State Water Planning

ENVIRONMENTAL SIGNIFICANCE OF WETLANDS IN THE PERTH TO BUNBURY REGION

Western Australian Water Resources Council

JEFF KITE

ENVIRONMENTAL SIGNIFICANCE OF WETLANDS IN THE PERTH TO BUNBURY REGION

Volume 1: Main Report
Volume 2: Appendices

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State Water Planning

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Volume 1: Main Report

Report to:

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7th December 1987

LSC Ref: J115
Report No. R164

Published by the
Western Australian Water Resources Council

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629 Newcastle Street
LEEDERVILLE WESTERN AUSTRALIA 6007

Telephone (09) 420 2928

Publication No. WRC 4/87
ISBN for complete set of 2 volumes: 0 7244 6895 1
ISBN for this volume: 0 7244 6903 6

STREAMLINE ABSTRACT

ENVIRONMENTAL SIGNIFICANCE OF WETLANDS IN THE PERTH TO BUNBURY REGION

Reviews wetland classification schemes developed internationally, nationally and for Western Australia and selects a scheme for classifying wetlands on the basis of landform and water characteristics, and for identifying regions of related wetlands.

Reviews evaluation systems for wetland assessment and develops criteria and a procedure for assessing conservation values of wetlands. Describes the application of the classification and assessment procedures in a pilot study and assesses their applicability. Provides a preliminary identification of environmentally significant wetlands in the Perth to Bunbury region based on the current knowledge of selected wetland experts.

Keywords:

Wetlands, Classification, Appraisal, Conservation, Ecosystems, Water Resources Planning, Western Australia.

WAWRC, Perth, 1987, ISBN 07244 6895 1, Western Australian Water Resources Council Publication No. 4/87:
Vol 1, ISBN 0 7244 6903 6, viii 74 p, 15 Tables, 14 Figures.
Vol 2, ISBN 0 7244 6911 7, vi 210 p, 15 Tables, 16 Figures.

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1. *Introduction*

1.1 Background and Rationale of Approach

The Western Australian Water Resources Council (WAWRC), in conjunction with the Water Authority of Western Australia (WAWA), has initiated a study of wetlands to facilitate the responsible planning and allocation of water resources in the Perth to Bunbury Region. The objective of the study was to assess the environmental and recreational significance of the rivers and wetlands to provide a foundation and methodology for systematically introducing environmental and recreational demands into future strategic water planning. LeProvost, Semeniuk & Chalmer, Environmental Consultants (LSC), were invited to participate in the study by providing input on environmental/ conservation aspects in order to identify wetlands of significant conservation values in the Perth to Bunbury region (alternatively referred to in this report as the Darling System) (Figure 1).

LeProvost, Semeniuk & Chalmer identified the following aspects needing investigation to allow identification of wetlands of environmental significance:

(1) development of a classification system for wetlands of the Darling System;

(2) development of a procedure (evaluation system) for assessment of the conservation value of wetlands;

(3) application of the classification and assessment procedures in a pilot study of selected wetlands to determine their applicability and practicality;

(4) preliminary identification of environmentally significant wetlands in the Darling System.

A Steering Committee on Water Resources Planning for the Environment and Recreation was established to monitor the progress of these studies.

Tasks 1, 2 and 3 were initially undertaken and the results and conclusions reviewed in order to refine the approach to the identification of significant wetlands in the Darling System.

Application of the classification and evaluation systems to selected wetlands in a pilot study showed that both were practical and workable and could be used to identify significant wetlands. However, the Steering Committee believed that there were some difficulties in scoring assessment criteria which related to the regional significance of a wetland. The pilot study also highlighted the need for more information on wetland vegetation types and fauna usage of wetlands.

The study was therefore redirected to:

(a) provide information on the regional distribution of wetland types (based on the selected classification system) as input to the evaluation of regional significance of wetlands;

(b) produce a preliminary wetland vegetation classification system to provide more information to augment the wetland classification.

A need was also identified for further investigation on fauna use of wetlands, but this was not undertaken as part of the present study.

The results of these studies, together with Tasks 1, 2 and 3 above, led to development of an overall approach to wetland assessment. This approach involves developing an **information base** on wetlands in the Darling System and an **evaluation** of wetland conservation values by applying **assessment criteria**. The components of this approach are conceptually summarised in Figure 2.

The studies show the complexity of wetland types in the region, the current paucity of information on many of the wetlands, and the high level of technical expertise required to make a valid assessment of conservation significance. These factors, together with cost and time constraints, meant that it was not possible to rigorously apply the approach developed during the study to all wetlands in the Darling System for Task 4 - identification of environmentally significant wetlands.

A preliminary exercise was therefore undertaken to identify significant wetlands on the basis of currently available information. A number of experienced workers on wetlands in the State were invited to identify the most environmentally significant wetlands in the Darling System on the basis of their knowledge and existing information, using the assessment criteria developed in this study as a guideline or a framework.

1.2 Structure of Report

The report structure is based on the conceptual approach to wetland evaluation shown in Figure 2.

Section 1 outlines the background, objectives, and approach to the study. Section 2 presents a summary of the results, conclusions and recommendations.

Section 3 presents a perspective on wetlands and details the **approach** to undertaking an assessment of wetlands in the Darling System.

Section 4 reviews **wetland classification** schemes developed overseas, nationally and locally, and proposes a system for classifying wetlands in the Darling System and for identifying regions of related wetlands.

Section 5 reviews **wetland evaluation systems** developed overseas and in Australia and proposes **criteria** for assessing the values of wetland resources in the Darling System.

Section 6 outlines a **procedure** for applying these criteria in order to assess wetland conservation values and identify wetlands of outstanding significance in the Darling System.

Section 7 gives the results of the application of these classification and assessment procedures in a **pilot study** of wetlands in a transect from Lake Joondalup to Walyunga, and assesses the practical applicability of the methods.

Section 8 uses the classification system adopted for the study to identify regions of related wetlands in the Darling System and identifies, in a preliminary fashion, the wetlands in these regions which are considered on the basis of available information to be of outstanding (international or national) **conservation significance.**

The studies which formed the basis of this report are presented in detail in appendices, and published collectively in Volume 2, copies of which are available from the Western Australian Water Resources Council.

Appendix 1: Classification of Wetlands;

Appendix 2: Regions of Related Wetlands in the Darling System, Southwestern Australia;

Appendix 3: The Classification of Wetland Vegetation;

Appendix 4: Guidelines for the Assessment of Wetland Conservation Values;

Appendix 5: Application of the Procedure for Assessment of the Conservation Value of Wetlands in the Darling System.

The report necessarily contains some technical and specialised vocabulary used to describe wetland features. These are defined wherever possible, and a Glossary has been included to assist readers.

1.3 Acknowledgements

The following groups and individuals contributed to the assessment of significant wetlands in the Darling System:

Dr J. Davis (Murdoch University)

Dr D. Edward (University of Western Australia)

Mr R. Jaensch (Royal Australasian Ornithologists Union)

Mr J. Lane (Department of Conservation and Land Management)

Dr N. Marchant (WA Herbarium)

Dr T. Riggert (Wetland Consultant)

Chris Semeniuk (VCSRG Pty Ltd)

Dr V. Semeniuk (LSC)

Dr A. Tingay (Wetland Consultant)

Botany Department Group University of Western Australia

Ken Youngson (Ninox Wildlife Consulting)

The following contributed to the Reference Panel on Water Resources Planning for the Environment and Recreation:

Dr J. Arnold (Environmental Protection Authority)

Mr J. Blyth (Department of Conservation and Land Management)

Mr D. Everall (State Planning Commission)

Mr R. Harvey (Water Authority of Western Australia)

Prof. A. J. McComb (University of Western Australia)

Mr R. Polglaze (Conservation Council)

Mr B. Sadler (Water Authority of Western Australia)

Mr P. Sharp (Department of Sport and Recreation)

Much of this report, particularly on the classification of wetlands and on the regions of related wetlands, is based on research undertaken and funded by Chris Semeniuk of VCSRG Pty Ltd.

The report was produced by Dr. V. Semeniuk with editorial assistance from Ian LeProvost and Karen Majer.

2. *Summary and Conclusions*

This study has achieved the following objectives:

(1) developed, and tested in a pilot study, a classification of wetland types in the Darling System;

(2) produced a map of wetlands in the Darling System to show the distribution of related wetlands in domains as a basis for determining the regional significance of particular wetlands;

(3) developed a procedure (evaluation system) for assessing wetland conservation values and identifying significant wetlands, and tested this procedure in a pilot study;

(4) provided a **preliminary** listing and map of wetlands in the Darling System which are known to a group of wetland experts to be of significant conservation value on the basis of currently available information.

The study has **not** identified **all** wetlands in the Darling System with values for conservation, but has developed the methodology to achieve this.

The recommended approach to identifying wetlands of significant conservation value is based on a two-tier or filter system. The first tier assessment identifies wetlands of outstanding significance, and the second tier further evaluates those wetlands not identified as outstanding in the first tier to determine management priorities.

Based on a review of overseas, national and local scientific literature on wetland classification and environmental assessment, the evaluation system which is conceptually summarised in Figure 3 is recommended as the most appropriate method for the first tier evaluation. The approach involves:

(i) establishing an **information base** on:
- types of wetlands (classification),
- regional distribution of the wetland types,
- wetland vegetation, and
- use of wetlands by fauna;

(ii) using these data as a basis for an **evaluation system** which uses a range of criteria to assess the values of the wetland resources and identify significant wetlands.

The wetland classification scheme of C.A. Semeniuk (1987a, b), based on the primary criteria of landform and water characteristics, was selected as the basis for classifying wetlands of the Darling System and identifying regions of related wetlands. The vegetation classification system developed by Semeniuk *et al.* (1987), was considered to provide useful additional description to augment the wetland classification.

The evaluation system was based on the approach of Semeniuk (1985) and LeProvost, Semeniuk & Chalmer (1981, 1984, 1985). The assessment is based on sixteen criteria which identify the major resources and values of a wetland. The wetland is scored on a scale of one to five for each criterion. A high score for a criterion indicates that the wetland has a high value for that resource or use. Assessment of the conservation value of the wetland is based on these scores - a high score on several criteria clearly indicates that the wetland is of outstanding value but a high score on a single criterion also highlights that the wetland has a component that is of significance.

The wetland classification and evaluation systems adopted in this study have been developed specifically for wetlands of southwest Western Australia. Application of the assessment procedure in a pilot study on a range of wetland types along a transect between Lake Joondalup and Walyunga showed that it is workable, can be rapidly applied and can highlight significant wetlands in a selected region. Specifically:

(a) the wetland classification system results in the production of useful working maps that identify wetland categories in terms of type, size and shape;

(b) the vegetation classification system provides site-specific descriptions which can add to the wetland classification and assist in evaluating the status of a wetland;

(c) identification of related wetland types in domains provides a regional perspective of the distribution of wetlands as a basis for evaluation of their regional significance;

(d) assessment of a wetland based on criteria which identify:
- regional significance,
- unique landforms, biota or other natural features, and
- important social, recreational, educational, scientific/ research or wildlife habitat/ sanctuary resources,

allows evaluation of the wetland resources and identification of important resources or values;

(e) significant wetlands can be recognised on the basis of one or more criteria by assigning a score (or rating) to a wetland for each criterion;

(f) identification of the criteria which contributed to the assessment of the wetland as significant (e.g. social/recreational values, natural/scientific values, education/research values) could provide input for determining appropriate future management priorities.

The study has highlighted the complexity of any approach to wetland assessment, and the paucity of information available.

The wetlands of the Darling System encompass a wide variety of types which differ in geomorphic setting, origin and maintenance, and therefore in ecologic function. Many of the wetlands are nationally unique. The variety of types means that:

- wetlands in a given locality cannot necessarily be considered as representative of the region;
- even wetlands of the same geomorphic type vary in terms of habitat and therefore the flora, fauna and human uses they support.

The current status of a wetland in terms of the nature and degree of impact of human use will also affect the value of that wetland as a representative of its type.

Because of this complexity, it is clear that assessment of a wetland must be based on a range of interdisciplinary information provided by workers with experience in the particular fields such as geomorphology, flora and fauna.

At present, **inadequate data are available to permit rigorous assessment of all wetlands in the Darling System using the recommended approach.** For many wetlands, virtually no information is available. Further research is needed, especially in the areas of wetland vegetation classification and fauna use of wetlands.

This study has provided a **preliminary identification** of significant wetlands. **Rigorous and reliable** assessment will require:

- establishment of an expert multidisciplinary team;
- regional field survey of the wetlands;
- application of the assessment criteria and approach described in this report to assess each wetland;
- identification of the significant or outstanding wetlands, known to date, on maps to be used by planners.

3. *The Approach to Assessing Wetlands in the Darling System*

3.1 Global and Regional Perspective of Wetlands

Wetlands, as inundated, wet or waterlogged areas of the earth's surface, are common features when viewed globally. However, examination on subcontinental, regional and parochial scales shows that wetlands vary from area to area in terms of physiography (physical geography), origin, vegetation and a multitude of soil, water quality and other environmental features. It is important to recognise that a wide variety of wetland types occur, and that wetlands in different areas cannot necessarily be compared. Even on a local scale, different wetlands and wetland systems often fulfil very different functions, and any attempt to assess the conservation significance of wetlands must take this variety of types and functions into account.

The wetlands of the Darling System in southwestern Australia (Figure 1) are dominated by a variety of types which include lakes, swamps, marshes, fens, meadows, rivers/streams and estuaries. These wetlands occur in three main settings:

- on a dissected plateau;
- on a sandy coastal plain;
- within an estuarine framework.

The main similarity between the wetlands of southwestern Australia and elsewhere in Australia is the presence of river/stream wetlands on the dissected plateau. Many of the wetlands that occur on the sandy coastal plain and associated with estuaries tend to be nationally unique, because of the geomorphic setting, stratigraphy (geological strata) and origin of units on the Swan Coastal Plain, and consequent differences in their soils, vegetation and fauna.

In consequence, much of the research on wetlands elsewhere in Australia and the world is not strictly applicable in detail to wetlands of southwestern Australia, although the philosophies of approach to wetland assessment and conservation may be relevant.

3.2 Definition of Wetland

The term wetland encompasses a range of types of wetland systems (Figure 4). Definitions adopted in the international literature cover a wide range of concepts (see Appendix 1). Many of these definitions are not directly applicable to the types of wetlands which occur in Western Australia. The definition adopted for the purposes of this report is:

> 'Areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries'.
>
> (Wetlands Advisory Committee, 1977)

However, artificial wetlands were not included in the scope of the study.

3.3 The Requirements for Wetland Evaluation

The approach to assessment of the conservation value of wetlands in a region should be carried out in three stages (LSC, 1985):

(i) wetlands should be **classified** to identify the types of wetlands and provide a basis for assessment of the wetland resources;

(ii) **criteria** should be developed to assess the conservation significance of these resources; and

(iii) a **procedure** should be developed to implement the assessment of the conservation value of the wetlands.

This approach allows identification of wetlands with a high value for one or more reasons (criteria). A wetland which is assessed as significant on the basis of several criteria is clearly of outstanding conservation value. However, a wetland which is assessed as being significant for even one criterion may have an important role, and this must be considered in future management.

The stages of the approach identified above are discussed in detail in the following sections.

4. *Classification of Wetlands*

4.1 Introduction

A classification scheme provides the necessary basis for assessing individual wetlands or wetland systems within the context of the overall wetland resources of the region. An appropriate classification scheme can provide:

(i) a framework and nomenclature for describing the wetland and its resources;

(ii) a basis for assessing the regional significance of a wetland according to whether the type is regionally widespread or restricted in distribution and whether a wetland type is representative of a region;

(iii) a basis for making preliminary assessments of a wetland's likely ecological functions and value for particular human uses; and

(iv) a basis for defining regions of related wetlands ('consanguineous wetland suites') to give a regional perspective to assessment.

In order to develop a classification scheme for wetlands of the Darling System, a desk study was undertaken to:

- review wetland classification systems developed overseas, nationally and locally to determine which, if any, are applicable to this study; and
- select and describe a wetland classification system to be used in this study.

The results and conclusions of C.A. Semeniuk (1987a), which were based on extensive field surveys and analysis of aerial photographs, were reviewed to define regions of related wetlands in the Darling System.

4.2 Wetland Classification Schemes - A Review

A number of wetland classification schemes have been developed by workers overseas and nationally (e.g. Martin *et al.*, 1953; Ruttner, 1953; Hutchinson, 1957; Goodrick, 1970; Bayly & Williams, 1973; Cowling, 1977; Cowardin *et al.*, 1979; Briggs, 1981; Ivanov, 1981; Jacobs, 1983; Wetzel, 1983; Paijmans *et al.*, 1985). Classification schemes have used a number of different approaches, e.g. biological, chemical, physical, geological, genetic (based on origins) and geomorphic. The features most often used in classification of "basin" wetlands have been vegetation, water permanence, water quality and occurrence of peat. Classification of rivers/streams has often been based on geomorphology and water quality.

Classifications have been developed specifically for wetlands of southwestern Australia, including the Darling System, notably by Riggert (1966) who identified wetland types used by avifauna, Tingay & Tingay (1976) and the Wetlands Advisory Committee (1977) who developed limnological systems, and C.A. Semeniuk (1987b) who used landform and water characteristics. These classification schemes were developed for specific purposes and all serve to illustrate the variety and complexity of wetland types in the region.

Review of both overseas and Australian wetland classification schemes (Appendix 1) has shown that, to date, most have not enabled adequate categorisation of the variety of wetlands in the Darling System from a geomorphic (landform) or habitat perspective. The preferred system for classification of wetlands in this area is the approach of C.A. Semeniuk (1987b) which is described below.

4.3 The Wetland Classification Scheme Adopted in This Study

C.A. Semeniuk (1987b) proposed a wetland classification scheme based on the primary criteria of water permanence and the shape of the "water container", i.e. cross-sectional landform geometry (basin, channel or flat). This system is described in detail in Appendix 1.

The classification allows recognition of seven main wetland types (Table 1), which appear to parallel habitat delineation and ecologic function. The terms proposed for these basic wetland types are:

• Permanently	inundated basin	LAKE
• Seasonally	inundated basin	SUMPLAND
• Seasonally	waterlogged basin	DAMPLAND
• Permanently	inundated channel	RIVER
• Seasonally	inundated channel	CREEK
• Seasonally	inundated flat	FLOODPLAIN
• Seasonally	waterlogged flat	PALUSPLAIN

Table 2 gives the definition and origin of these terms. Table 3 compares these terms with those previously established in the literature.

By the use of "descriptors" which are adjectives that describe water characteristics (salinity and consistency or variability) and landform (shape and size of the wetland) (Fig. 5), the classification encompasses most of the wetland types in the Darling System. Descriptive terms for categories shown in Figure 5 are defined in Table 4 (salinity), Table 5 (consistency), and Table 6 (scale). Terms for describing wetland shapes (plan geometry) are illustrated in Figure 6.

