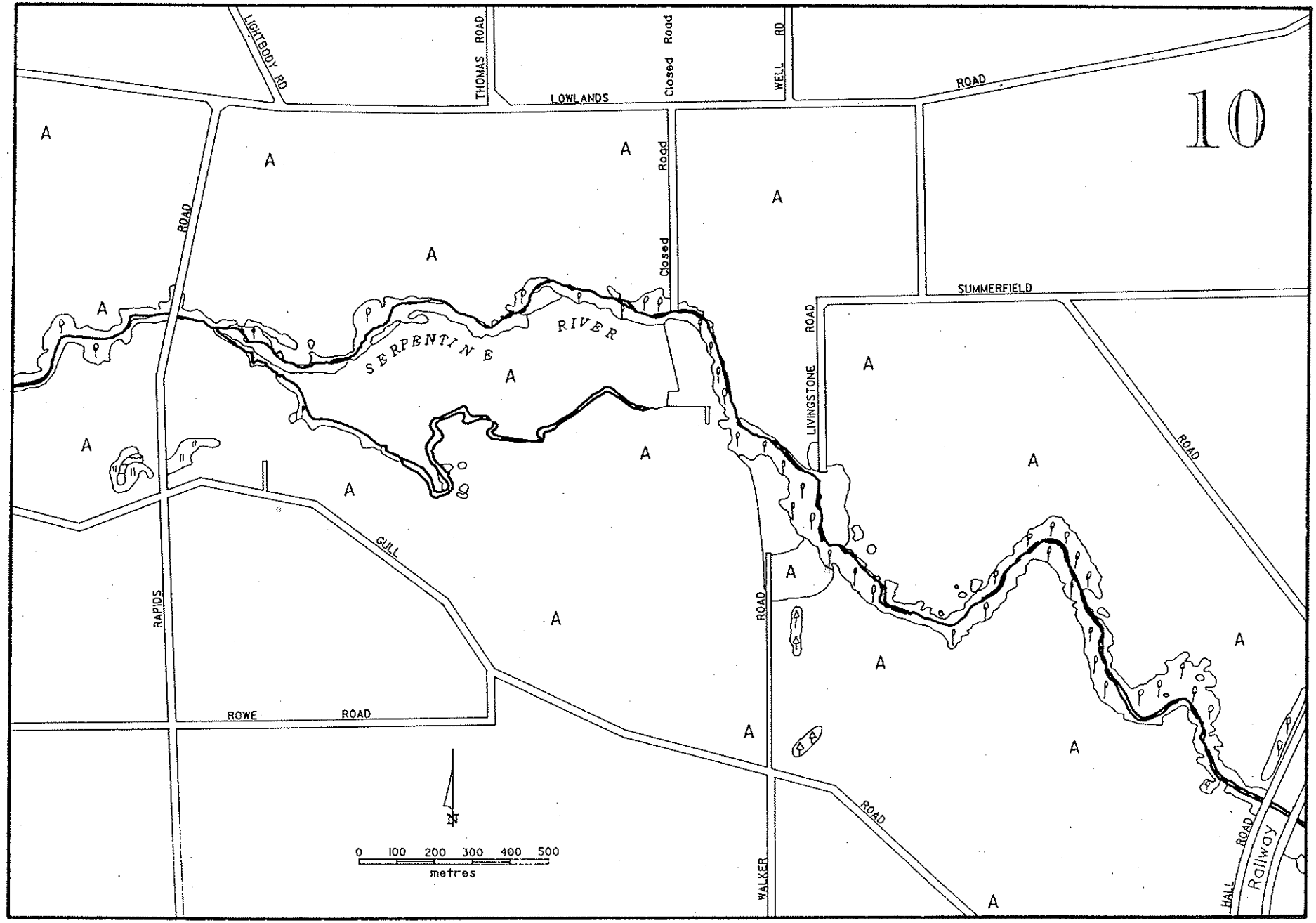
Scattered grasses



Sand



Standing water


10
LIGHTBODY RD
THOMAS ROAD
LOWLANDS
Closed Road
WELL RD
ROAD
ROAD
Road
Closed
SERPENTINE RIVER
SUMMERFIELD
LIVINGSTONE ROAD
ROAD
GULL
RAPIDS
ROAD
ROWE ROAD
ROAD
WALKER
ROAD
HALL ROAD
Railway
0 100 200 300 400 500
metres

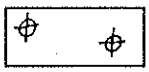
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

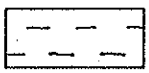
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

