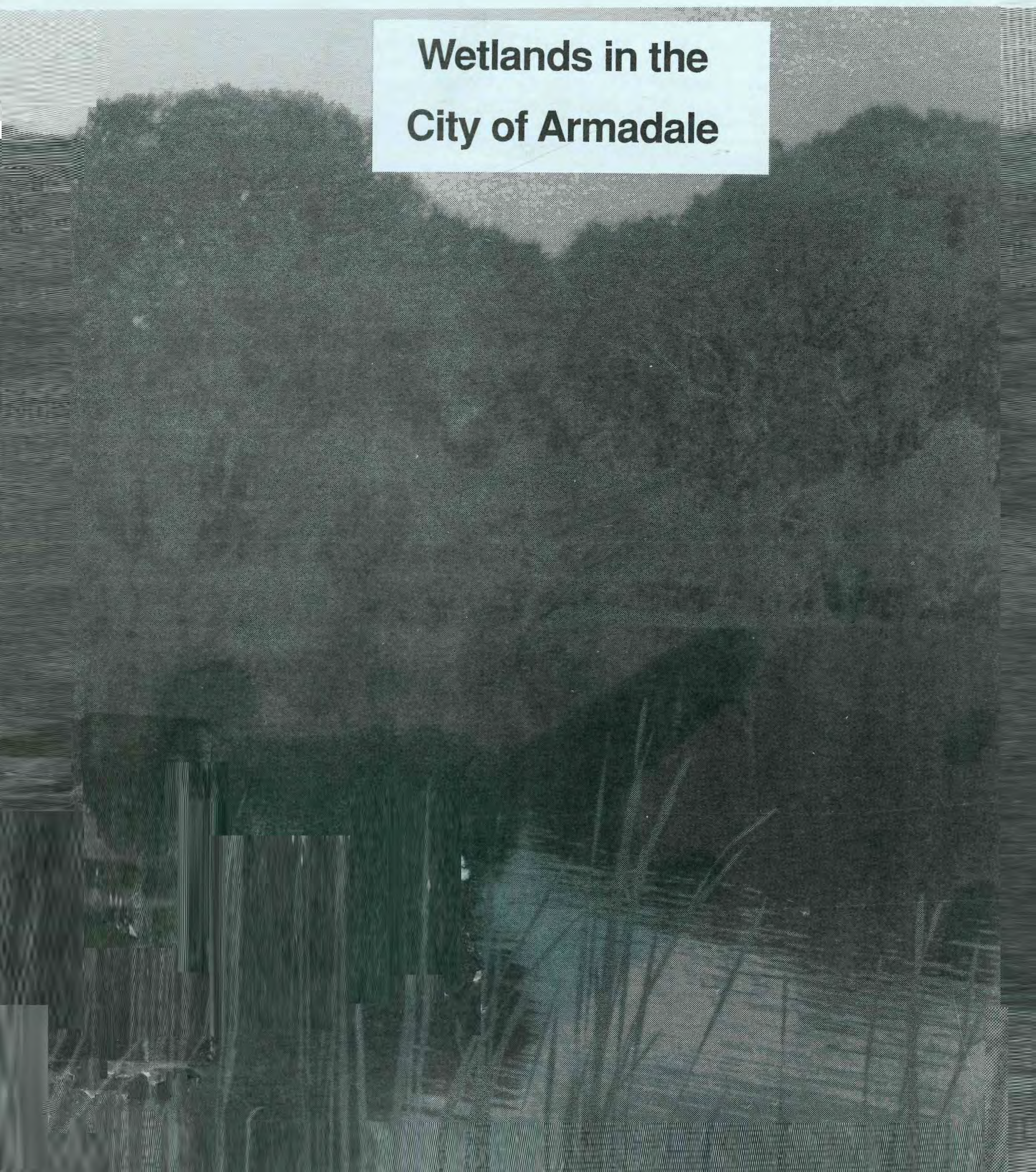




Water Authority
of Western Australia

**Wetlands in the
City of Armadale**





**Water Authority
of Western Australia**

Wetlands in the City of Armadale

Joan Payne

(edited by Andrew Del Marco)

A report to the
Water Authority of Western Australia
and the
Environmental Protection Authority

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This report has been published by the Water Authority to assist in disseminating information on the region's wetland resource to encourage better water resources management. The report provides information from two regional wetland projects which include the City of Armadale.