Vegetation is not used as a primary wetland characteristic in the classification, but it can be readily incorporated as an additional modifier to allow more detailed description of a wetland (see Section 4.4).

This classification system has the advantages that it:

- is based on the two major features (water and landform) which determine the existence of wetlands;
- provides a framework for understanding the various types of wetlands in the region, their distribution and ecological function;
- distinguishes a practicable number of wetland types with a minimum of field surveys;
- allows increasing description and descrimination of individual wetlands by adding descriptors as more information becomes available;
- provides a useful basis for mapping, since the various wetland types may be readily identified and mapped as categories;
- allows classification of the wetland even if it has been substantially altered by clearing of vegetation or soil disturbance.

The application of this classification system to selected wetlands in a pilot study of wetlands in a transect from Lake Joondalup to Walyunga in the Darling System is described in Section 7.2.

4.4 Classification of Wetland Vegetation

Characteristics of the vegetation of a wetland are important in establishing the ecological functions of the wetland and ecological linkages between chains or series of wetlands. Semeniuk (1987b) proposed that wetland vegetation characteristics should be used as descriptors to elaborate the basic wetland classification.

The most comprehensive classification of wetland vegetation in the Darling System to date is that of Semeniuk *et al.* (1987) (Appendix 3). Semeniuk *et al.* (1987) recognised nine basic categories of wetland vegetation based on the primary criteria of cover (full, patchy or peripheral) and internal organisation (homogeneous, zoned or heterogeneous). These types were informally named Type A, Type B, etc. (Table 7).

Additional descriptors add information about the scale of the vegetation (terms used to describe scale are defined in Table 8), and the predominant structural form or structural floristic component (e.g. forest, scrub, heath) (according to Specht, 1970). For example, the vegetation in Herdsman Lake can be classified as macroscale Type A sedgeland. Other examples of the application of the classification system are given in Table 9.

This approach provides a descriptive classification of wetland vegetation that conveys size, structure, extent of cover, and organisation of the vegetation complex.

4.5 Identifying Regions of Related Wetlands

4.5.1 Consanguineous Wetlands

The wetland classification system (Section 4.3) provides a basis for identifying and mapping related suites of wetlands to allow regional assessments of wetlands. The Darling System encompasses a wide range of wetland types, which vary in attributes of size, shape, water characteristics, stratigraphy (geological strata) and vegetation. When the factors of geomorphic setting, origin and maintenance are common to a group of wetlands, a marked similarity is evident and wetland types can be seen to be related or consanguineous. For example, a system of closely related wetlands of similar size, shape, water characteristics and soils, such as a chain of lakes, may constitute a consanguineous suite.

Other consanguineous wetlands may incorporate a variety of wetland types, such as a river and associated creeks and floodplains, which are related by causative factors.

The criteria used by C.A. Semeniuk (1987a) for identifying con-sanguineous wetlands are:

(1) Wetlands occur in reasonable proximity to each other, although proximity alone may be no indication of wetland relationship as other factors such as geomorphic processes and hydrologic regime may become significant.

(2) Similarity in wetland size and shape.

(3a) Recurring pattern of similar wetland form, i.e. a single wetland type predominates, or an assemblage of wetland types predominate.

OR

(3b) Heterogeneous pattern representing a spectral range of interrelated wetland forms, or an association of dissimilar, but genetically related wetlands.

(4) Similarity of hydrological dynamics (e.g. whether wetlands are recharged and maintained by ponding, seepage, surface runoff, groundwater rise).

(5) Similarity of water salinity.

(6) Similar stratigraphy and hence similar developmental history.

(7) Similar origin, e.g. karstification (cave formation).

(8) Similar underlying causative factors, e.g. fluvial processes.

Most of the features listed in the criteria result in consanguineous wetlands because they are interrelated factors that, when acting in concert, result in specific and similar wetland features. Vegetation is not used as a criterion to identify consanguineous wetlands. Vegetation responds to physical and chemical factors, and may not be a primary causative factor of many wetland features.

4.5.2 Domains

The term domain is used to convey the concept of the occurrence, in discrete areas, of consanguineous wetlands (C.A. Semeniuk, 1987a). Wetlands that occur in these discrete areas are influenced by similar causative factors acting on the areas to produce consanguineous wetlands. The recognition of domains rests on identifying localities of consanguineous wetlands. The first step in this procedure is to identify wetlands in the same geomorphic setting. Thereafter it is necessary to isolate those tracts of landform that have wetlands with similar geometry, size, spacing, and disposition and appearance (phototones) on aerial photography. A domain boundary is drawn around a set of consanguineous wetlands.

The distribution of consanguineous wetlands in domains throughout the Darling System is described in Appendix 2 and summarised in Section 8.2.

5. *Criteria For Wetland Evaluation*

5.1 Introduction

In order to assess the conservation value or potential of a wetland (or wetland system), it is necessary to determine the resources that the wetland contains, and which of these resources may be at risk due to alternate use, disturbance, or destruction of the wetland. The resources of a wetland include (but are not limited to):

- water;
- landform;
- vegetation;
- fauna;
- human or social uses (including education and research).

Each of these resources needs to be characterised and described in such a way that its value can be assessed and compared between wetlands.

The assessment of the social and scientific value of any resource is based on many criteria, the most *significant* of which include:

(i) regional significance - is it regionally widespread and common or is it restricted to local areas?

(ii) are there unique landforms, biota or other natural features that are of statewide, national or international importance?

(iii) are there important social, recreational, educational, scientific/research, or wildlife habitat/sanctuary resources?

In order to identify specific criteria upon which to base an assessment of the wetland resources of the Darling System, wetland evaluation schemes developed overseas, nationally and locally were reviewed. Assessment criteria were then developed specifically for the local situation.

5.2 Wetland Evaluation Systems - A Review

Wetland assessment or evaluation systems have been developed in various parts of the world (e.g. Larson, 1976; Ratcliffe, 1977; Rabe & Savage, 1979; Morgan, 1982; MacMillan, 1983; Gilligan, 1984 Pressey, 1984. A review of these approaches, and the criteria on which they were based (Appendix 4), shows that none have been universally accepted to date. Most approaches have been developed for specific localities or purposes, or are not sufficiently rigorous in identifying criteria for assessing wetland conservation values.

In Western Australia, procedures have been developed for assessing the environmental impact of proposed roads in wetland areas [Main Roads Department (MRD), 1982; Department of Conservation and Environment (DCE), 1984].

In March 1985, the DCE, in conjunction with the MRD, released guidelines for environmental assessment of roadworks with the aim of creating an awareness of the effects that road projects may have on the environment, and to enable assessment of the effects of individual projects. Measures to minimise negative effects were suggested, and there was a classification of projects into categories based on degree of environmental effects. However, the published guidelines by the MRD (1982) and the DCE (1984) do not provide criteria for assessing the value of a wetland. This is an important omission since the conservation value of a wetland is a major factor in impact assessment.

The Western Australian Environmental Protection Authority (EPA) has recently released draft guidelines for an environmental assessment procedure for wetlands based on scoring a variety of natural and human use attributes (EPA, 1986). These guidelines are a positive step towards raising awareness of wetland values and the need to take these values into account in determining future management. However, the method of assigning scores to various wetland attributes implies that there is a standard 'ideal' wetland and appears to be oriented towards waterbird usage. For example, scoring the percentage of emergent vegetation cover, with the highest score for 40-60%, does not recognise the variety of wetland types which exist. This is especially the case for comparing wetlands that occur in different geomorphic settings, and for comparing wetlands with different vegetation formations even within the same geomorphic setting. Ideally, a separate question sheet and score sheet must be devised for wetlands in each of the different physiographic settings to address the wide variability in wetland categories. The scoring also fails to highlight as significant, wetlands which may be partly degraded but have an outstanding feature which is sufficiently important to determine future management of the wetland. As a result, certain wetlands which receive a low (Category 4 and 5) score by this method have been identified as significant by other workers (e.g. Roe Swamp, Bollard Bullrush, Wright Lake, Careniup, Yangedi, Balanup).

Any assessment system which is to be used as a basis for determining appropriate future uses and management of a wetland must be rigorous and recognise the different values of a variety of wetland types, otherwise there is a risk of assigning low status to important wetlands. The EPA guidelines are a useful input towards developing such a system, but are not considered to be suitable in their present form for the purposes of this study.

Semeniuk (1985) developed an evaluation system for Western Australian wetlands which was applied to mangrove swamp systems (Semeniuk, 1985), inland wetlands (LSC, 1985), estuarine wetlands (LSC, 1981) and general ecosystems (LSC, 1984). The scheme was originally based on 15 criteria that included aspects such as regional significance, use by resident or migrating fauna, socio-economic factors, heritage factors, use as a research/education resource, recreational values and wildlife sanctuary or habitat values. A scoring system was applied to assess the value of the wetland for each of the criteria. Various experts in a given field can devise their own system of check points appropriate to a given wetland to achieve a score for the criterion that they are assessing. In its philosophy of approach and use of varied criteria, the scheme is not too dissimilar to that of Larson (1976). Ten criteria are common to the evaluation systems of Larson (1976) and Semeniuk (1985).

The approach of Semeniuk (1985) and LSC (1985) is considered to be the most appropriate basis for identifying wetlands of outstanding value in the Darling System.

The main advantages of the scheme of Semeniuk (1985) are:

- it was developed on a local data base and is directly applicable to the southwestern Australian region, particularly in its identification of the importance of wetlands to migrating fauna and use as a wildlife sanctuary;
- it can be applied to all types of wetlands (rivers, basins and flats);
- the scheme is fairly comprehensive and flexible in its use of important, internationally recognised conservation criteria and allows individual workers, expert in a particular field, to construct a scoring system appropriate for a given wetland;
- the scoring system provides an overall assessment of the conservation value of a wetland and the criteria which scored highly indicate the environmental/scientific/social aspects which are considered to be significant.

The disadvantages of the scheme are that it does not include the criterion of "representativeness", it does not specifically identify the importance of diversity of habitats in wetlands, and it does not explicitly identify degraded wetlands as areas of low priority (i.e. although "pristine" is a term used in the criteria, the explicit definition and identification of "pristine" wetlands are not provided).

A proposed wetland evaluation system based on that of Semeniuk (1985), with modifications to accommodate the disadvantages of the scheme, is outlined below.

5.3 Criteria Adopted in This Study

Criteria which can be used to evaluate a wetland, taking into account both natural values and current and potential uses, are listed in Table 10. The criteria adopted in this study are based on those developed previously by LSC (1981, 1984, 1985) and Semeniuk (1985), but have been modified to address the concepts of "representativeness" and "diversity" of wetlands.

The criteria listed in Table 10 allow preliminary identification of the range of potential values of the wetland resources. The significance of a wetland can be assessed by allocating a score or rating to each criterion. The approach to evaluating the criteria is described below.

5.4 Evaluating the Criteria

For a particular wetland, the criteria are scored by assessing the value of the wetland for each purpose on a scale of 1-5 (Semeniuk, 1985). A rating of:

1 = not significant

2-4 = graded scale of moderate significance

5 = high significance

For some criteria, these parallel a significance ranking of:

1 = local

2 = parochial

3 = regional

4 = national

5 = international

The 16 criteria presented in Table 10 are described in Appendix 4 in terms of some of the aspects that need to be addressed in order to arrive at a rating or score for the value of a wetland for each criterion.

It is important to note that some criteria may be assessed on the basis of available information or field inspection of the wetland, but other aspects will require advice from experts in particular subject areas who have a regional knowledge and perspective.

6. The Assessment Procedure

6.1 Introduction

It is proposed that the evaluation system for this study should follow a two-tier approach or "filter system". The first tier identifies wetlands that are outstanding or highly significant because of one or more outstanding natural or cultural values, and the second tier is used to further evaluate the natural resource values of wetlands which did not score outstandingly in the first assessment.

The criteria listed in Table 10 have identified, in a preliminary fashion, the range of potential conservation values of the resources of a given wetland. The significance of a wetland may be determined by giving a score or rating to each of these criteria as outlined in Section 5.4. A wetland which scores highly on several criteria would clearly be of high conservation value, but a high rating on a single criterion would also assign a degree of significance because the wetland is important for at least some purpose or to some sector of the community. Wetlands of outstanding value, based on one or more attributes, can therefore be recognised in this "first tier" assessment. A wetland which does not appear to be of outstanding significance on the basis of these criteria can be further assessed in the "second tier" assessment. Such a wetland may still have important values which warrant preservation, rehabilitation or management for particular purposes (e.g. recreation or education).

A method for "first tier" assessment of wetland conservation values is outlined here, and described in more detail in Appendix 4.

6.2 Assessing Wetland Conservation Values

It is suggested that the following procedure for wetland assessment be adopted:

(1) Identify wetland.

(2) Assess the value(s) of the wetland by attempting to answer each of the questions listed as assessment criteria (see Section 5). (Some criteria may be assessed on the basis of available information or field inspection of the wetland. Other aspects will require advice from experts in particular areas.)

(3) Apply a rating to each criterion. A rating of 1 = not significant; 2-4 = graded scale of moderate significance; 5 = high significance. (For some of the criteria, these parallel a ranking of local, parochial, regional, national and international significance.)

(4) Construct a histograph of ratings values **versus** criterion (see Fig.7).

(5) Assess the wetland on a preliminary basis using the histograph. This is amplified below.

The assessment of a wetland on the basis of the histograph rests on the premise that if one or more criteria has a significance score of greater than 2 then that wetland is **moderately to highly significant to some component of the community.** A wetland which ranks highly on several criteria would clearly be of high conservation value, but a high rating on a single criterion would also assign a degree of significance to the wetland (see Fig.7). The scoring procedure highlights that a given wetland has some component that is of significance and this should be critically examined. Wetlands that score highly, even in one attribute, essentially have been "snared" by the first filter.

These wetlands would then undergo a thorough assessment to determine land management priorities. Analysis of the histograph in terms of which criteria contributed to the assessment of the wetland as significant (social/recreational values, natural or scientific values, educational/research values) could provide a basis for determining appropriate future management priorities.

If all criteria are assigned a score of less than 2 and the wetland does not appear to be of outstanding significance on the basis of the first tier criteria (see Fig. 7), then it can be assessed on the second tier evaluation system. As a result of the second evaluation, a wetland might still be considered for conservation, rehabilitation or management for a specific purpose.

6.3 Considerations in Implementing Wetland Assessment

Any attempt to implement the approach described above to wetland assessment must incorporate several factors:

(i) For many wetlands **insufficient data** are available for assessment.

(ii) Many wetlands are already destroyed or severely altered such that those remaining must in general be viewed as significant. In 1966 it was estimated that nearly half of the wetlands of the Swan Coastal Plain had been destroyed through drainage and filling (Riggert, 1966). Development over the last 20 years has undoubtedly destroyed further substantial areas of wetland. Thus the remaining wetlands acquire a greater conservation importance because of the depleted amount of wetland resources now available.

(iii) There are conflicting demands for use of wetlands by social, government, developmental, educational and research groups.

(iv) The perceived value judgement of a minority group needs to be appreciated, but has to be integrated and balanced. A scientific community, although a minority, may have information about a natural system such as to warrant its conservation, even though the public is not aware of these values and does not necessarily share the same perspective. Equally, a minority group may place importance on a wetland in their area that the wider conservation bodies do not necessarily agree with. Both value judgements are valid, although they may need to be judged against community standards.

(v) Many of the decisions of today will have impact on generations of the future and such decisions should not unduly pre-empt or pre-determine the attitudes of and values of the future.

(vi) Finally, although all the various criteria or values of wetlands listed in Table 10 are important, some may be given different priorities in certain circumstances. For example, if a wetland is one of only a few remaining as habitats for a rare or endangered species, then that criterion alone may determine the conservation value and future management of the wetland. Similarly, if there is a demonstrated need for more open-water areas for active recreation, then that criterion may rank high in determining a wetland's perceived value.

It should also be noted that all of the wetland classifications cited in Section 4.2 illustrate the complexity of wetland types. For example, since vegetation responds to variations in habitat, wetlands of the same geomorphic type may contain quite different vegetation, in terms of structure and composition, because of locality, variable geomorphic history, vegetation history/dynamics, subtle variation in stratigraphy, soil and water relationships, and degree of human use and disturbance. Consequently, the following conclusions are important in any consideration of wetland conservation:

(1) wetlands of the Darling System (Swan Coastal Plain and Darling Plateau) are variable in type, origin and maintenance;

(2) a suite of wetlands in a given locality cannot necessarily be considered as representative of the region;

(3) each geomorphic setting contains its own suite of interrelated wetlands;

(4) even wetlands of the same geomorphic type vary in terms of habitat and hence the flora, fauna and human uses which they can support;

(5) the current status of a wetland in terms of nature and degree of impact of human use will affect the value of that wetland as a representative of its type.

It is therefore evident, both from the descriptions of the assessment criteria and from the variability in the wetland resources, that a wetland cannot be adequately or rigorously assessed unless a range of interdisciplinary information is available. This conclusion should not be surprising since researchers are now beginning to appreciate just how complex wetlands systems are, and how wetlands perform a range of multifarious functions. In effect, each of these functions has to be assessed by an appropriate worker who has experience in the particular field related to the wetland function or the specific wetland attribute.

7. Application of the Procedure for Wetland Assesssment - A Pilot Study

7.1 Introduction

In order to assess the practicality and applicability of the wetland classification and assessment procedures selected for use in this study, field surveys were undertaken to apply the procedures to a selected area of wetlands along a belt transect extending from Lake Joondalup to Walyunga in the Darling System (Fig. 8). The belt transect was 5 km wide and 50 km long, and encompassed an area that contains a wide variety of wetlands representative of the different geomorphic units in the Darling System (Fig. 9). Selected wetlands along the transect were classified using the system of C.A. Semeniuk (1987b) (Section 4), the status of the vegetation was noted, and conservation values were assessed by applying the criteria described in Section 5. It should be noted that although the assessment procedure (scoring of selected criteria) was carried out for each wetland, the analysis of conservation significance was undertaken for only ten selected wetlands. Time constraints precluded analysis of conservation values for all wetlands in the transect and this was beyond the scope of the survey, which was to evaluate the practical application of the procedure.

The results of these assessments and an evaluation of the applicability of the assessment procedure for identifying environmentally significant wetlands in the Darling System are presented in Appendix 5 and summarised below.

7.2 Classification of Wetlands in the Lake Joondalup - Walyunga Transect

Wetlands along the transect were classed as to geomorphic/habitat type, size, shape, water salinity and consistency of salinity (if known). The results of the classification are presented in Table 11 and Figure 9a.

7.3 Status of Vegetation of Wetlands in the Lake Joondalup - Walyunga Transect

The extent of native vegetation cover was determined as a basis for evaluating the assessment criteria which depend on a pristine or semi-pristine environment [e.g. Criteria 6, 7, 11 (Table 10)].