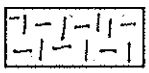


Schoenoplectus validus
closed sedgeland

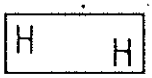
FRINGING ESTUARINE FOREST VEGETATION



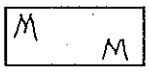
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

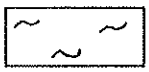


Melaleuca viminea
low open - closed forest



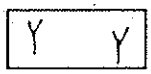
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



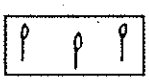
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

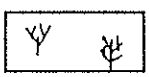


Melaleuca spp. - Baeckea spp.
low open - closed forest

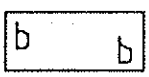
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



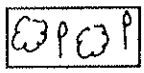
Kunzea spp.
closed thicket



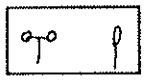
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

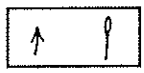
Melaleuca rhaphiophylla
low closed (swamp) forest



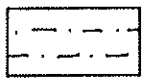
Eucalyptus rudis
pastured woodland



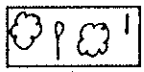
Eucalyptus spp. - Banksia spp.
closed woodland



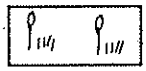
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

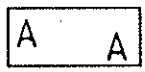


E. gomphocephala - E. rudis
pastured woodland

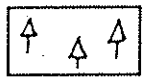


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

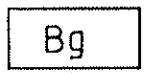


Cleared agricultural land

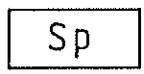


Pinus pinaster - P. radiata
pine plantation

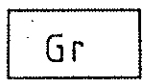
Pasture



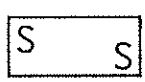
Bare ground



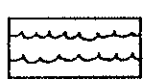
Salt pan