The first project, to identify, map and classify the wetlands of the Perth to Bunbury Region, was conducted by the V & C Semeniuk Research Group for the Water Authority of Western Australia between 1989 and 1993.

The second project, wetland evaluation was conducted by Joan Payne and Jan Rodda as consultants nominated by the Conservation Council of Western Australia. This project was co-funded by the Water Authority of Western Australia and the Environmental Protection Authority with the aims of:

- (i) Improving water resources management in the City and place the attributes of the City's wetlands in a regional context for regional water allocation studies and sub-regional water resource management plans;
- (ii) Support wetland conservation by fostering the use of EPA Bulletin 374 by interested members of the community as part of the State Conservation Strategy.

This work complements other local authority wetland evaluation work carried out by Murdoch University from 1988 to 1992.

Waterbird observations used in the evaluations were gathered by David James and bandicoot information was made available by Glen Collis and Tony Friend of CALM.

This wetland mapping and evaluation work has been facilitated by Alan Hill of the Water Resources Planning Branch of the Water Authority of Western Australia. "Wetlands of the City of Armadale" was written by Joan Payne and edited by Andrew Del Marco.

As a consultants report, the views expressed in this report are not necessarily those of the Water Authority.

Other reports in this Series

- Wetlands in the City of Gosnells
- Wetlands in the City of Rockingham
- Wetlands in the Shire of Kalamunda
- Wetlands in Belmont, Bayswater and Bassendean
- Draft Management proposals have also been produced for wetlands in the following local authorities by Murdoch University in conjunction with the Water Authority: Shire of Gingin (1989), City of Wanneroo (1990), Shire of Chittering (1990), City of Mandurah (1992), Shire of Murray (1992), Shire of Serpentine-Jarrahdale (1992), City of Canning (1992), City of Melville (1992) and City of Cockburn (1992).

Related Publications

- Wetland and Natural Resource Folio
- Perth: A City of Wetlands Broadsheet
- Wetland Evaluation broadsheet

Cover Photograph: Piara Reserve, looking west from Nicholson Road ("Piara" is the Aboriginal word for "place of the *Banksia attenuata*"). Photo by Alan Hill, 1991.

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EXECUTIVE SUMMARY

The wetlands of the City of Armadale have been mapped, classified and evaluated to provide a clearer picture of the City's wetlands and their management and conservation needs. This has shown the City's wetlands to be an extensive resource dominated by seasonally inundated and waterlogged areas which are often hydrologically and physically connected. Many of the City's wetlands fulfil regional roles such as the formation of natural wildlife corridors, the support of remnant vegetation and rare species and the enhancement of the region's amenity.

Wetlands were mapped and classified according to the geomorphic wetland classification system of C.A. Semeniuk which recognises all natural wetland types within the City including those subject to seasonal waterlogging. The City's wetlands have been mapped and classified as one of seven basic types: damplands, sumplands, lakes, palusplains, floodplains, creeks and rivers. Geomorphic wetland mapping covers all of the City west of Old Albany Road and is shown on Map 1.

There is a clear distinction between the wetlands of the Coastal Plain and those of the Darling Plateau. While more than 60% of the Swan Coastal and Pinjarra Plains within the City are covered by basin and flat wetland types the Darling Plateau is deeply incised and supports few basin or flat wetlands but a number of creeks and rivers.

The wetlands of the Coastal and Pinjarra Plains, with the exception of Forrestdale Lake, are seasonally waterlogged or inundated. Damplands (seasonally waterlogged basins) and sumplands (seasonally inundated basins) are largely restricted to the north and west of Forrestdale Lake while palusplain (seasonally waterlogged flat) covers the Pinjarra Plain to the east of the Lake and much of the Southern River catchment. The seasonally waterlogged wetland types - damplands and palusplain - make up 85% of the City's wetland resource.

Damplands are the most poorly understood and least protected of the City's wetlands. They are connected both hydrologically and physically with sumplands and link up to form diverse, productive habitats for waterbirds and other native fauna. The City's damplands are especially important for their floristic diversity and rarity and provide habitat for the Rare and Endangered Southern Brown Bandicoot. All but one of the known Rare and Endangered species supported by the City's wetlands were found to occur on damplands or palusplains.