Five categories of vegetation cover were recognised:

(I) natural vegetation present in wetland and natural vegetation present in surrounding upland system;

(II) natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared;

(III) wetland vegetation partly modified or partly cleared, or with introduced species;

(IV) natural vegetation present in wetland but surrounding upland vegetation totally modified or cleared;

(V) wetland vegetation totally cleared or destroyed.

The status of vegetation in wetlands along the Lake Joondalup-Walyunga transect is shown in Figure 9b and the categories are listed in Table 11.

7.4 Conservation Value of Wetlands in the Lake Joondalup - Walyunga Transect

The wetlands in the transect were evaluated using ten of the sixteen assessment criteria listed in Table10. Criteria not relevant to wetlands in this region and recreational values were not evaluated. Criteria 13 (Aboriginal Heritage) was not developed in this study. It is considered to be an important aspect, however, and its omission reflects time and budget constraints rather than low priority.

The results of the assessment are presented in Table 11.

For ten selected wetlands, the scores for the criteria were plotted as histograms (Fig. 10) to allow assessment of the conservation value of these wetlands by the method outlined in Section 6. The conclusions resulting from this assessment are presented in summary form as notes in Figure 10.

7.5 Applicability of the Assessment Procedure

The pilot study of wetlands along the Lake Joondalup-Walyunga transect indicated that:

(1) The classification scheme of C.A. Semeniuk (1987b) adopted in this study is workable

and results in the production of useful working maps that show the different wetland categories in the region in terms of the type (lake, sumpland, dampland, etc.), size and shape.

(2) The application of the evaluation system adopted in this study to highlight outstanding wetlands indicates that the assessment procedure can be rapidly employed and is also workable. Overall, the personnel involved in the assessment procedure had little difficulty in providing assessment in their area of expertise.

(3) The assessment procedure allowed identification of wetlands of significant conservation value and highlighted the values/resources which contributed to this assessment.

8. *Preliminary Identification of Significant Wetlands in the Darling System*

8.1 Introduction

8.1.1 Background

A preliminary assessment was carried out to identify those wetlands in the Darling System that are considered to be outstanding or significant on the basis of currently available information.

Eleven groups or individuals expert in different and various matters of wetland ecology or environment were invited to undertake this appraisal.

It must be emphasised from the outset that the resulting listing is preliminary and it is not intended to dismiss those wetlands which were not highlighted. In many cases, insufficient information was available to make an assessment. Wetlands which were not identified as significant in this study may later be found to have high conservation values, or they may, in fact, be degraded and/or not significant.

It is also important to note that although the assessment was based on the procedures developed for assessment of wetland conservation values (Sections 5 and 6), it was not rigorous. Only those wetlands personally known by one or more of these groups or individuals were assessed, and there was insufficient information to apply all the assessment criteria to each wetland.

8.1.2 Approach

The wetlands of the Darling System were assessed by:

(i) Identifying regions of related wetlands (consanguineous wetland suites) in the Darling System.

(ii) Systematically working through the maps of "domains" of related wetlands. Each group/individual was asked to identify, if possible, at least one wetland with which they were familiar in each domain.

(iii) Assessing the conservation value of the selected wetlands by asking each group/individual to assess the wetlands with which they were familiar on the basis of their particular area of expertise and any other available information. [The assessment criteria (Table10) were provided as background information for this assessment but were not rigorously applied to each wetland.]

(iv) Identifying significant wetlands.

In total, from the collective expert input, some 185 wetlands or wetland systems were assessed.

Given the large number of wetlands, their extensive distribution throughout the Darling System, and the fact that workers in specific fields would not be familiar with all aspects of wetlands, nor would they have worked in or observed all the wetlands in the region, it is obvious that **no worker could contribute to an assessment of every wetland identified in this study.** Each wetland worker or group had knowledge or experience of, on average, some 20 to 40 specific wetlands, or wetland systems such as drainage basins. They were invited to assess these wetlands using a significance index of:

- international
- national
- state
- regional
- parochial
- local

If two-thirds of the wetland workers concurred on the significance of a wetland being greater than regional, then that wetland was highlighted as being regionally to internationally significant for the purposes of this preliminary listing. This does not imply that the other wetlands should be considered unimportant. In some cases, one or two workers were familiar with a given wetland and scored it highly, but the other nine or ten workers were not familiar with that wetland. Accordingly, although that wetland might rate as significant if it were better known, it was not identified as significant in this listing.

Where a wetland system was identified as significant, there may be portions of the system known to have high environmental value and other portions which have become degraded. Identification of specific significant areas was beyond the scope of this study.

The results of this assessment procedure are presented.

8.2 Identification of Related Wetlands in the Darling System

8.2.1 Regional Setting

A variety of regional physical features are important in the development of wetland types and their distribution. These are:

- geology, geomorphology and geomorphic processes;
- climate;
- hydrology.

Regional and local variation in these features can produce variability of wetland types. The regional setting for wetlands in the Darling System is described in terms of these factors in Appendix 2, drawing on a literature review by C.A. Semeniuk (1987a). Figure 11 shows the major geomorphic units, geological features and geomorphic elements of the Darling Region. The major geomorphic units are described in Table 12.

8.2.2 Consanguineous Wetlands in the Darling System

Based on the criteria listed in Section 4.5.1, C.A Semeniuk (1987a) recognised some 42 types of consanguineous wetland suites in the Darling System. These suites were named according to a geographic locality where the given suite is best developed. Examples of some consanguineous wetlands are illustrated in Figure 12.

Many of the suites correlate strongly with the geomorphologic systems described by McArthur & Bettenay (1960) (Fig.11), since the geometry and water characteristics of wetlands in general reflect geomorphic setting, geomorphic processes, hydrology and geomorphic history. The wetland suites were therefore described in groups representative of the geomorphic elements and the interfaces between the elements. In all, there are 14 broad-scale categories of geomorphic elements and their interfaces that provide the framework for the consanguineous wetland suites; from west to east these are:

(1) Quindalup Dunes;

(2) Quindalup Dunes - Spearwood Dunes, or Quindalup Dunes - Yoongarillup Plain interface;

(3) Spearwood Dunes;

(4) Yoongarillup Plain;

(5) Spearwood Dunes - Bassendean Dunes interface;

(6) Bassendean Dunes;

(7) Bassendean/Pinjarra Plain transition zone or Bassendean with fluvial features;

(8) Pinjarra Plain;

(9) Estuaries;

(10) Coastal Plain rivers;

(11) Dandaragan Plateau;

(12) Darling Plateau/Dandaragan Plateau interface;

(13) Darling Plateau;

(14) Collie Basin.

The wetland suites within these categories of geomorphic setting are listed in Table 13 and are described in terms of location, geomorphic setting, variety of wetlands, description of primary wetlands in suite, stratigraphy and inferred origin in Appendix 2.

8.2.3 Wetland Domains in the Darling System

The distribution of consanguineous wetlands in domains throughout the Darling System is mapped in Figure 13.

8.3 Assessment of Selected Wetlands

The results of the assessment of selected wetlands in each of the wetland domains in the Darling System are presented in Table 14.

A list of wetlands considered to be regionally to internationally significant by the majority of the wetland workers who undertook the assessment is presented in Table 15, and the location of these wetlands is shown in Figure 14.

It is suggested that Table 14 should be used to pinpoint wetlands of significant conservation value on the basis of the assessment of the individual wetland experts. Table 15 and Figure 14 should be used to highlight those significant wetlands most workers are familiar with. It is worth noting once more that wetlands not included in the listings in Table 14 or Table 15 may be found to be significant when more information becomes available. At present, there is insufficient data on which to base a comprehensive assessment of wetlands of the Darling System using the full range of assessment criteria.

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GLOSSARY

Avifauna	all the birds in a particular region.
Consanguineous Wetlands	wetlands that are distinctly related because of similarity in size, shape, soils, water, setting and origin.
Creek	seasonally inundated channel of variable shape and size.
Dampland	seasonally waterlogged basin of variable size and shape.
Domain	the occurrence, in discrete areas, of consanguineous wetlands.
Estuary	the tidal part of a river.
Fen	waterlogged, spongy ground containing alkaline decaying vegetation.
Floodplain	seasonally inundated flat.
Fluvial	of, or pertaining to, a river or rivers.
Fresh (water)	salinity less than 1000 mg/L.
Geomorphic	the form of the earth or its surface features.
Geomorphology	form and development of the earth's surface.
Groundwater	subsurface water in the zone of saturation.
Hydrology	science of water properties, circulation and distribution.
Lake	permanently inundated basin of variable size and shape.
Leptoscale	fine scale (see Table 6 for definitions of wetland categories according to scale).
Limnology	the study of inland bodies of water with reference to their plant and animal life, physical properties, geographical features, etc.
Macroscale	large scale (see Table 6 for definitions of wetland categories according to scale).
Marsh	a water-saturated, poorly drained area, intermittently or permanently watercovered, having aquatic and grasslike vegetation, essentially without the formation of peat.

Megascale	very large scale (see Table 6 for definitions of wetland categories according to scale).
Mesoscale	medium scale (see Table 6 for definitions of wetland categories according to scale).
Mesosaline	salinity 20 000-50 000 mg/L.
Microscale	small scale (see Table 6 for definitions of wetland categories according to scale).
Mixosaline	see brackish.
Palusplain	seasonally waterlogged flat.
Physiography	physical geography.
Poikilohaline	water of variable salinity, fluctuating from one salinity field to another.
Precipitation	water that falls to the surface from the atmosphere as rain, hail or sleet.
River	permanently inundated channel of variable size and shape.
Salinity	the total quantity of dissolved salts in water.
Sedimentology	scientific study of sedimentary rocks and of the processes by which they were formed; the description, classification, origin and interpretation of sediments.
Stasohaline	water of relatively constant salinity, remaining in a given salinity field.
Stratigraphy	geological study of strata and their succession.
Subhaline	salinity 1 000-3 000 mg/L.
Sumpland	seasonally inundated basin of variable size and shape.
Topography	the general configuration of a land surface or any part of the earth's surface, including its relief.
Waterlogged	area in which water stands near or at the land surface.

TABLE 1

MAJOR WETLAND TYPES BASED ON WATER LONGEVITY AND LANDFORM

(after C.A. Semeniuk, 1987b)

	LANDFORM		
Water Longevity	Basin	Channel	Flat
Permanent inundation	Permanently inundated basin	Permanently inundated channel	-
Seasonal (or inter-mittent) inundation	Seasonally inundated basin	Seasonally inundated channel	Seasonally inundated flat
Seasonal (or inter-mittent) waterlogging	Seasonally waterlogged basin	-	Seasonally waterlogged flat

TABLE 2

WETLAND TYPES - DEFINITION AND ORIGIN OF TERMS

WETLAND TERM	DEFINITION	DEFINED BY	ORIGIN OF TERM	USAGE IN C.A. SEMENIUK, 1987b
LAKE	Permanently inundated basin of variable size and shape	Hill (1900-1910) Monkhouse (1965) Bates & Jackson (1980) Fairbridge (1968) Ruttner (1953)	Established term, from Latin lacus, a hollow	The usage in this paper does not distinguish between shallow lakes and deep lakes
SUMPLAND	Seasonally inundated basin of variable size and shape	This paper	After "sump" meaning site of water retention or ponding or accumulation; the term is fortuitously similar to "sumpf" the German term for swamp	As defined
DAMPLAND	Seasonally waterlogged basin of variable size and shape	This paper	After "damp" meaning moist or wet. Thus it refers to a dampness or waterlogging of soils of some basin wetlands	As defined
RIVER	Permanently inundated channel of variable size and shape	Swayne (1956) Trowbridge (1962) Morisawa (1968)	Established term from Latin rivus, a stream (Shipley, 1982)	This usage conforms with the concept of most authors that river is defined as channelled water flow but is different to most authors in its necessity for permanence of water. The permanence of water also generally implies a channel of large rather than small size
CREEK	Seasonally inundated channel of variable size and shape	Whittow (1984) Monkhouse(1965) Trowbridge (1962) Bates & Jackson (1980)	Established term	This usage generally conforms with that of Australia and southwestern U.S.A.

TABLE 2 (cont'd)

FLOODPLAIN	Seasonally inundated flat	Mill (1900-1910) Monkhouse (1965) Moore (1949)	Established term	This differs from other authors in that inundation of the plain need not be linked to a river; in general, however, a floodplain is associated with a river or creek
PALUSPLAIN	Seasonally waterlogged flat	This paper	After Latin palus meaning "marshy"; thus the term refers to flats which are similar to dampland basins	As defined
WATERLOGGED	Area in which water stands near or at the land surface		Established term	Usage conforms with Golet and Larson (1974), Martin et al., (1953) and most other authors

TABLE 3

COMPARISON OF WETLAND TERMS USED IN THIS REPORT WITH ESTABLISHED CLASSIFICATIONS

C.A. SEMENIUK (1987b) AND THIS REPORT	MARTIN *et al.* (1953)	COWARDIN et al. (1979)	GOLET & LARSON (1974)	PAIJMANS *et al.* (1985)	GENERAL EUROPEAN	GENERAL N.AMERICAN
LAKE	Open fresh water Deep fresh marshes Open saline water	LACUSTRINE	Open water Shrub swamp Deep marsh	Lakes Swamp Coastal water bodies	Lake Swamp	Lake Swamp
SUMPLAND	Wooded swamp Seasonally flooded basins Shallow fresh marshes Deep fresh marshes Saline marshes Open saline water	PALUSTRINE	Deep marsh Shallow marsh Shrub swamp Wooded swamp Open water	Lakes Swamp	Marsh	Marsh Meadow
DAMPLAND	Fresh meadows Wooded swamp	PALUSTRINE	Meadow			Meadow
RIVER		RIVERINE		River and creek channels	River, Stream, Creek, Brook	River, Stream Creek, Brook
CREEK		RIVERINE		River and creek channels		Arroyo
FLOODPLAIN	Shrub swamp Wooded swamp		Seasonally flooded flats	Land subject to inundation	Floodplain	Floodplain Seasonally flooded flat
PALUSPLAIN	Wooded swamp Saline flat Salt meadow?	PALUSTRINE				

TABLE 4

CLASSIFICATION OF WATER SALINITY BASED ON TOTAL DISSOLVED SOLIDS

(after C.A. Semeniuk, 1987)

SALINITY mg/L	WATER CATEGORY
less than 1 000	Fresh
1 000 - 3 000	Subhaline
3 000 - 20 000	Hyposaline
20 000 - 50 000	Mesosaline
50 000 - 100 000	Hypersaline
100 000 and greater	Brine

The terms and boundaries for "fresh", "subhaline", "hyposaline", "mesosaline" and "hypersaline" are from Hammer (1986); the term "brine" is delineated by Davis and DeWiest (1966).

TABLE 5

CLASSIFICATION OF THE CONSISTENCY OF WATER QUALITY - DEFINITION AND ORIGIN OF TERMS

WETLAND TERM	DEFINITION	DEFINED BY	ORIGIN OF TERM	USAGE IN THIS REPORT
STASOHALINE	Water of relatively constant salinity remaining in a given salinity field	C.A. Semeniuk (1987b)	After staso (Greek) meaning constant	As defined
POIKILOHALINE	Water of variable salinity fluctuating from one salinity field to another	Originally defined Dahl (1956)	After poikilo (Greek) meaning variable	As defined

TABLE 6

WETLAND CATEGORIES ACCORDING TO SCALE
(after C.A. Semeniuk, 1987b)

(A) BASINS AND FLATS

- Megascale: Very large scale wetlands larger than a frame of reference 10 km x 10 km.
- Macroscale: Large scale wetlands encompassed by a frame of reference 1000 m x 1000 m to 10 km x 10 km.
- Mesoscale: Medium scale wetlands encompassed by a frame of reference 500 m x 500 m to 1000 m x 1000 m.
- Microscale: Small scale wetlands encompassed by a frame of reference 100 m x 100 m to 500 m x 500 m.

(B) CHANNELS
(width to length relationship)

- Macroscale: Large scale channels 1 km and greater wide, by several to tens of kilometres long.
- Mesoscale: Medium scale channels hundreds of metres wide, by thousands of metres long.
- Microscale: Small scale channels tens of metres wide, hundreds of metres long.
- Leptoscale: Fine scale channels several metres wide, tens of metres long.

TABLE 7

CATEGORIES OF WETLAND VEGETATION BASED ON EXTENT OF COVER AND INTERNAL ORGANISATION

(after Semeniuk *et al.*, 1987)

Organisation	Vegetation Cover on Wetland		
	Full cover	Patchy Cover	Peripheral Cover
Homogeneous Organisation	Type A	Type B	Type C
Zoned	Type D	Type E	Type F
Heterogeneous Organisation	Type G	Type H	Type I

TABLE 8

SCALAR TERMS USED TO DESCRIBE VEGETATION

(after Semeniuk *et al.*, 1987)

- Megascale - Wetland vegetation complex larger than a frame of reference 10 km x 10 km.
- Macroscale - Wetland vegetation complex encompassed by a frame of reference 1000 m x 1000 m to 10 km x 10 km.
- Mesoscale - Wetland vegetation complex encompassed by a frame of reference 500 m x 500 m to 1000 m x 1000 m.
- Microscale - Wetland vegetation complex encompassed by a frame of reference 100 m x 100 m to 500 m x 500 m.
- Leptoscale - Wetland vegetation complex smaller than a frame of reference 100 m x 100 m.

TABLE 9

EXAMPLES OF WETLAND VEGETATION TYPES CLASSIFIED BY THE SCHEME OF SEMENIUK *et al.* (1987)

CLASSIFICATION	VEGETATION TYPE	EXAMPLE
Macroscale	Type G marsh-scrub	Vegetation in Lake Pinjar
Macroscale	Type E forest-sedgeland	Peripheral vegetation in Lake Joondalup
Microscale	Type D heath and forest	Zoned vegetation in Stable Swamp
Mesoscale	Type E forest-marsh	Zoned peripheral vegetation of Lake Coogee

TABLE 10

CRITERIA FOR ASSESSING CONSERVATION VALUE OF A WETLAND
("First Tier" Assessment)

* (1) Is the wetland type regionally widespread or is it restricted in distribution? If the latter, then it may warrant conservation. (If the former, it may still be significant for conservation purposes - see below).

Having identified why a given wetland is regionally significant and thus requires conservation and management, it would then be necessary to identify the range of conservation values which apply to specific resources within the wetland. To do this, one needs to resolve the various other conservation criteria listed below. These criteria would require input from a range of natural history scientists but would mainly draw on the experience of geomorphologists and biologists.

(2) Is the wetland type representative of the region in that it provides an example of typical features of the natural systems.

This factor would ensure conservation of some typical wetlands even though they may be regionally widespread, given that other examples of similar wetlands elsewhere are degraded.

(3) Is the wetland important as a productive area upon which depend such commercial endeavours as fisheries (e.g. in coastal areas mangroves function as nursery areas for fisheries)?