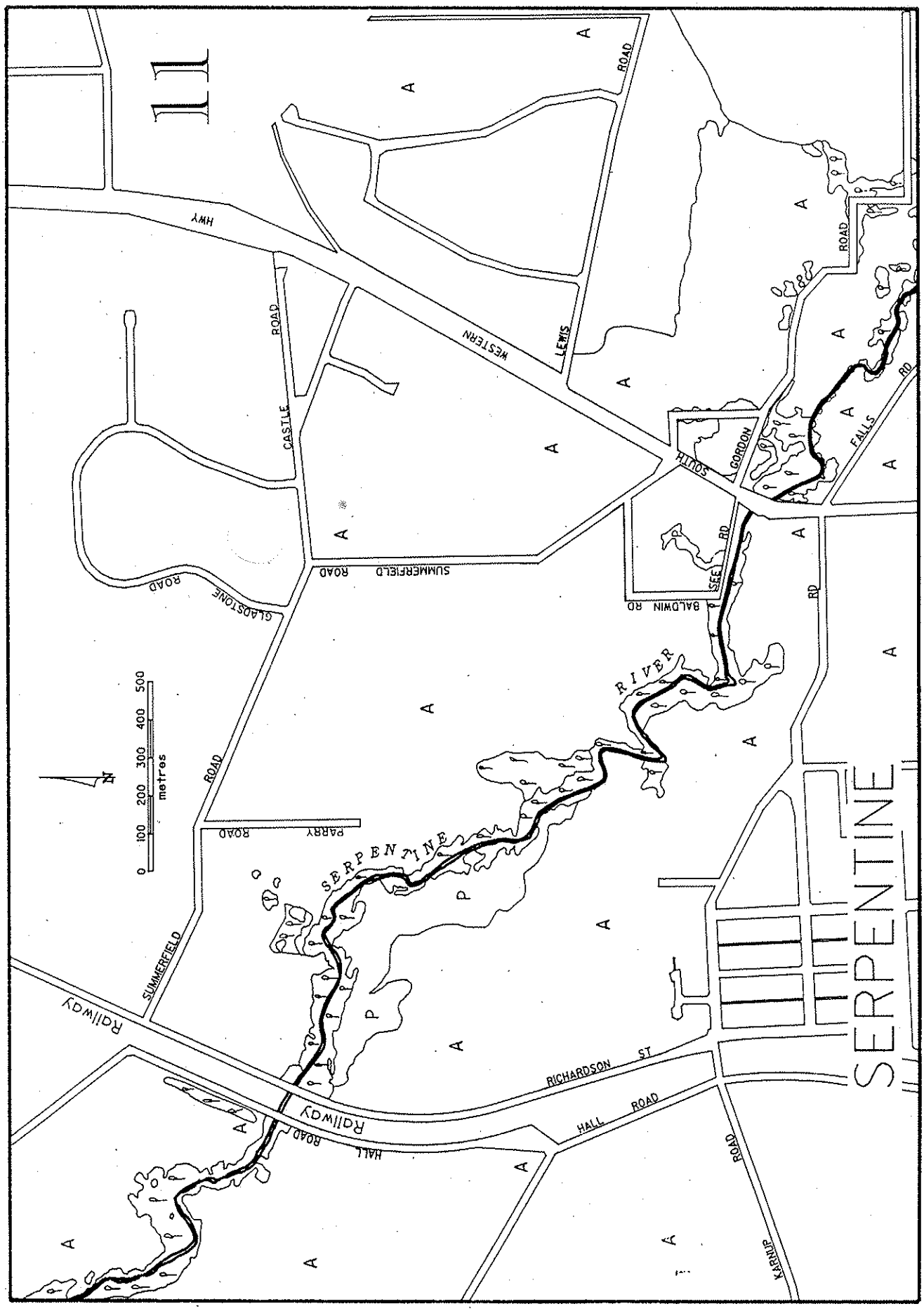
Scattered grasses



Sand



Standing water


11
HWY
WESTERN
LEWIS
ROAD
CASTLE
ROAD
SUMMERFIELD
ROAD
GLADSTONE
ROAD
SOUTH
GORDON
FALLS
RD
BALDWIN RD
SEE
RD
RIVER
SERPENTINE
PARRY
ROAD
SUMMERFIELD
ROAD
RAILWAY
RICHARDSON ST
RAILWAY
HALL ROAD
HALL
ROAD
KARNUP
SERPENTINE
0 100 200 300 400 500
metres
N

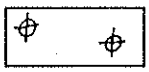
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

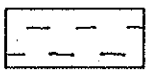
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

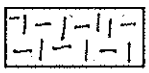


Schoenoplectus validus
closed sedgeland

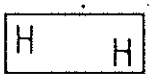
FRINGING ESTUARINE FOREST VEGETATION



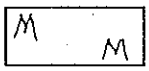
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

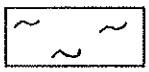


Melaleuca viminea
low open - closed forest



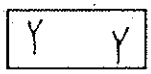
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



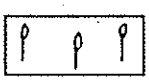
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

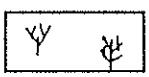


Melaleuca spp. - Baeckea spp.
low open - closed forest

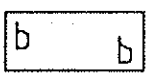
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



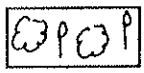
Kunzea spp.
closed thicket



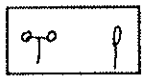
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

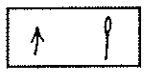
Melaleuca rhaphiophylla
low closed (swamp) forest



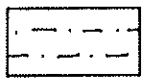
Eucalyptus rudis
pastured woodland



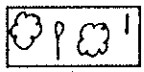
Eucalyptus spp. - Banksia spp.
closed woodland



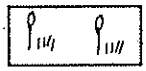
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