For terrestrial wetlands of the Swan Coastal Plain this may not be relevant but may be relevant for the estuarine flats adjoining the river systems.

*(4) Is the wetland important to maintain the quality of human or animal and plant life (e.g. vegetation to arrest soil erosion)?

For wetlands on the Swan Coastal Plain and Darling Plateau this aspect would involve water quality relevant for the resident animal/plant population, maintenance of habitats for the migratory, nomadic or resident wildlife, and natural recharge/discharge processes. This criterion also incorporates the aspect of 'diversity' of habitat in which there is also a diversity of vegetation floristics and structure, and consequent diversity of fauna.

*(5) Does the wetland have important ecological or geological features of national or international significance (comparable to the significance of the Shark Bay stromatolites, Pinnacles at Cervantes)?

For wetlands this includes landforms, vegetation assemblages and other examples of regionally unique ecological and geological features. Some wetlands in Western Australia have international significance under the Ramsar Treaty.

*(6) Is the wetland important in providing relatively pristine or little modified environments or habitats (or system of these units) which are a research resource (comparable to the corals of the Ningaloo Reef; terrestrial vegetation of the Mitchell Plateau; strandplain of the Gascoyne delta)?

For wetlands this includes the range of interactions between landforms and habitats, the evolution of landforms, stratigraphic history of wetlands, ecological relationship between the above and population dynamics of various species of flora, aquatic fauna and other vertebrate fauna such as tortoises, avifauna.

*(7) Could the wetland function as an important pristine to semi-pristine or even altered environment for use by primary, secondary or tertiary educationalists because of scientific features and accessibility (e.g. geological localities for illustrating earth science principles, wetland localities for illustrating ecological principles)?

For wetlands this would include any of the suite of landforms, their associated biota, interdependence and evolution.

[*Note*: In Western Australia, there is inadequate reservation for scientific/educational purposes of the various types of wetland which occur within or close to the Metropolitan Area. These areas are under intense pressure for recreational and other development. This trend has been identified by numerous authors and must be expected to continue to grow as population pressures increase.]

TABLE 10 (cont'd)

*(8) Does the wetland function as the habitat of rare and endangered species?

For example, Bullsbrook swamps for the Short-necked Tortoise.

*(9) Does the wetland function as an important regional wildlife sanctuary, even if the flora/fauna are not rare or endangered?

For wetlands this would include those areas that provide water, refuge or breeding grounds for a variety of reptiles, avifauna, mammals, etc., and should include the aspect of habitat diversity, or vegetation diversity and interspersion, with its consequential implication of diverse faunal usage.

*(10) Is the wetland important as either a seasonal or temporary habitat or breeding ground of large numbers of migratory or nomadic animals, particularly waterbirds?

For wetlands in general this factor is likely to be important.

*(11) Can the wetland function as a semi-pristine to pristine area or wilderness for use by naturalists, bush-walkers, etc. (e.g. Kakadu National Park in the Northern Territory or Herdsman Lake in the Perth Metropolitan Area)?

Wetlands close to the population centre of Perth have special value to naturalists, professional ornithologists, amateur bird observers, outdoor enthusiasts, etc.

(12) Does the wetland have importance from the point of view of aesthetics?

Well-vegetated and/or water-filled wetlands provide a contrast to the adjacent, heavily-developed residential areas.

(13) Does the wetland have importance as an historic or actively-utilised Aboriginal heritage site?

There are some recorded Aboriginal sites at wetlands and therefore this factor has to be assessed for each site.

(14) Does the wetland have value for active water-based recreation?

There is increasing pressure for use of wetlands for boating and other water sports, including duck hunting.

*(15) Does the wetland, regardless of whether it is pristine or degraded, constitute part of a linked natural system, either physical or biological (biological: in terms of usage by waterbirds, particularly migrating or nomadic species) such that its destruction or alternate use would result in disturbance/alteration to adjoining wetlands or to fauna species using the system?

(16) Does the wetland have social values evidenced by community concern for its conservation, regardless of scientific values?

* indicates criteria used to evaluate the wetlands in the Lake Joondalup-Walyunga transect.

TABLE 11

SUMMARY OF CLASSIFICATION AND ASSESSMENT OF THE WETLANDS ALONG THE LAKE JOONDALUP-WALYUNGA TRANSECT

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA 1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Lake Joondalup		lake, elongate, macroscale, fresh, poikilohaline	II	4	4	2/3	4	5	4	4	5	4	4
Lake Mariginiup		lake, round, macroscale, fresh stasohaline	II	3	4	1	2	3	3	3	4	2	4
Rousset Road		sumpland, irregular, microscale fresh, stasohaline	III	1	1	1	1	1	1	1	1	1	1
Townshend Road		dampland, ovoid, microscale, fresh, stasohaline	II	1	1	1	1	1	1	1	1	1	1/2
Little Dundarbar Swamp		sumpland, ovoid, mesocale, fresh, stasohaline	V	1	1	1	1	1	1	1	1	1	1
Damian Road		dampland, ovoid, microscale, fresh, stasohaline	IV	4	3	1	2	2	1	1	2	1	1/2
Ross Street		sumpland, ovoid, microscale, fresh, stasohaline	IV	1	1	1	1	1	1	1	1	1	1
Ross Street		dampland, round, microscale, fresh, stasohaline	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sydney Road		dampland, round, microscale, fresh, stasohaline	II	2	3	1	1	2/3	1	1	1	1	3
Stoney Road		dampland, round, microscale, fresh, stasohaline	V	N/A	1	N/A	1	1	1	1	1	1	1
Jandabup Lake		lake, ovoid, macroscale, fresh stasohaline	II	2/3	4	1	4	4	4	4	4	4	4
Hawkins Road North		sumpland, ovoid, mesoscale, fresh, stasohaline	III	2	3	1	2	2/3	1	2	1	4	3
Pine Forest	A	built on; not classified	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pine Forest	B	sumpland, irregular, macro-scale, fresh, stasohaline	III	4	4	1	2	3	1	2	1	3	4
Pine Forest	C	sumpland, ovoid, microscale, fresh, stasohaline	III	2	3	1	2	2/3	1	2	1	2/3	3/4
Pine Forest	D	sumpland, ovoid, microscale, fresh, stasohaline	III	2	3	1	1	2/3	1	1	2	2	2/3

N/A : not applicable

\- : no assessment carried out for this criterion at this site

* : category I - natural vegetation present in wetland, and natural vegetation present in surrounding upland systems.
category II - natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared.
category III - wetland vegetation partly modified or partly cleared, or with introduced species.
category IV - natural vegetation present in wetland, but surrounding upland vegetation totally modified or cleared.
category V - wetland vegetation totally cleared or destroyed.

TABLE 11 (cont'd)

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA									
				1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Pine Forest	E	dampland, ovoid, microscale, fresh, stasohaline,	III	4	3	1	2	2/3	1	2	1	2/3	1
Pine Forest	F	dampland, elongate, mesoscale fresh, stasohaline	III	4	3	1	1	2/3	1	1	2	2/3	2/3
Pine Forest	G	dampland, irregular, micro-scale, fresh, stasohaline	IV	4	2	1	1	2/3	1	1	1	1/2	1/2
Pine Forest	H	dampland, round, microscale, fresh, stasohaline	III	4	3	1	2	2/3	1	2	1	2/3	3
Pine Forest	I	sumpland, elongate, micro-scale, fresh, stasohaline	III	4/5	3	1	2	2/3	1	2	1	2/3	3
Pine Forest	J	dampland, elongate, micro-scale, fresh, stasohaline	III	3	3/4	1	-	2/3	1	2	1	2/3	3/4
Pine Forest	K	dampland, oivoid, microscale, fresh, stasohaline	III	3	3/4	1	-	2/3	1	2	1	2/3	3/4
Pine Forest	L,M,N, O,P	dampland, irregular, macro scale, fresh, stasohaline	III	4/5	5	1	4	4	2	3	3	4	5
Pine Forest	Q	dampland, irregular, meso-scale, fresh, stasohaline	III	4	4	1	2	2/3	1	2	2	3	4
Pine Forest	R	dampland, irregular, meso-scale, fresh, stasohaline	II	4/5	5	1	4	3	2	3	3	3/4	4/5
Pine Forest	S	dampland, ovoid, microscale fresh, stasohaline	III	3	3	1	2	2/3	1	2	1	2	3
Pine Forest	T	dampland, round, microscale, fresh, stasohaline	III	3	3	1	2	2/3	1	2	1	2	3
Pine Forest	U	sumpland, irregular, meso-scale, fresh, stasohaline	III	4	3	1	2	2/3	1	2	1	2	3
Pine Forest	V	dampland, irregular, meso-scale, fresh, stasohaline	IV	4	3	1	1	2/3	1	1	2	2	3
Pine Forest	W	dampland, round, microscale, fresh, stasohaline	III	4	3	1	1	2/3	1	1	2	2	2/3
Pine Forest	X	dampland, ovoid, microscale, fresh, stasohaline	IV	1/2	-	N/A	-	2/3	-	-	-	N/A	-
Pine Forest	Y	dampland, ovoid, microscale, fresh, stasohaline	IV	1/2	-	N/A	-	2/3	-	-	-	N/A	-

N/A : not applicable

\- : no assessment carried out for this criterion at this site

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category III - wetland vegetation partly modified or partly cleared, or with introduced species.
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category V - wetland vegetation totally cleared or destroyed.

TABLE 11 (cont'd)

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA									
				1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Eastern Gnangara Wetlands	1	palusplain, freshwater, stasohaline, mesoscale	I	4/5	5	1	4	2/3	2	3	3	3/4	5
	5	sumpland, mesoscale, ovoid, stasohaline, fresh	tracks and some rubbish but continuous vegetation	4	4	1	2	4	2	2	2	3	4
	6	sumpland, mesoscale, elongate	V	1	3	1	1	4	1	1	2	2/3	2
	7	sumpland, microscale, ovoid	IV	2	-	1	-	4	-	-	-	-	-
	8	creek, braided, leptoscale	V	1	-	1	-	4	-	-	-	-	-
	9	dampland, microscale, ovoid	IV	3	-	1	-	4	-	-	-	-	-
	10	palusplain, mesocale, freshwater, stasohaline	I	1	-	1	-	4	-	-	-	-	-
	11	sumpland, microscale, elongate freshwater	I	4	-	1	-	4	-	-	-	-	-
	12	sumpland, mesoscale, irregular	I	4	5	1	4	4	1	3	2	4	3
	13	dampland, microscale, elongate freshwater	I	2	3	1	2	4	1	1	1	2/3	3
	14	dampland, microscale, linear, freshwater	I	2	4	1	3	4	1	2	2	3	2
	15	sumpland, microscale, round, freshwater	I	3	3	1	2	4	1	2	2	-	2
	16	sumpland, microscale, ovoid, freshwater	IV	2	-	1	-	2	-	-	-	-	-
	17	sumpland, microscale, ovoid	IV	1	2	1	1	4	1	1	1	2	2
	18	sumpland, microscale, ovoid	III	2	4	1	3	2	1	2	2	3	3
	19	sumpland, microscale, ovoid	I	3	4	1	3	4	1	2	1	3	3
	20	dampland, microscale, ovoid, freshwater	I	2	4	1	3	4	1	2	2	3	3
	21	dampland, microscale, ovoid, freshwater	I	4	4	1	3	4	1	2	2	3	3
	22	sumpland, macroscale,irregular	I	4	4	1	3	4	1	2	2	3	2
	23	dampland, microscale, linear, freshwater	I	3	4	1	3	4	1	2	2	3	3
	24	sumpland, microscale, ovoid	I	4	4	1	3	3	1	2	2	3	2

N/A : not applicable

\- : no assessment carried out for this criterion at this site

* : category I - natural vegetation present in wetland, and natural vegetation present in surrounding upland systems
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category III - wetland vegetation partly modified or partly cleared, or with introduced species
category IV - natural vegetation present in wetland, but surrounding upland vegetation totally modified or cleared
category V - wetland vegetation totally cleared or destroyed

TABLE 11 (cont'd)

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA									
				1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Narala Road	1	floodplain, mesoscale	IV	1	4	1	1	2	1	1	3	2	4
	2	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	3	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	4	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	5	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	6	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	7	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	8	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	8a	floodplain, microscale	I	4	4	1	3	3/4	1	2	2	3	4
	9	sump, microscale	V	1	4	1	1	2	1	1	3	2	4
	10	creek, microscale, meandering	III	1	4	1	1	2	1	1	3	2	4
	11	creek, meandering, microscale	IV	1	4	1	1	2	1	1	3	2	4
	11b	floodplain, mesoscale	IV	1	4	1	1	2	1	1	3	2	4
	12	dampland, microscale, elongate, freshwater	IV	1	4	1	1	2	1	1	3	2	4
	13	creek, microscale, meandering + floodplain	V	1	4	1	1	2	1	1	3	2	4
	14	sumpland, microscale, round	V	1	4	1	1	2	1	1	3	2	4
Twin Swamps	1	sumpland, mesoscale, irregular	I	5	5	1	5	4	5	5	3	5	4
	2	sumpland, microscale, elongate	I	3	5	1	2	4	5	5	3	5	4
	3	sumpland, microscale, ovoid	I	3	5	1	5	4	5	5	3	5	4
	4	sumpland, microscale, round	I	3	5	1	5	4	5	5	3	5	4

N/A : not applicable

\- : no assessment carried out for this criterion at this site

* : category I - natural vegetation present in wetland, and natural vegetation present in surrounding upland systems
category II - natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared
category III - wetland vegetation partly modified or partly cleared, or with introduced species
category IV - natural vegetation present in wetland, but surrounding upland vegetation totally modified or cleared
category V - wetland vegetation totally cleared or destroyed

TABLE II (cont'd)

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA									
				1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Ellen Brook	1	creek + floodplain, mesoscale	II	2	3	1	2	2	2	3	2	2/3	5
	2	creek, leptoscale	V	N/A	2	N/A	1	N/A	1	1	1	1	1
	3	creek, leptoscale	V	N/A	2	N/A	2	N/A	1	1	1	1	1
	4	creek, leptoscale	V	N/A	2	N/A	1	N/A	1	1	1	1	1
Martyn Res.	5	floodplain, mesoscale	I	5	5	1	5	4	5	5	3	5	5
	6	floodplain, mesoscale	V	N/A	2	N/A	1	N/A	1	1	1	1	1
	7	paluspiain, microscale	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Walyunga	1	creek, leptoscale, meandering, incised	I	2	3	1	4	4	3	1	2	2/3	4
	2	creek, leptoscale, meandering, incised	I	2	3	1	4	4	3	1	2	2/3	4
	3	creek, leptoscale, meandering, incised	I	2	3	1	4	4	3	1	2	2/3	4
	4	creek, leptoscale, meandering, incised	I	2	3	1	3	4	3	3	2	3	2
	5	river, microscale, meandering	I	5	4	1	4	4	3	4	3	4	4
	6	creek, leptoscale, u-shaped	IV	1	3	1	2	2/3	3	2	2	2/3	2
	7	river, microscale	I	5	4	1	4	4	3	4	3	4	4
	8	creek, leptoscale, incised	I	2	3	1	2	4	3	2	2	3	2
O'Brien Road	1	creek, leptoscale, meandering	IV	1	-	1	-	4	-	-	-	-	-
	2	creek, microscale, u-shaped	V	1	2	N/A	1	N/A	1	1	2	1	2
	3	creek, microscale, braided	I	2/3	2	1	1	2	1	2	2	2	2
	4	creek, microscale, incised, meandering	I	5	4	1	3	2	2	2	3	2/3	2
	5	creek, microscale, incised	I	2/3	2	1	1	2	1	1	1	2	2
	6	creek, microscale, u-shaped	I	2/3	4	1	2	2	2	1	2	2	4
	7	creek, leptoscale, incised	I	2	-	1	-	2	-	-	-	2	-
	8	creek, microscale, u-shaped meandering	I	2/3	4	1	2	2	2	1	2	2	4
	9	creek, leptoscale	IV	1	3	1	1	1	1	1	1	2	1
	10	creek, leptoscale	III	1	2	1	1	2	1	1	1	2	1
	11	creek, leptoscale	II	1	2	1	1	1	1	1	1	1	1

N/A not applicable

\- no assessment carried out for this criterion at this site

* category I - natural vegetation present in wetland, and natural vegetation present in surrounding upland systems
category II - natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared
category III - wetland vegetation partly modified or partly cleared, or with introduced species
category IV - natural vegetation present in wetland, but surrounding upland vegetation totally modified or cleared
category V - wetland vegetation totally cleared or destroyed

TABLE 11 (cont'd)

NAME OF WETLAND	TRAN-SECT	WETLAND TYPES	STATUS OF VEGETATION COVER *	CRITERIA 1 REGIONAL DISTRIBUTION	4 QUALITY OF LIFE	5 ECOLOGICAL FEATURES	6 RESEARCH RESOURCE	7 EDUCATIONAL	8 RARE AND ENDANGERED	9 REGIONAL WILDLIFE	10 SEASONAL HABITAT	11 USE BY NATURALISTS	15 LINKED SYSTEM
Rean Road	1	creek, leptoscale, meandering	IV	1	3	1	1	2	1	2	2	2	4
	2	creek, microscale, meandering	IV	1	3	1	1	2	1	2	2	2	4
	3	springs	V	1	2	1	1	1	1	2	2	1	3
	4	creek, leptoscale, meandering	IV	1	2	1	1	1	1	1	1	1	1
	5	creek, leptoscale, meandering	IV	1	2	1	1	1	1	1	1	1	1
	6	creek, microscale, meandering, incised	III	1	3	1	1	2	1	2	3	2	4
	7	creek, leptoscale, meandering	V	1	3	1	1	2	1	2	3	2	3
	8	creek, microscale, meandering	III	1/2	4	1	1	2	1	2	3	2	3
	9	creek, microscale, meandering, incised	I	2/3	4	1	1	2	1	2	3	2	3
	10	creek, leptoscale	V	1	2	1	1	1	1	1	2	1	1
	11	creek, microscale, u-shaped	I	2/3	4	1	2/3	3	2	3	3	3	2
	12	creek, microscale, meandering	I	2/3	4	1	4	3	2	3	3	4	2
	13	creek, leptoscale, meandering	III	1	-	1	1	-	-	-	-	-	-
	14	creek, leptoscale, meandering	III	1	-	1	1	-	-	-	-	-	-
Reserve Road	A	creek, leptoscale, u-shaped	IV	1	-	1	1	-	-	-	-	-	-
	B	creek, leptoscale, meandering	V	1	-	1	1	-	-	-	-	-	-
	C	creek, leptoscale, meandering	IV	1	-	1	1	-	-	-	-	-	-
	D	creek, microscale, braided	I	2/3	-	1	2/3	-	-	-	-	-	-
	E	creek, microscale, meandering	III	1	-	1	1	-	-	-	-	-	-
	F	palusplain, microscale	IV	4	-	1	2	-	-	-	-	-	-

N/A : not applicable

- : no assessment carried out for this criterion at this site

* : category I - natural vegetation present in wetland, and natural vegetation present in surrounding upland systems
category II - natural vegetation present in wetland, surrounding upland vegetation partly modified or cleared
category III - wetland vegetation partly modified or partly cleared, or with introduced species
category IV - natural vegetation present in wetland, but surrounding upland vegetation totally modified or cleared
category V - wetland vegetation totally cleared or destroyed

TABLE 12

DESCRIPTION OF GEOMORPHIC UNITS IN THE DARLING SYSTEM

(after C.A. Semeniuk, 1987a)

GEOMORPHIC UNIT	DESCRIPTION	UNDERLYING MATERIALS	WETLAND FEATURES
The Darling Plateau	broadly undulating surface, average height of 400 m above sealevel; dissected by steep-sided valleys with incised channels and by steep-sided valleys with broad, flat ribbon flood plains and small channels	laterite overlying Precambrian crystalline rocks	fluvial geomorphic processes are dominant
The Collie Basin	large topographic depression; very low relief, 200 m to 250 m above sealevel	underlain by laterite-capped Permian and younger rocks	fluvial processes are dominant
Dandaragan Plateau	200 m above sealevel, gently undulating	Mesozoic rocks laterite-capped surface	fluvial processes are dominant
The Swan Coastal Plain	low relief, 20-30 km wide, marked zonation of distinct large-scale landforms either arranged parallel to the coast or associated with major rivers (McArthur & Bettenay, 1960; McArthur & Bartle, 1980a,b). From east to west these are: the Ridge Hill Shelf, with underlying sediments of Pleistocene laterite and sand; the Pinjarra Plain, a flat to gently undulating system of alluvial fans; the Bassendean Dunes, an undulating plain of low degraded quartz sand hills; the Spearwood Dunes and Yoongarillup Plain, large-scale linear continuous parallel ridges, predominantly Pleistocene aeolianites; the Quindalup Dunes, Holocene dune ridges	surficial deposits Pleistocene to Holocene age of sedimentary and pedogenic origin	Pinjarra Plain: dissected by many microscale channels with occasional lakes and sumplands dominated by channels, flats and plains. Bassendean dunes: alternating hills and basins, channels generally absent. Spearwood dunes: sheet wash basin sedimentation, karstification are important in development of wetlands. Quindalup dunes: deflated areas, linear depressions, locally lakes formed by marine influences. Estuaries formed by fluvial processes

TABLE 13

LIST OF CONSANGUINEOUS WETLAND SUITES CORRELATED WITH MAIN GEOMORPHIC UNITS OF THE DARLING SYSTEM

(after C.A. Semeniuk, 1987a)

GEOMORPHIC SETTING	ABBREVIATION OF GEOMORPHIC SETTING USED IN THIS REPORT	CONSANGUINEOUS WETLAND SUITES	ABBREVIATION USED IN THIS REPORT (Fig. 3)
QUINDALUP DUNES	Qu	Cooloongup Becher Peelhurst	Qu.1 Qu.2 Qu.3
QUINDALUP-YOONGARILLUP INTERFACE	Q/Y	Preston	Q/Y.1
SPEARWOOD DUNES	S	Yanchep Balcatta Coogee Stakehill	S.1 S.2 S.3 S.4
YOONGARILLUP	Y	Clifton Kooallup	Y.1 Y.2
SPEARWOOD/ BASSENDEAN INTERFACE	S/B	Bibra Hamden	S/B1 S/B2
BASSENDEAN DUNES	B	Pinjar Gnangara Jandakot Riverdale	B1 B2 B3 B4
BASSENDEAN/ PINJARRA TRANSITION <u>OR</u> BASSENDEAN WITH FLUVIAL FEATURES	B/P	Beermullah Mungala Muchea Bennett Brook Benger	B/P1 B/P3 B/P2 B/P4 B/P5

..... cont'd

TABLE 13 (cont'd)

GEOMORPHIC SETTING	ABBREVIATION OF GEOMORPHIC SETTING USED IN THIS REPORT	CONSANGUINEOUS WETLAND SUITES	ABBREVIATION USED IN THIS REPORT (Fig. 13)
PINJARRA PLAIN	P	Keysbrook	P1
ESTUARIES	E	Moore Estuary Swan Estuary Peel-Harvey Est. Leschenault Est.	E1 E2 E3 E4
COASTAL PLAIN RIVERS	R	Moore River Swan River Ellen Brook Goegrup	R1 R2 R3 R4
DANDARAGAN PLATEAU	Dp	Red Gully Coorang Clewley Mogumber	Dp1 Dp2 Dp3 Dp4
DANDARAGAN PLATEAU DARLING PLATEAU INTERFACE	Dp/D	Wannamal	DpD
DARLING PLATEAU	D	Walyunga Little Dardanup Harris River Nalyerin Hotham Brockman	D1 D2 D3 D4 D5 D6
COLLIE BASIN	C	Schotts	C1

TABLE 14

LIST OF SELECTED WETLANDS IN THE DARLING SYSTEM WITH ASSESSMENT OF SIGNIFICANCE

[Wetland workers who contributed to this study are identified in Section 1.3. They are identified here only as worker A, B, etc.]

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
Richmond	r	L	n	s		r/p		p			r
Walyungup	r	VH	n	r	s/r	r/p		s			s/r
Cooloongup	r	H	n	r	s/r	r/p	r	s		H	s/r
Whitford's Beach				r							p
Becher				r				p			r
Peelhurst				r				p			r
Lake Preston	r	M	n	s	s/r	i/s	r	s			n
Loch McNess	i	H/M	s	r	s	s		)	)		s
Pippidinny				p				)	)		p
Yonderup				r				)	)		r
Carabooda		M		r		l		) s/i	) n/l		p
Nowergup		M		r				)	)		p
Neerabup		M		r		l		)	)		r
Joondalup	i	VH		r	s/r	s	r	)	)	H	s
Goollelal	s	VH	p	r	s/r	s		)	)	M	r
Barragoon		M/H		r							p
Carine	l/p	M/H		p			p	)	)		p
Careniup	l/p	H		p				)	)		p
Karrinyup	l/p			p				)	)		p
Gwelup	l/p	VH	p	r				) p/l	) p/l	M	p
Herdsman	i	VH	r	p	i			) p	) p	H	p
Lake Claremont	l/p			p	l			)	)	M	p
Monger	l/p			p/r	r/p		r	)	)	H	p
Jackadder	l/p			l	p			)	)	L	l
Perry Lakes				l				)	)	L/M	l
Marning Lake		M		p				l	l	L/M	l
Coogee	l/p	M	r	p				r	r		r
Henderson		H		r	l		s	r	r		r
Mt Brown		H		r				r	r		r

[1] Wetlands are listed in groupings that relate to consanguineous wetland suites. The listing is ordered by geomorphic unit, progressing from west to east. Within each unit, wetlands are ordered from north to south.

[2] Significance ranking:
i: international
n: national
s: state
r: regional
p: parochial
l: local
VH: very high
H: high
M: medium
L: low

)
) block assessment
)

TABLE 14 (cont'd)

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
Long Swamp											r
Leda	l/p	M		p							p
Stakehill System A	l/p	L		p	l			) s	) s		p
System B/C	l/p	M		r	l			) s	) s		r
Anstey Stakehill J	l/p	M		r	l		r	) s			r
Stakehill System M	l/p	L		r	l			) s			p
Clifton	i	H	n	s	r/s	i	r	) i		H	i
Martin Tank	s/r	H	n	s				)			n
Pollard	s/r							)			n
Duck Pond	s/r							)			n
Myalup											p/r
Mialla		H/M									p
Koonallup		M		p				p			p
Bidaminna				r							r
North Lake	r	M	p/l	p	r/s	p		)		M	p
Bibra	r	M/H	l/p	r		p		)	s	H	r
Kogolup		M		p		l	r	)			p
Yangebup	r	M		r		l	r	) s		H	r
Thompson	r	M	s	p	r	i	s	)	s	H	p
Banganup	r	H		p		r		)		H	p
Spectacles	r	H		r				)		H	r
Bollard Bulrush	r	H		p				)			r
Mealup	r	H				r		) s		H	r
McLarty	r	M						)		H	r
Hamden	l	M		r				s			r
Pinjar	r	M	s	s	r/p			p	l		r/s
Moore River											
National Park System	s			s				)			i
Culcadarra				r				)			r
Gnangara	l/p	H	r	p	l	s	r	)			p
Jandabup		H		r		s	r	)		H	r
Adams		H		p	p			)			p

TABLE 14 (cont'd)

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
Mariginiup		H		r	r	s		) s			r
Sydney Road Swamp P.				r				)			r
Sydney Road Swamp H.				r				)			r
Yeal				p				)			p
Bindiar		M		p				)			p/r
East Gnangara #12				r	p			)			r
East Gnangara #13				r				)			r
Pine Forest L, M, N #7				r				)			r
Melaleuca Pk				r	l/p			)			r
Pine Forest A-W				p	l			)			p
Gingin Br. N.				r				) s			p
East Mandurah				p				)			p
Red Lake								)			
Willie Pool											
Roe Swamp				r	r	)		)			r
Piney Lakes		M		r	)	)		)			r
Booragoon				p	) l/p	) s		)			p
Blue Gum				l	)	)	) r	) s		L	p
Jandakot				p	)	)	)	)			p
Muckenburra				p				p			p
Riverdale		M	s	r	p/r			p			r
Beermullah Flat		H		r							r
Beermullah Lake				r		)		)		M	r
White Lake				r		)		)		M	r
Big Bootine		H		r		)		) s		M	r
Little Bootine		H		r		) s		)			r
Nambung		VH	s	r		)		)		L	r
Nambung Swamp A & B				r		)		)			r
Coonabidgee				r		)		)			r
Bambun		H	s	r		)		) s	s/n	H	r
Mungala		H	s	r		) s		)		M	r
Wright Road		M		r		)		)			r

TABLE 14 (cont'd)

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
Balannup		Ṁ		p		)		)			
Wright Lake				p		)		)			
Mary Carroll		M		p		)		)		M	p
Forrestdale		M		r	i	) s		) s		H	r
Tomato Lake				l	l	)		)			l
Hazelmere Lakes				l		)		)			l
Kooljerrenup Area						)		)			
Muchea						)					r
Bennett Brook		H		r		) s					
Yangedi		M		r		)					
Benger	r	VH	s	r	i	s	n/i	s	s	H	r
Terang	r	H		r				r			r
Keysbrook		M/L		p							p
Brixton-Yule Complex	i			s							r/s
Tomah Road				r							r/p
Twin Swamps				n	i		i				s
Martin's Reserve				n	i						s
Moore River Estuary	r	M/L	s	s		s		p	s		s
Swan Estuary[3a]	s/i	H	s	s	s/i	s	r	s	s	H	s
Peel-Harvey Estuary[3b]	i	VH	s	i	s/i	s	i	s	s	H	n
Leschenault Estuary[3c]	r	H	s/n	s	s/i	s	n	s	s	H	n
Moore River	r	M	n	p		s		s	s		s
Swan River	s	H	s	s	p	s		s	s		s
Canning River	s	H	s	s	p	s		s	s	H	s

3 The following parts of estuaries are considered particularly significant:

(a) Swan: Alfred Cove
Pelican Point
Melville with freeway foreshore
Belmont/Bayswater tidal marsh

(b) Peel Harvey: Mouth of Murray River
Mouth of Harvey River
Boggy Bay
Coodanup
Styx
Heron Point

(c) Leschenault: Samphire Buffalo Road
Leschenault Barrier

TABLE 14 (cont'd)

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
N. Dandalup River	s	H	s	s	p	s		s	s		s
S. Dandalup River	s	H	s	s	p	s		s	s		s
Serpentine River	s	H	s	s	p	s		s	s		s
Murray River	s	H	s	s	p	s		s	s	H	
Harvey River	s	H	s	r	p	s		s	s	L	
Preston River	s	H	s	s	p	s		s	s		
Collie River	s	H	s	s	p	s		s	s		
Ellen Brook	s	H	s	r	p			r		H	r
Jane Brook	s	H	s	r				r			
Chandala	r			r							r
Guanarnup	r	VH		r				s			r
Yalbanberup	r	VH		r				s			r
Goegrup	r	VH		r			r	s			s
Willows		M	n	r							r
Red Gully		M	n	r				r			r
Clewley		L	n	r				r			r
Mogumber		M	n	r				r		M	r
Wannamal		VH	s	s		r	r	s		H	s
Lake Nangar				p							
Walyunga				r							
Red Swamp	)	) M	) n		1/p	r/s		s			r
Woorooloo Brook #1	)	)	)	r	)			)			r
Avon River	)	)	)	r	)			)			
Gidgegannup Brook #1	)	)	)	s/r	)			)			
Goonaring	)	)	)	r	)			)			
Belaring	)	)	) s/n	r	) 1/p	r/s		) s			
Black Swamp	)	) H	)	r	)			)			
Helena River #1	) r	)	)	r	)			)			
Jane Brook #1	)	)	)	r	)			)			
Swan River #1	)	)	)	r	)			)			
Serpentine River #1	)	)	)	r	)			)			

TABLE 14 (cont'd)

WETLAND[1] (listed in groups within consanguineous suites, following C.A. Semeniuk, 1987)	ASSESSMENT OF CONSERVATION SIGNIFICANCE[2]										
	A	B	C	D	E	F	G	H	I	J	K
Murray River #1	)	)	)	r	)			)			
Ernest River #1	)	)	)	r	)			)			
Augustus River #1	)	)	)	r	)			)			
Creeks crossing Scarp	) r	H	s/n	r	1/p			s			
North Dandalup		)	s/n	r	)			)			
Harvey River		) M	s/n	r	) r	r/s		) r			
Wungong Area		)	s	r	)			)			
Darkan Swamp				r/s							r
Darkan River Headw				r							r
Canning River Headw	)	)	)	r	)			)			
Serpentine River Headw	)	)	)	r	)			)			r
Harris River	) r	) M	) r	r	) 1/p	r/s		) r			
Bingham River	)	)	)	r	)			)			
Collie River East	)	)	)	r	)			)			
Nalyerin	r	M	s	r/s	)			s			r
Yourdamung	r	M	s	r/s	) 1/p	r/s		s			r
Manaring Lake		M	s	r/s	)			s			r
Hotham River	r	H	s	s	1/p	r/s					
Brockman River	r	M		s	1/p	r/s		r/s			
Gooninong										L	
Cantalin Pools											
Lake Needoonga			s	r		r/s		r/s			
Lake Chittering			s	r		r/s		r/s			
Avon #6	r	M	s	r	1/p	r/s		r/s			
Schotts	r	M		r	1/p	s		r			r
Muja		M		p							r

TABLE 15

PRELIMINARY LIST OF WETLANDS OF REGIONAL TO INTERNATIONAL SIGNIFICANCE IN THE DARLING SYSTEM[1]

[Note: This listing identifies wetlands in the Darling System which are considered by a number of wetland experts, on the basis of currently available information, to be of regional to international significance. It is **not** intended to be used as a final or comprehensive list.]

COASTAL PLAIN WETLANDS

Richmond	Spectacles	Mungala
Walyungup	Bollard Bulrush	Wright Road
Cooloongup	Mealup	Forrestdale
Becher	McLarty	Bennett Brook
Peelhurst	Hamden	Benger
Lake Preston	Pinjar Lake	Terang
Loch McNess	Moore River National Park System	Twin Swamps
Yonderup	Culcadarra	Martin's Reserve
Joondalup	Gnangara	Brixton-Yule Complex
Goolellal	Jandabup	Moore River Estuary
Gwelup	Mariginiup	Swan Estuary
Herdsman	Sydney Road Swamp P.	Peel-Harvey Estuary
Monger	Sydney Road Swamp H.	Leschenault Estuary
Coogee	East Gnangara #12	Moore River
Henderson	East Gnangara #13	Swan River
Mt Brown	Pine Forest L,M,N	Canning River
Stakehill System B/C	Roe Swamp	N. Dandalup River
Anstey (Stakehill J)	Piney Lakes	S. Dandalup River
Lake Clifton	Riverdale	Serpentine River
Martin Tank	Beermullah Flat	Murray River
Pollard	Beermullah Lake	Harvey River
Duck Pond	White Lake	Preston River
Bidaminna	Big Bootine	Collie River
North Lake	Little Bootine	Ellen Brook
Bibra Lake	Nambung	Jane Brook
Yangebup	Nambung Swamps	Chandala
Thompson	Coonabidgee	Guanarnup
Banganup	Bambun	Yalbanberup
		Goegrup

[1] Where a wetland system has been identified as significant, there may be portions of the system of high environmental value and other portions which have become degraded. Identification of specific significant areas was beyond the scope of this study.

TABLE 15 (Cont'd)

PLATEAU WETLANDS

Willows	Helena River #1	Canning River Headwaters
Red Gully	Jane Brook #1	Serpentine River Headwaters
Clewley	Swan River #1	Harris River
Mogumber	Serpentine River	Bingham River
Wannamal	Murray River #1	Collie River East
Walyunga	Ernest River #1	Nalyerin
Red Swamp	Augustus River #1	Yourdamung
Wooroloo Brook #1	Creeks crossing Scarp	Manaring Lake
Avon River	North Dandalup	Hotham River
Gidgegannup Brook #1	Harvey River	Brockman River
Goonaring	Wungong Area	Lake Needoonga
Belaring	Darkan Swamp	Lake Chittering
Black Swamp	Darkan River Headwaters	

Wetlands are listed in groupings that relate to consanguineous wetland suites. The listing is ordered by geomorphic unit, progressing from west to east. Within each unit, wetlands are ordered from north to south.