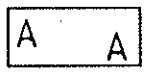


E. gomphocephala - E. rudis
pastured woodland

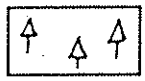


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

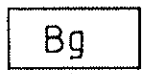


Cleared agricultural land

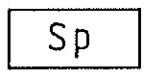


Pinus pinaster - P. radiata
pine plantation

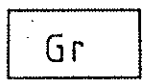
Pasture



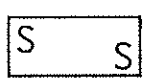
Bare ground



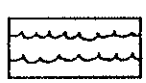
Salt pan



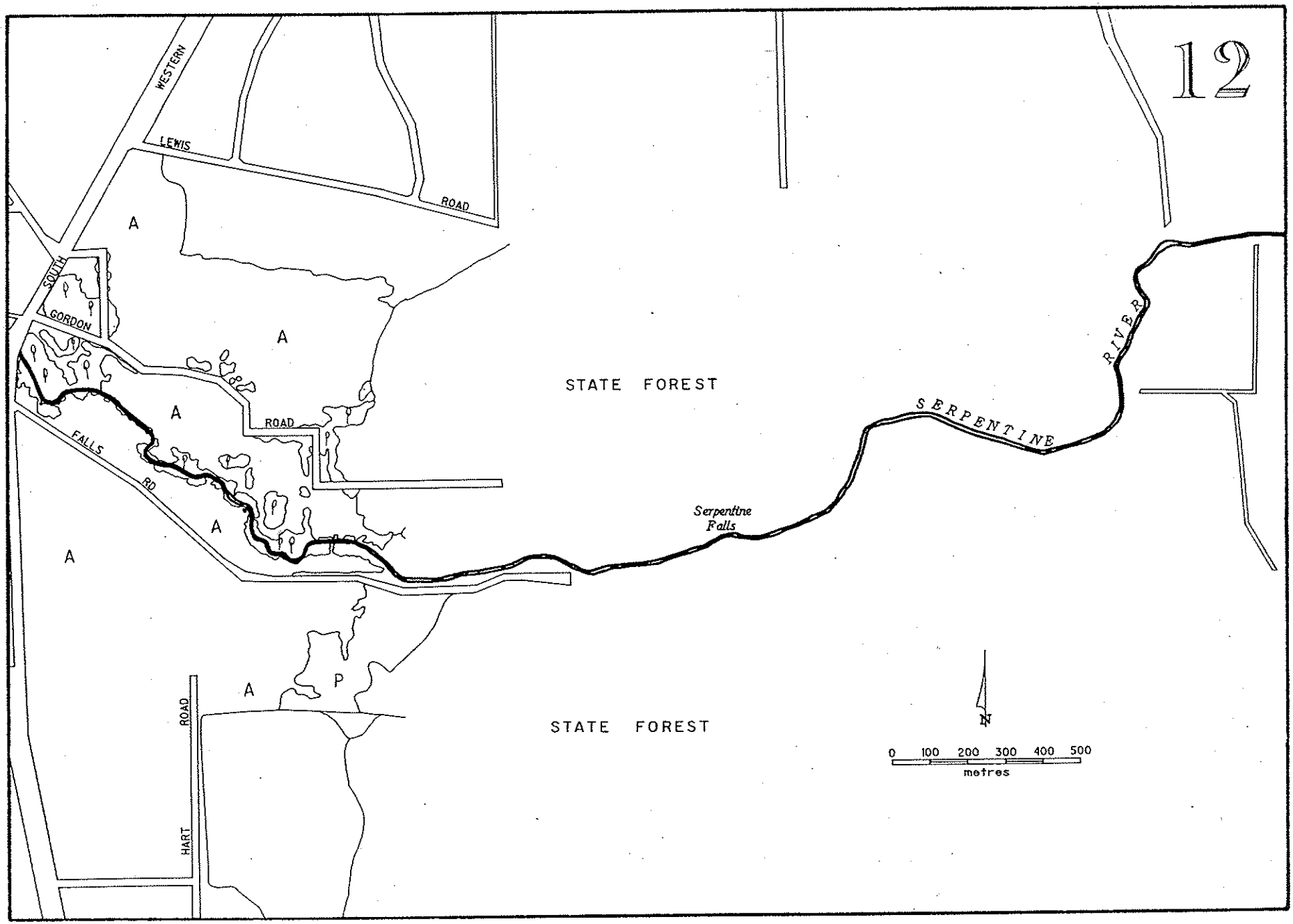
Scattered grasses



Sand



Standing water


12
WESTERN
LEWIS
ROAD
SOUTH
GORDON
A
STATE FOREST
ROAD
FALLS
RD
SERPENTINE
RIVER
Serpentine
Falls
P
ROAD
HART
STATE FOREST
N
0 100 200 300 400 500
metres

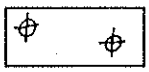
LEGEND

SALT MARSH VEGETATION

Juncus kraussii
closed sedgeland

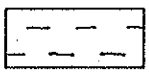
Sarcocornia quinqueflora
salt-marsh complex

FRINGING VEGETATION

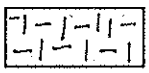


Schoenoplectus validus
closed sedgeland

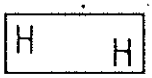
FRINGING ESTUARINE FOREST VEGETATION



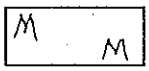
Melaleuca cuticularis
low open - closed forest



Melaleuca rhaphiophylla - M. cuticularis
low open forest

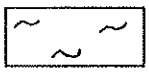


Melaleuca viminea
low open - closed forest



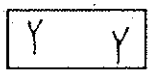
Melaleuca spp.
open - closed thicket

FRESHWATER VEGETATION



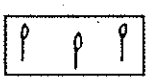
Baumea juncea
sedgeland

Melaleuca rhaphiophylla
low open - closed forest

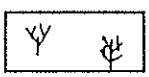


Melaleuca spp. - Baeckea spp.
low open - closed forest

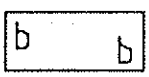
SANDY RISE VEGETATION



E. rudis - M. rhaphiophylla
woodland



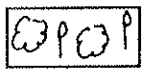
Kunzea spp.
closed thicket



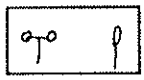
Banksia spp.
open - closed woodland

OTHER PLANT COMMUNITIES

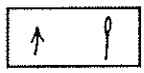
Melaleuca rhaphiophylla
low closed (swamp) forest