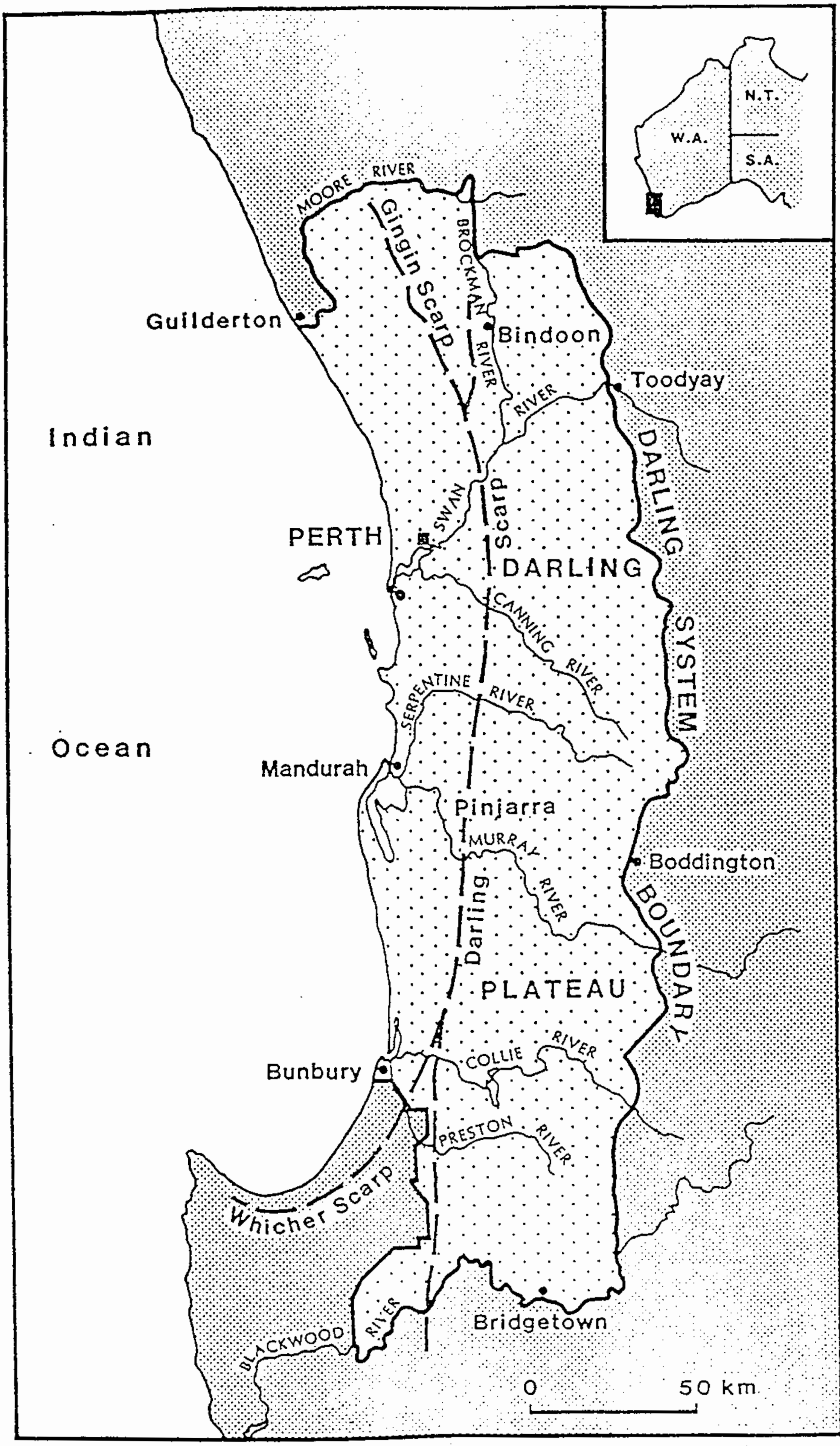


Figure 1: Location map (after C.A. Semeniuk, 1987b).

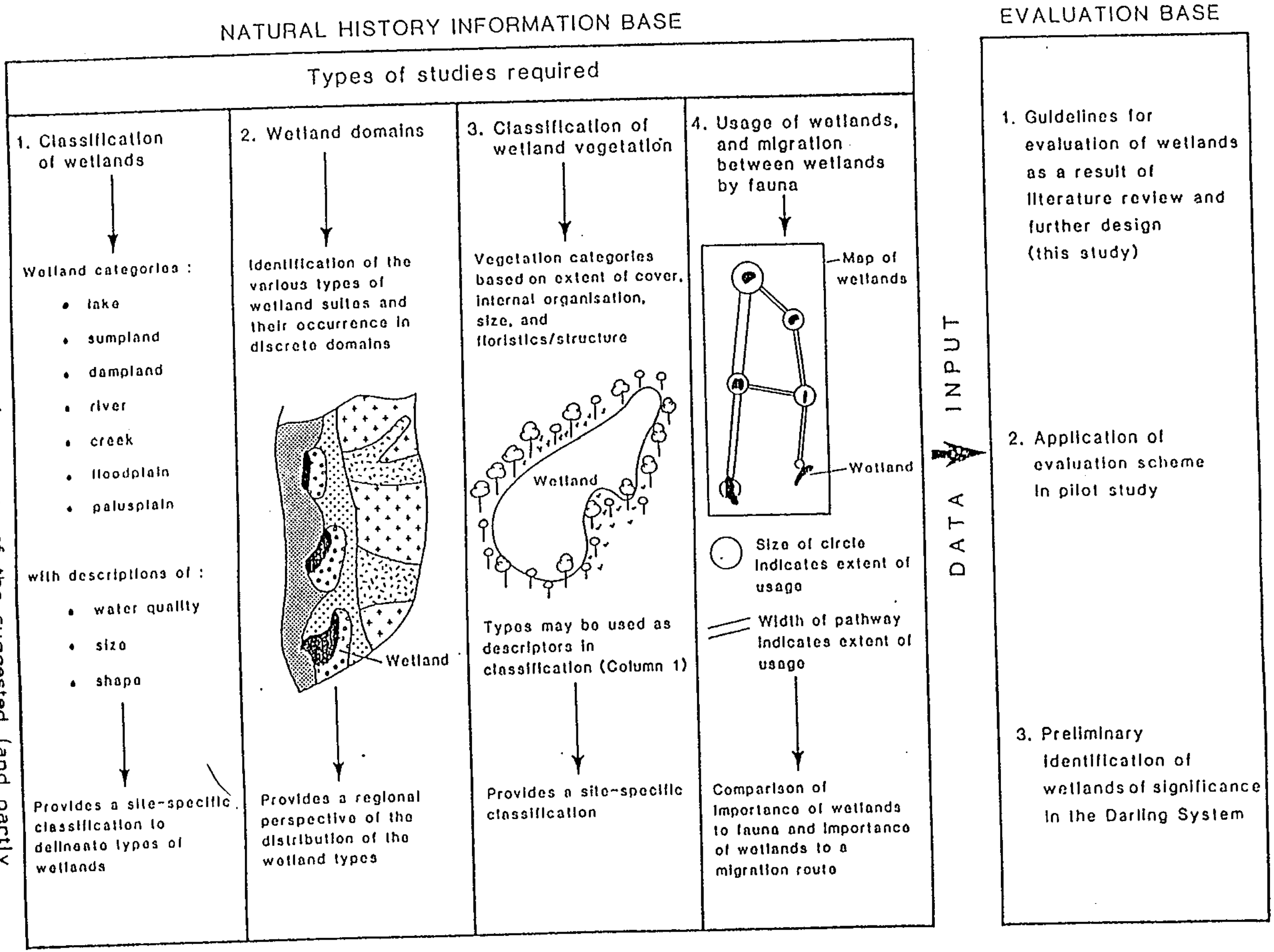


Figure 2: Conceptual summary of the suggested (and partly implemented) components of this study.

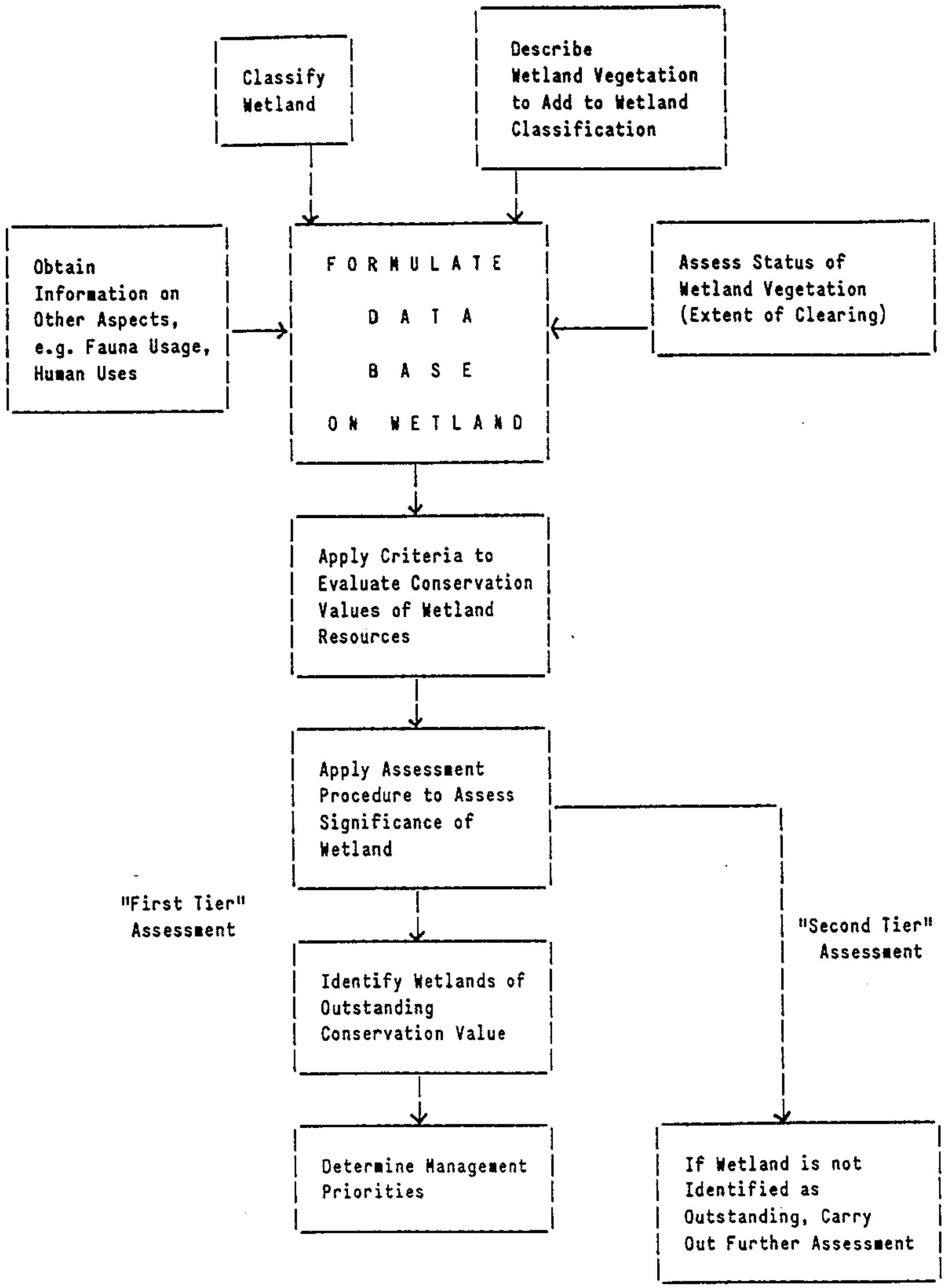
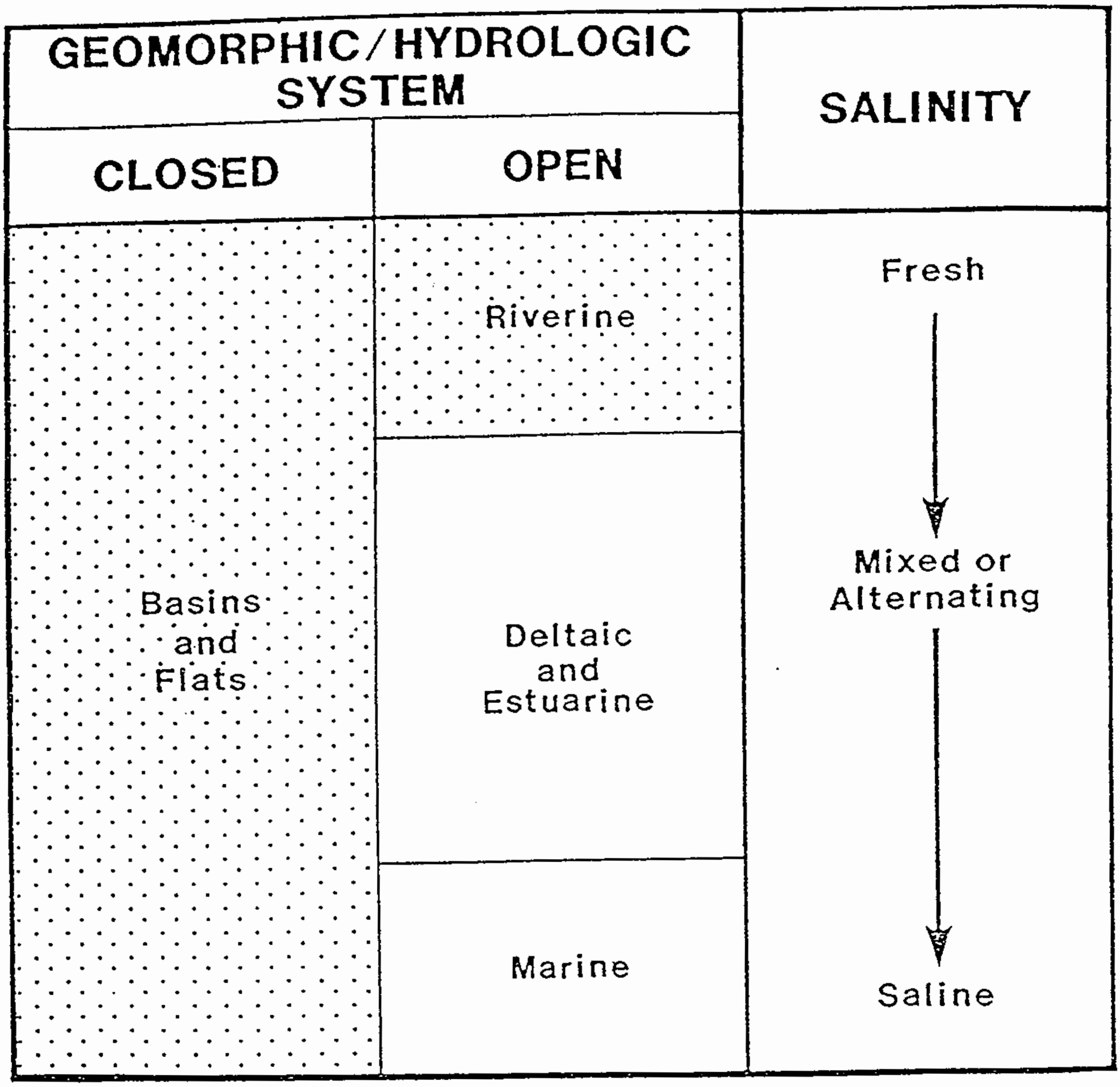


Figure 3: Conceptual summary of the approach to wetland evaluation.

BROAD CATEGORIES OF WETLAND SYSTEMS



Stippled area marks the categories of land-based wetlands that are the subject of this paper

Figure 4:
(after C.A. Semeniuk, 1987b)

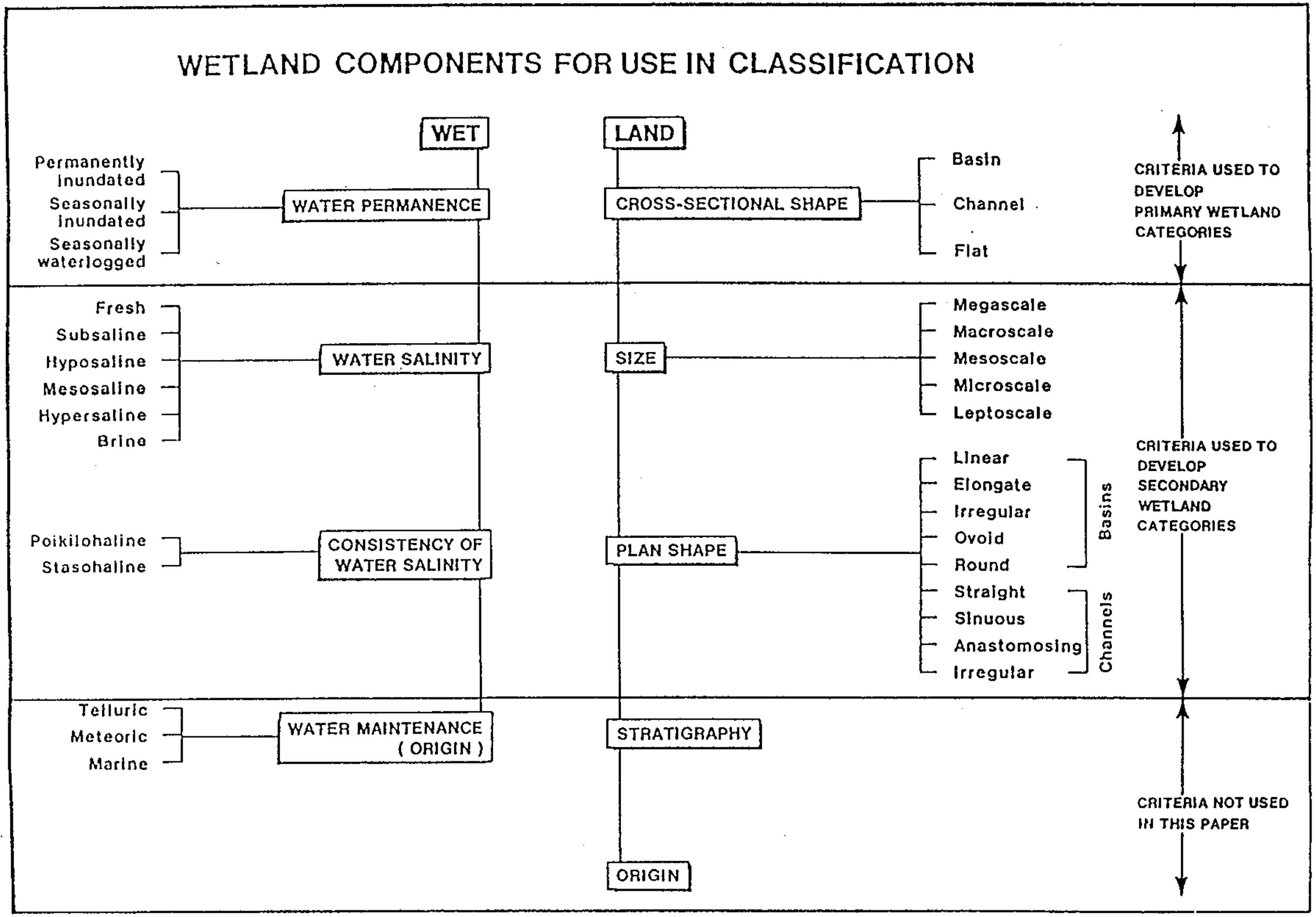


Figure 5:
(after C.A. Semeniuk, 1987b).

PLAN GEOMETRY OF WETLANDS

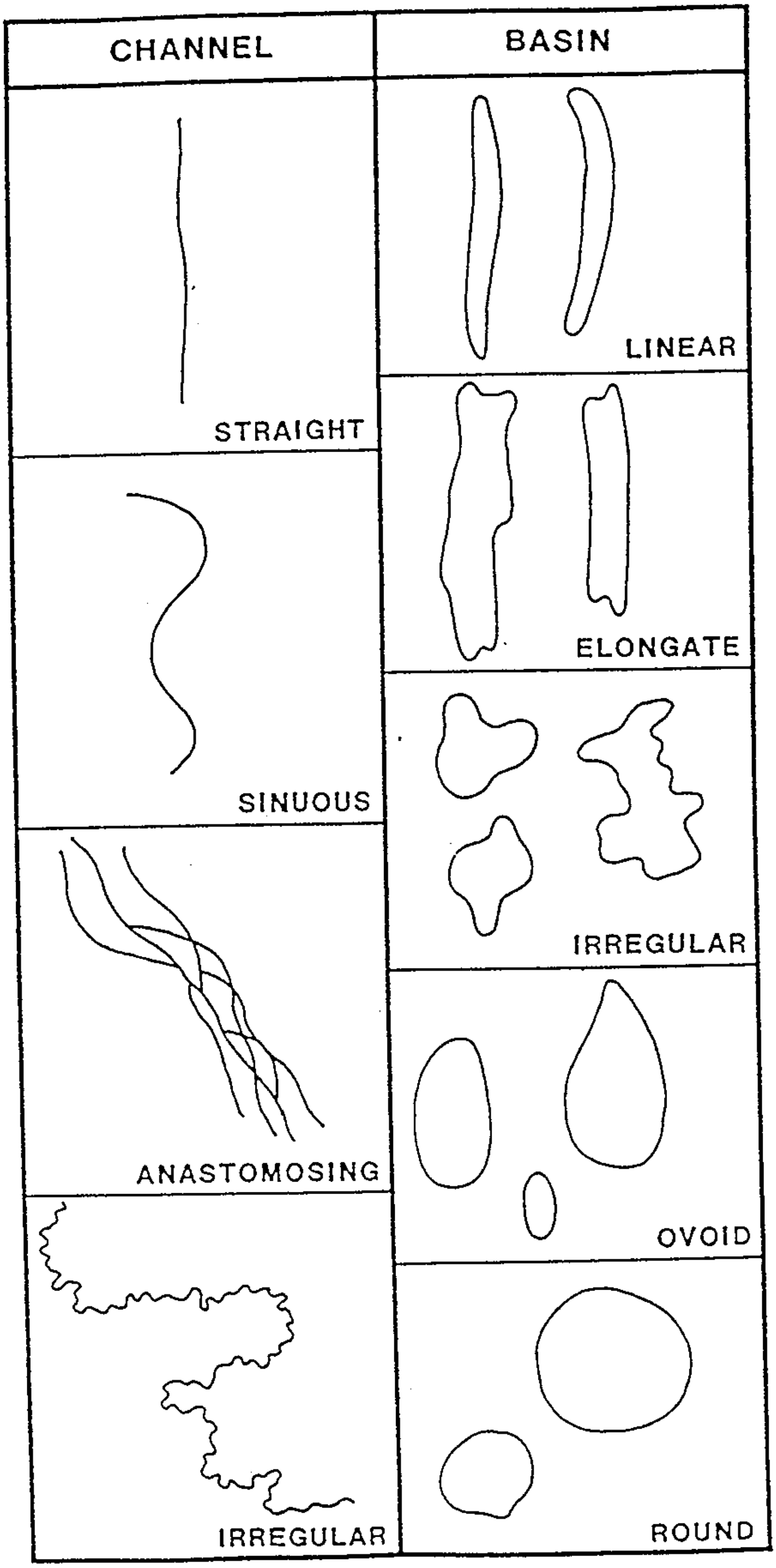


Figure 6:
(after C.A. Semeniuk, 1987b).

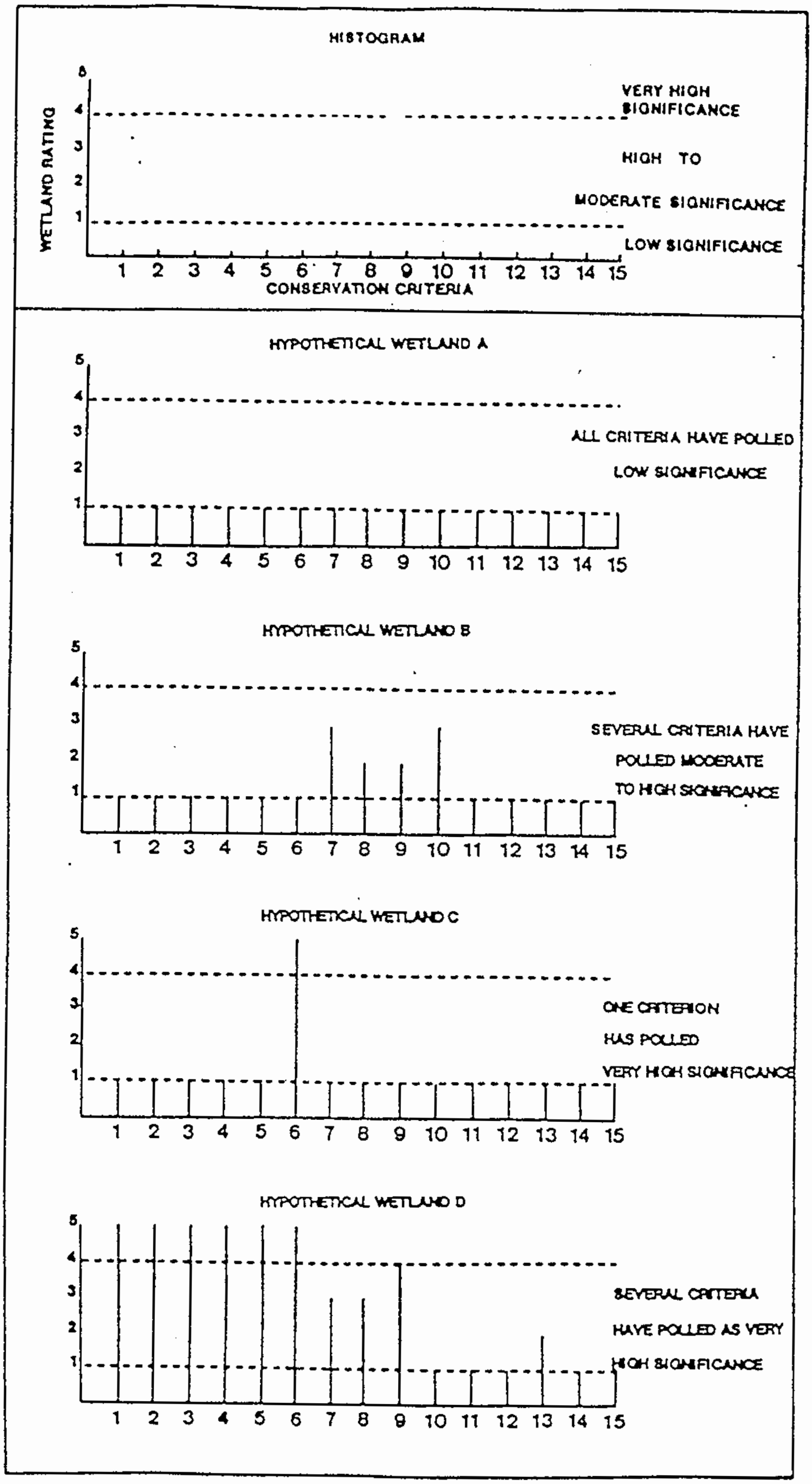


Figure 7: Histograms illustrating techniques for assessing the conservation value of wetlands utilising 15 criteria, each scored on a scale of -5 (after LSC, 1985).

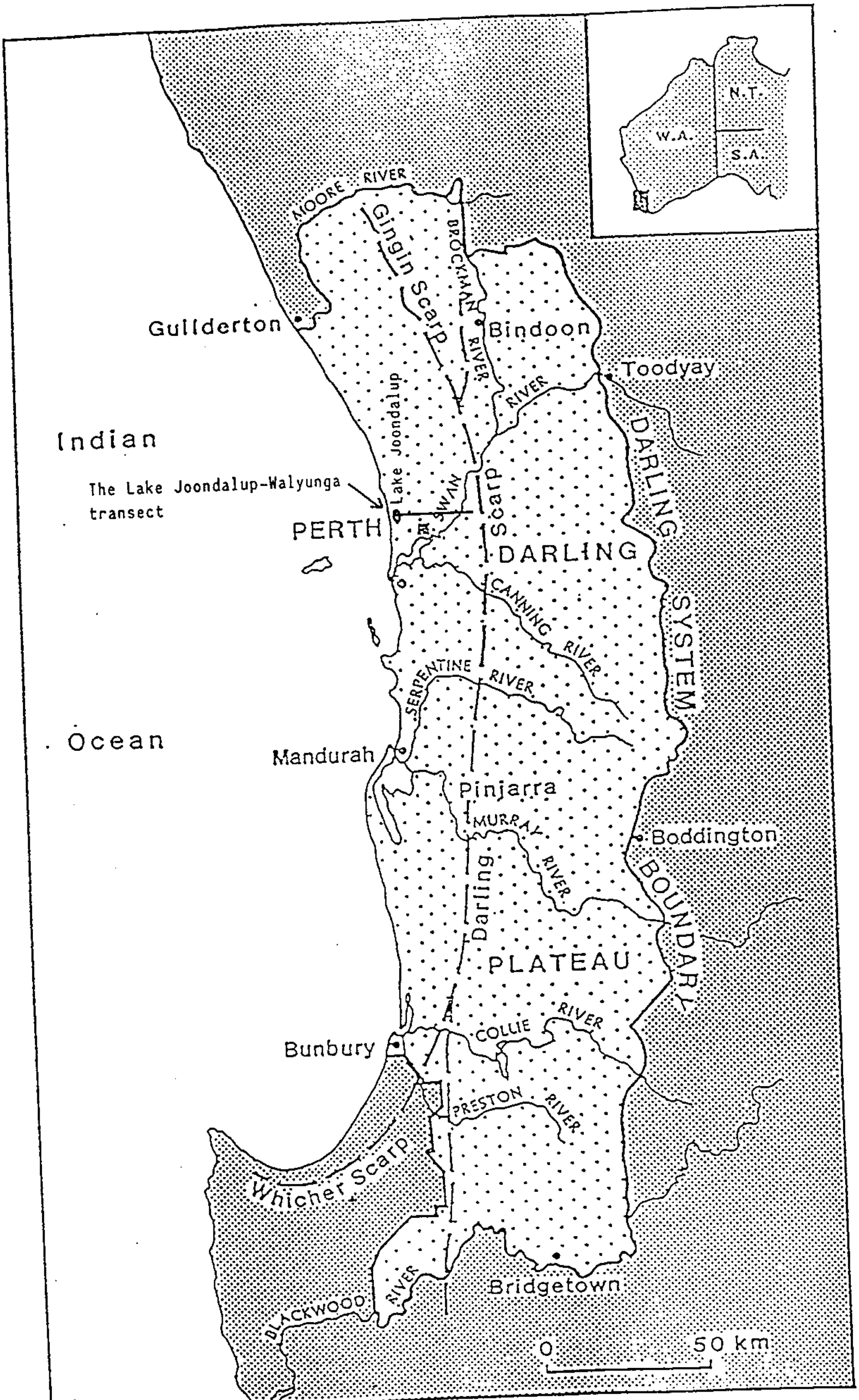


Figure 8: Location of the Lake Joondalup to Walyunga wetland transect.

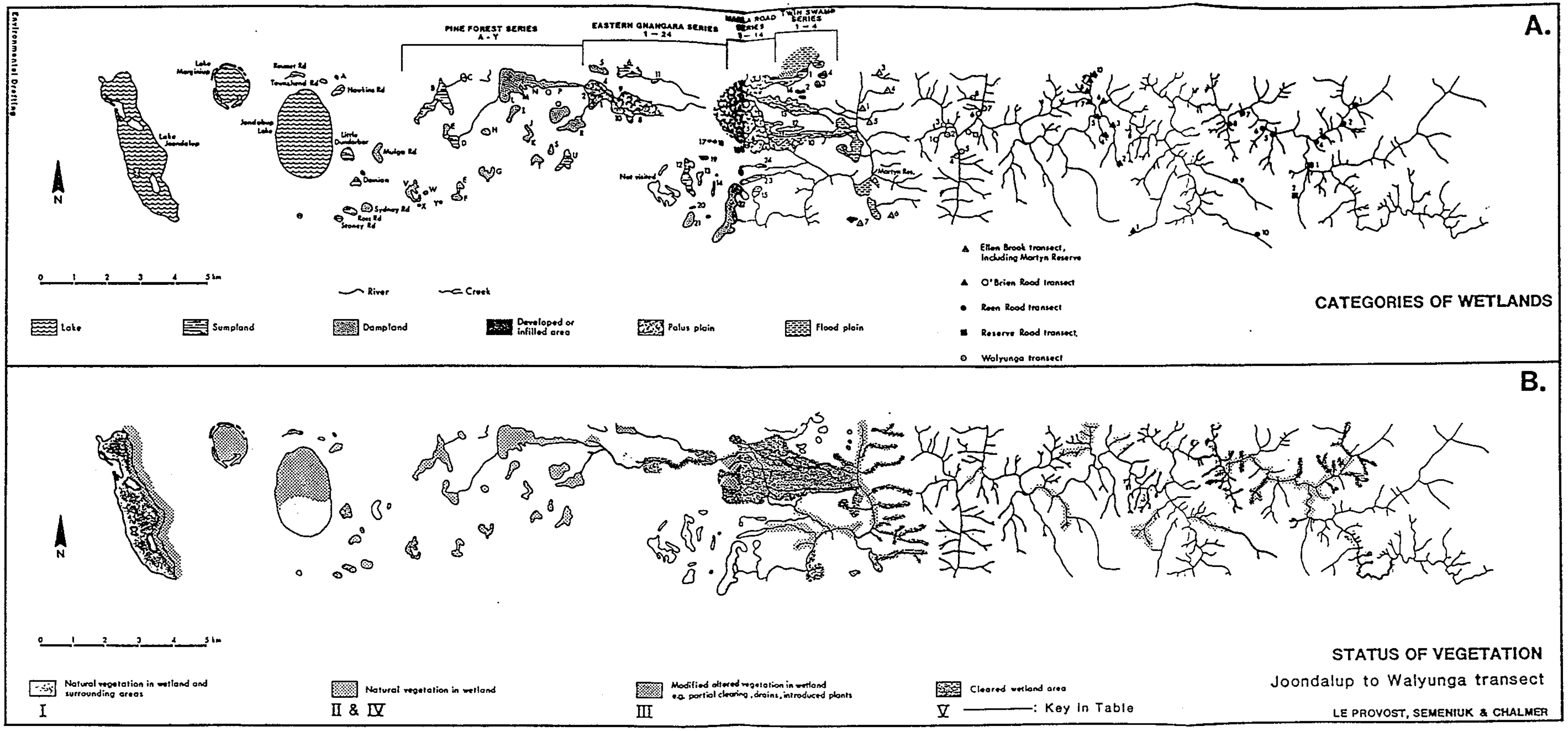


Figure 9: Lake Joondalup to Walyunga wetland transect:

A. categories of wetlands;
B. status of vegetation.

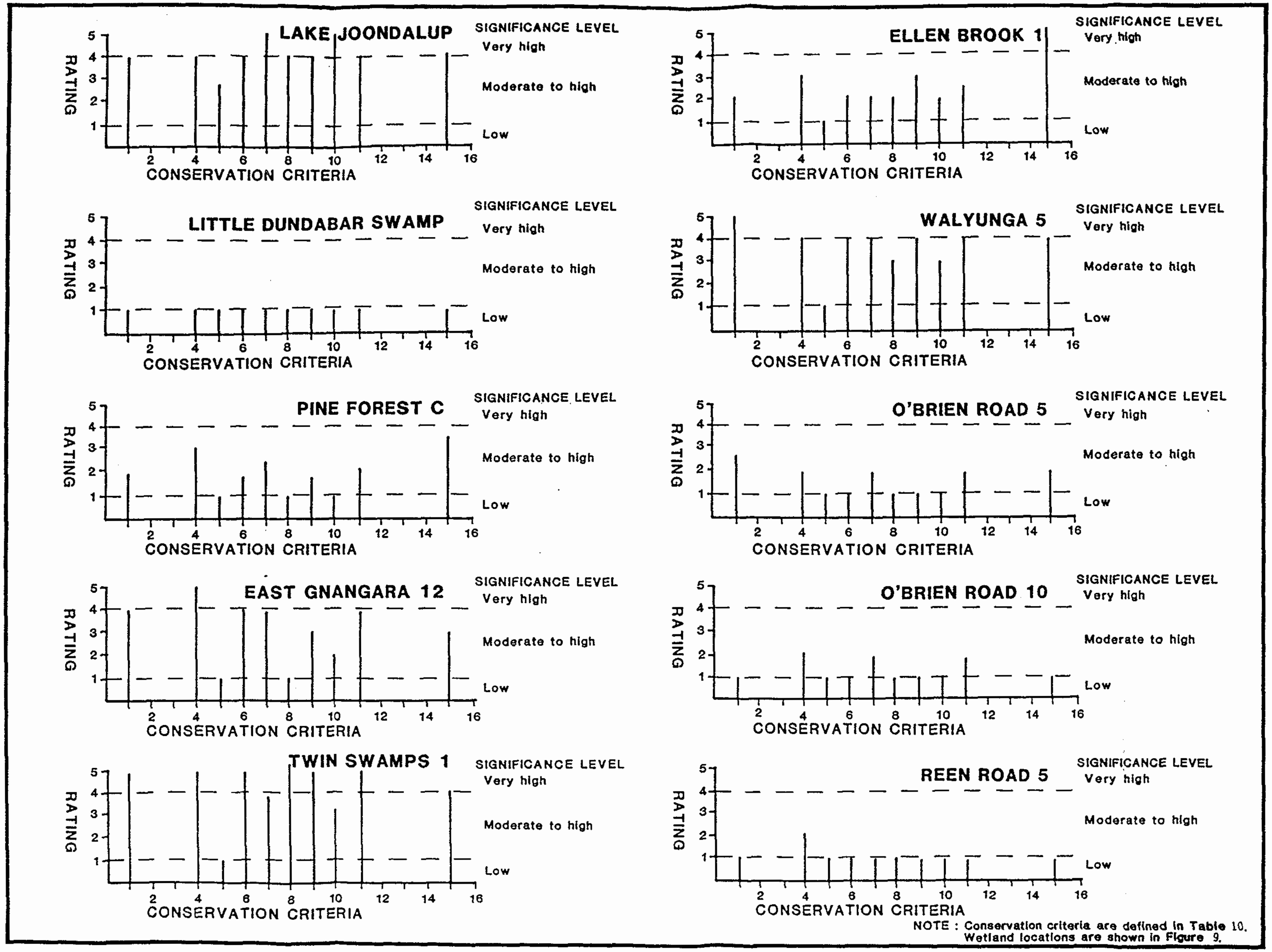


Figure 10 A: Histograms illustrating the technique for "first-tier" assessment of the conservation value of selected wetlands in the Lake Joondalup-Walyunga transect.