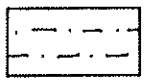
Eucalyptus rudis
pastured woodland



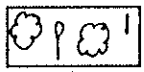
Eucalyptus spp. - Banksia spp.
closed woodland



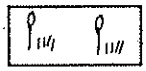
E. calophylla - E. marginata
open - closed forest



Eucalyptus spp. - Juncus spp.
open forest

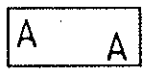


E. gomphocephala - E. rudis
pastured woodland

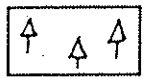


E. rudis - Isolepis nodosa
open woodland

Baeckea spp.
low open - closed scrubland

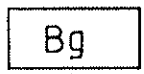


Cleared agricultural land

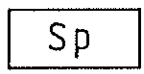


Pinus pinaster - P. radiata
pine plantation

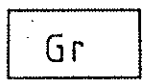
Pasture



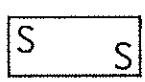
Bare ground



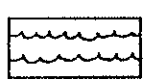
Salt pan



Scattered grasses



Sand



Standing water

APPENDIX 1: AERIAL PHOTOGRAPHS USED FOR VEGETATION MAPPING OF THE SERPENTINE RIVER

	FRAME No.	ROLL No.	RUN No.
3.1.92	5244	3055 (C)	13
	5288	3055 (C)	14
4.1.92	5014	3051 (C)	8
	5016	3051 (C)	8
	5018	3051 (C)	8
	5231	3054 (C)	9
	5233	3054 (C)	9
	5127	3054 (C)	10
	5008	3054 (C)	11
	5110	3054 (C)	12

All of the aerial photographs were taken for the Metro Street Directory Run, at a scale of 1 : 20 000.

APPENDIX 2: SCIENTIFIC NAMES, VERNACULAR NAMES AND SHORT DESCRIPTIONS OF THE FRINGING PLANT SPECIES

Scientific name	Common name	Description
Acacia alata	Winged wattle	small tree
Acacia rostellifera	Wattle	small tree
Acacia saligna	Golden-wreath wattle	small tree
Adenanthos cygnorum	Woolly bush	medium shrub
Adenanthos sp.	Woolly bush	medium shrub
Agonis linearifolia	Swamp peppermint	small tree
*Agrostis avenacea**	Blown grass	annual grass
Allocasuarina fraseriana	Sheoak	medium tree
Allocasuarina obesa	Saltwater sheoak	small tree
Allocasuarina sp.		tree
Anigozanthos manglesii	Mangles kangaroo paw	perennial herb
*Arundo donax**	Giant reed	bamboo-like
*Aster subulatus**	Wild aster	annual herb
*Avena barbata**	Bearded oats	annual grass
*Avena fatua**	Wild oats	annual grass
Baeckea sp.	Baeckea	medium shrub
Banksia attenuata	Candle banksia	small tree
Banksia grandis	Bull banksia	small tree
Banksia ilicifolia	Banksia	small tree
Banksia littoralis	Swamp banksia	medium tree
Banksia menziesii	Firewood banksia	small tree
Baumea articulata	Jointed twig-rush	tall sedge
Baumea juncea	Bare twig-rush	tall sedge
Bolboschoenus caldwellii	Marsh club-rush	perennial herb
*Briza maxima**	Blowfly grass	annual grass