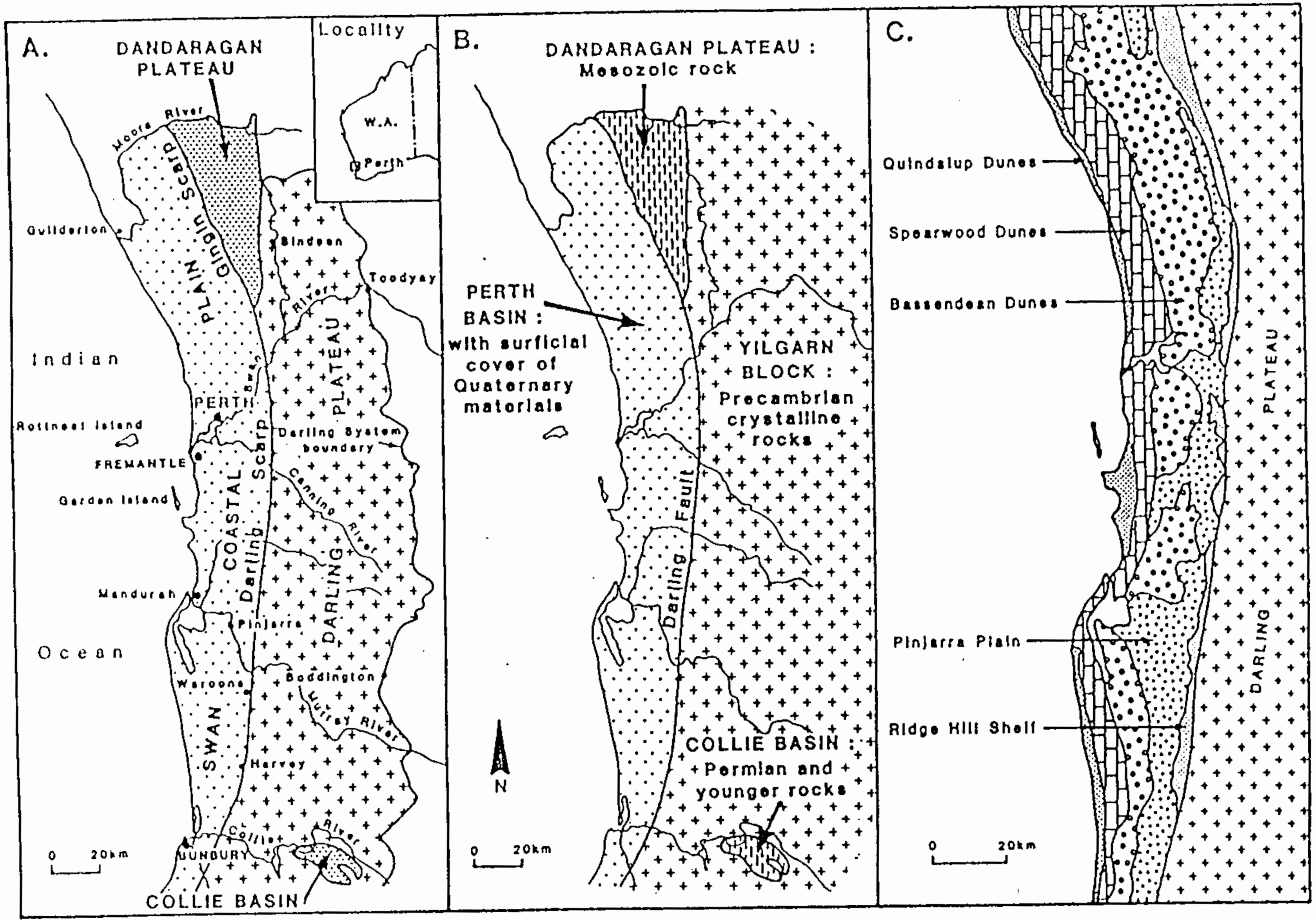
- **Lake Joondalup** and **Twin Swamps 1** scored highly (4 or 5) on almost all criteria, and are clearly of outstanding conservation value. Similarly, **East Gnangara 12** and **Walyunga 5** scored highly on several criteria and are assessed as having significant importance for conservation.

- **Ellen Brook 1** scored on the low to moderate scale (1 to 3) for most criteria, but scored highly (5) on criterion 15 as part of a linked natural system. This wetland would therefore be assessed as significant on the basis of this criterion alone, as its destruction or alternate use could reduce the conservation value of the wetland system for a number of purposes including fauna migration.

- The wetlands designated as **Pine Forest C**, **O'Brien Road 5**, **O'Brien Road 10** and **Reen Road 5** scored in the low to moderate range (1 to 3) on all criteria. While not of outstanding conservation value, these wetlands have some value at the local, parochial or regional level for some purposes and these values must be considered in making future decisions on their development or management. For example, *O'Brien Road 5 scored 2/3 on criterion 1*, as it was assessed as an undisturbed, regionally significant example of a wetland type which is restricted in distribution.

- **Little Dundarbar Swamp**, a disturbed, degraded wetland, scored 1 on all criteria, and would therefore be assessed as currently having low conservation value. Such wetlands may still have local significance and could be considered for rehabilitation if there is a local need, for example for recreational areas.

Figure 10 B: Notes on interpretation of histograms.



A: **Geomorphic units**
(after Churchward & McArthur, 1980)

B: **Geology**
(after Biggs _et_ _al_., 1980)

C: **Geomorphic elements**
(after McArthur & Bettenay, 1960)

Figure 11: Regional setting.

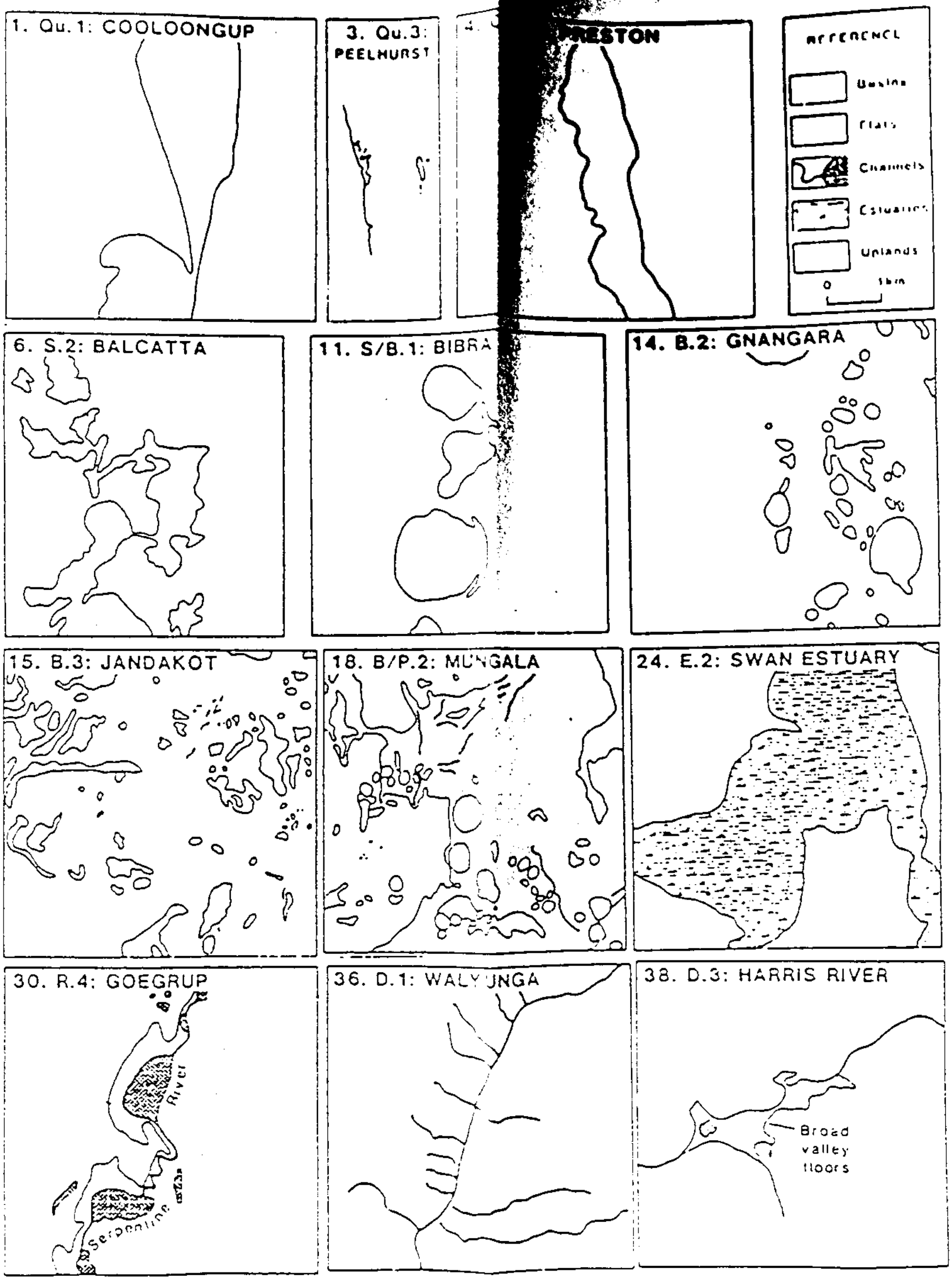
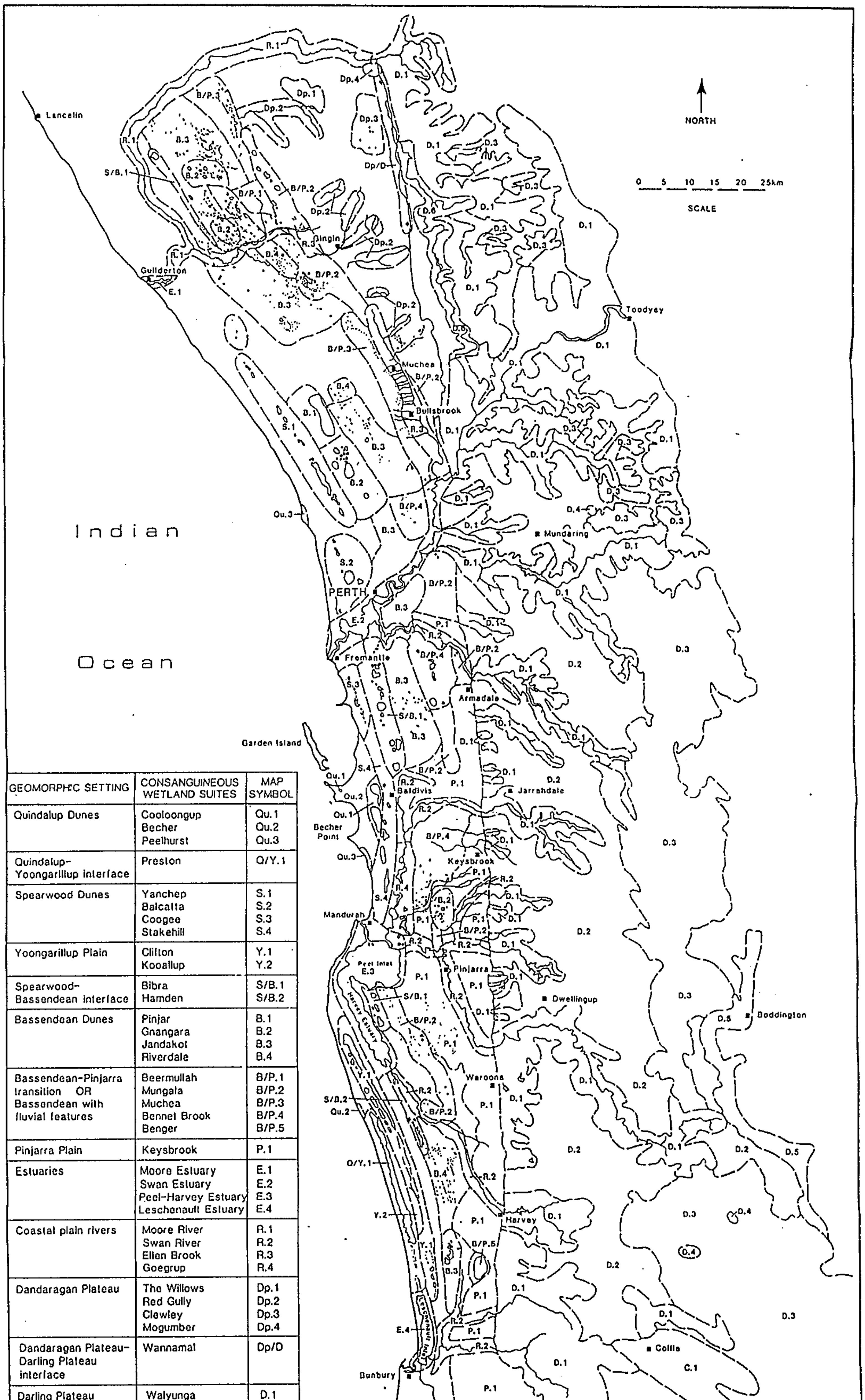


Figure 12: Selected examples of some consanguineous studies of wetlands (after C.A. Semeniuk, 1987a).



GEOMORPHIC SETTING	CONSANGUINEOUS WETLAND SUITES	MAP SYMBOL
Quindalup Dunes	Cooloongup Becher Peelhurst	Qu.1 Qu.2 Qu.3
Quindalup-Yoongarillup interface	Preston	Q/Y.1
Spearwood Dunes	Yanchep Balcatta Coogee Stakehill	S.1 S.2 S.3 S.4
Yoongarillup Plain	Clifton Kooallup	Y.1 Y.2
Spearwood-Bassendean interface	Bibra Hamden	S/B.1 S/B.2
Bassendean Dunes	Pinjar Gnangara Jandakot Riverdale	B.1 B.2 B.3 B.4
Bassendean-Pinjarra transition OR Bassendean with fluvial features	Beermullah Mungala Muchea Bennet Brook Benger	B/P.1 B/P.2 B/P.3 B/P.4 B/P.5
Pinjarra Plain	Keysbrook	P.1
Estuaries	Moore Estuary Swan Estuary Peel-Harvey Estuary Leschenault Estuary	E.1 E.2 E.3 E.4
Coastal plain rivers	Moore River Swan River Ellen Brook Goegrup	R.1 R.2 R.3 R.4
Dandaragan Plateau	The Willows Red Gully Clowley Mogumber	Dp.1 Dp.2 Dp.3 Dp.4
Dandaragan Plateau-Darling Plateau interface	Wannamal	Dp/D
Darling Plateau	Walyunga Little Dardanup Harris River Nalyerin Hotham Brockman	D.1 D.2 D.3 D.4 D.5 D.6
Collie Basin	Scholts	C.1

Figure 13: Distribution of the consanguineous wetland suites in domains throughout the Darling System (after C.A. Semeniuk, 1987a).

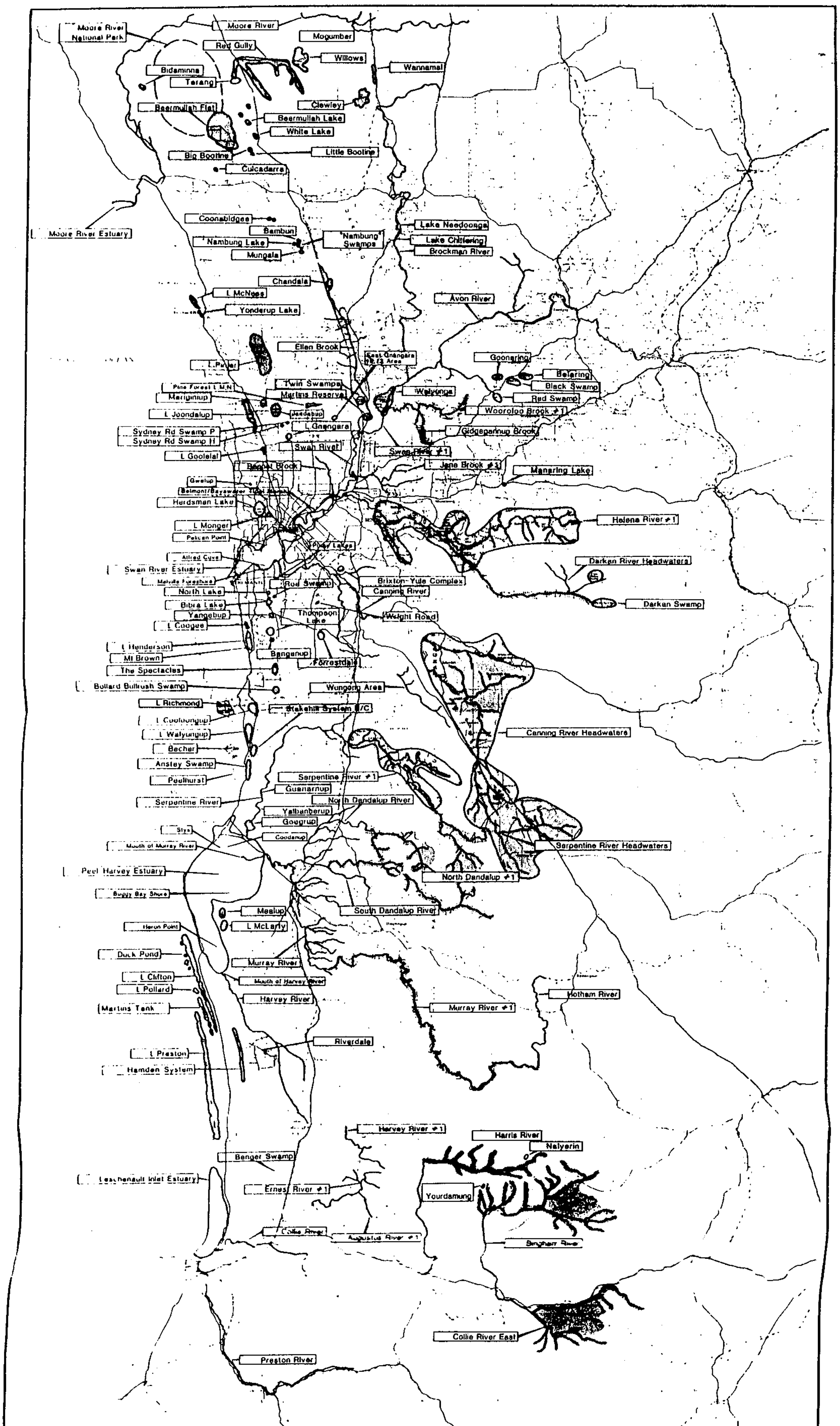


Figure 14: Location of selected significant wetlands in the Darling System.