Carpobrotus spp.	Pigface	prostrate shrub
*Cassytha flava**	Golden dodder	creeper
Centella cordifolia	Pennywort	creeping herb
*Cotula coronopifolia**	Waterbutton	small herb
*Cynodon dactylon**	Couch	perennial creeping grass
*Cyperus eragrostis**	Umbrella sedge	perennial herb
Darwinia citriodora	Lemon-scented Darwinia	medium shrub
Dasypogon bromeliifolius	Pineapple bush	tufted perennial
Daviesia sp.	Daviesia	small shrub
Digitaria sanguinalis	Crab grass	annual herb
Diosma	Diosma	medium shrub
Dryandra sessilis	Parrot bush	small tree
*Ehrharta calycina**	Perennial veldt grass	tufted grass
Eucalyptus calophylla	Marri	medium to large tree
Eucalyptus gomphocephala	Tuart	large tree
Eucalyptus haematoxylon	Mountain marri	
Eucalytpus laeliae	Darling Range ghost gum	medium-large tree
Eucalyptus marginata	Jarrah	medium-large tree
Eucalyptus patens	Yarri	medium-large tree
Eucalyptus rudis	Flooded gum	medium-large tree
Hakea prostrata	Hakea	prostrate shrub to small tree
Hakea trifurcata	Two-leaf hakea	large shrub to small tree
*Hordeum leporinum**	Common barley grass	annual grass
Hovea spp.		low shrub
Isolepis nodosa	Knotted club-rush	perennial herb

Jacksonia furcellata	Grey stinkwood	large shrub
Jacksonia sternbergiana	Green stinkwood	large shrub
Juncus holoschoenus	Jointleaf rush	perennial herb
Juncus kraussii	Shore rush	perennial herb
*Juncus microcephalus**	Rush	perennial herb
Juncus pauciflorus	Rush	perennial herb
Juncus pallidus	Rush	perennial herb
Kingia australis	Kingia	large arborescent shrub
Kunzea ericifolia	Spearwood	medium shrub
Kunzea sp.	Spearwood	medium shrub
Lantana sp.	Lantana	prickly creeping shrub
Lepidobolus sp.		perennial herb
Leptocarpus aristatus	Bearded twine-rush	perennial herb
Lepidosperma longitudinale	Pithy sword sedge	perennial herb
Lolium spp.*	Rye grasses	annual and perennial grasses
Lupinus spp.*	Lupins	annual herbs
Macrozamia riedlei	Zamia palm	Cycad
Melaleuca cuticularis	Saltwater paperbark	medium tree
Melaleuca hamulosa		small tree
Melaleuca lateritia	Red robin	large shrub to small tree
Melaleuca preissiana	Moonah	medium-tall tree
Melaleuca rhaphiophylla	Freshwater paperbark	small tree
Melaleuca sp.		
Melaleuca teretifolia	Paperbark	small tree
Melaleuca viminea	Paperbark	small tree
*Mentha pulegium**	Pennyroyal	prostrate perennial herb

Nuytsia floribunda	Christmas tree	parasitic small tree
Opuntia stricta	Prickly pear	small perennial tree
*Paspalum dilatatum**	Paspalum	tufted perennial grass
*Paspalum urvillei**	Water couch	perennial creeping grass
*Pennisetum clandestinum**	Kikuyu	mat grass
Pteridium esculentum	Bracken fern	terrestrial fern
*Ricinus communis**	Castor oil tree	small tree
*Rubus fructicosa**	Blackberry brambles	thorny creeping shrub
*Rumex obtusifolius**	Broad-leaf dock	perennial herb
Samolus repens	Creeping brookweed	perennial herb
Sarcocornia quinqueflora	Samphire	decumbent small shrub
Schoenoplectus validus	Lake club-rush	perennial herb
Schoenus elegans	Schoenus	annual herb
Schoenus sp.	Schoenus	annual herb
*Solanum sodomeum**	Apple of Sodom	rounded shrub
*Stenotaphrum secundatum**	Buffalo grass	perennial creeping grass
Stipa sp.	Speargrass	tufted perennial
*Taraxacum officinale**	Dandelion	perennial herb
Trifolium sp.*	Clovers	annual or perennial herbs
*Trisetaria cristata**	Annual cat's tail	annual grass
Typha domingensis	Native bulrush	tall perennial herb
*Typha orientalis**	Introduced bulrush	tall perennial herb
Watsonia sp.*	Watsonia	bulbous herb

Xanthorrhoea preissii	Blackboy	large arborescent shrub
Xylomelum occidentale	Woody pear	small tree
*Zantedeschia aethiopica**	Arum lily	herb

* Denotes exotic species

Size	Scale
Small tree	<10 m
Medium tree	10-30 m
Large tree	>30 m
Small shrub	<0.25 m
Shrub (medium)	0.25-2 m
Large shrub	2 m
Herb	0.25-1 m
Small herb	0.1-0.25 m
Tiny herb	<0.1 m
Small sedge	<0.5 m
Sedge (medium)	0.5-1 m
Tall sedge	>1 m
Rush	<1.5 m
Large rush	>1.5 m
Grass	< 1 m
Tall grass	> 1 m