Evaluation of the City's wetlands on the Swan Coastal and Pinjarra Plains using EPA Bulletin 374 has identified high natural attribute wetlands by assigning them preliminary management categories of High Conservation and Conservation. High natural attribute wetlands support substantial areas of remnant vegetation, and in the case of High Conservation wetlands, rare species of flora and fauna. Management categories for all of the City's evaluated wetlands are shown on Map 2.

"High Conservation" wetlands require active, protective management to maintain their high level of naturalness. Wetlands assigned to this management category include the Anstey/Keane dampland, Green's Swamp and the palusplain on Reserve 27165 east of Forrestdale Lake. "Conservation" management category wetlands include the Gibbs Road Sumpland, Balannup "Lake" and the Forrest/Anstey Road Dampland 4(D)D which is important in linking Forrestdale Lake with the Anstey/Keane Road Dampland. The well-vegetated channel wetlands of the Darling Range also support a high number of natural attributes but were not evaluated due to the functional and geographical limitations of Bulletin 374.

Only one quarter of the Cities remaining damplands supported remnant vegetation and were assigned management categories of High Conservation or Conservation. Armadale's vegetated damplands and palusplains are of regional importance as most of Perth's other seasonally waterlogged wetlands have been cleared or severely degraded. Conservation of damplands and palusplains is important if the diversity of Perth's wetland types and species is to be maintained.

Wetland conservation and protection in the City of Armadale is partially achieved through System Six recommendations, the EPA Lakes Environmental Protection Policy and the proposed Jandakot Botanical Park. These measures protect, or propose to protect, each of the City's High Conservation wetlands except the Anstey/Keane Dampland, wetland 4(A)D. Conservation and management of this important wetland should receive the highest priority. Initial surveys have shown that it supports 293 plant species over 150 hectares making it more diverse than Kings Park or Bold Park.

"Conservation" wetlands, and in particular "Conservation" damplands are less well protected by the existing and proposed conservation mechanisms. Only the future Jandakot Botanical Park is planned to protect portions of dampland including the Gibbs/Taylor Road wetland (4(N)D) and a small part of the Anstey/Keane dampland. Priority should be given to the conservation of damplands 4(D)D and 4(J)D and the parts of other "Conservation" damplands outside of conservation and protection areas.

For the effective conservation of all wetland types the management of adjoining vegetation is of major importance. It is recommended that this be achieved through planning for a minimum buffer of 50 metres of upland vegetation to protect the wetland. Evaluation has shown that wetlands buffered by intact, native vegetation are more likely to be in a near-pristine condition, worthy of conservation and free from potential management problems.

Wetland mapping, classification and evaluation has shown that the City of Armadale has the potential to conserve a number of wetlands in a near-pristine condition. Hence, it is important that wetland issues such as conservation, buffers areas, rare species, wildlife corridors and management are integrated into the City's overall planning and operation. This should be facilitated by the management categories and objectives identified in this report which may be used to assist in directing current planning and management activities. More detailed work is required to consolidate these management categories and ensure that future planning and management decisions are based on the most up-to-date knowledge of these complex ecosystems.

1. INTRODUCTION

Like other parts of the Perth Metropolitan Area, the City of Armadale has witnessed the loss and degradation of much of its wetland area. The once vast wetland systems of the City have been significantly reduced by agriculture and urbanisation, leaving the remaining fragments under enormous pressure. However, significant wetlands remain, a number of which are in a pristine or near-pristine condition.

1.1 The Importance Of Wetlands

Wetlands provide many ecological, practical and intrinsic services which no other part of the environment can support. Australia's wetlands have been recognised as wet "islands" in a dry continent which play a major role in sustaining the south west region's diverse flora and fauna. Seddon (1972) in a "Sense of Place", described Perth's wetlands as:

"areas of high biological productivity which directly or indirectly support most of the wildlife of the Swan Coastal Plain."

This can be supported by the many other ecological and hydrological functions carried out by wetlands which include :

- (i) support of complex food chains,
- (ii) provision of essential habitat for native plants and animals, many of which are rare and endangered,
- (iii) provision of habitat for birds, particularly migratory waterbirds which have regional and international significance, some of which are protected under international treaties,
- (iv) retention of run-off waters, water quality improvement and groundwater and stream recharge, and
- (v) use as environmental indicators (eg. monitoring groundwater levels and quality, impacts of climate change).

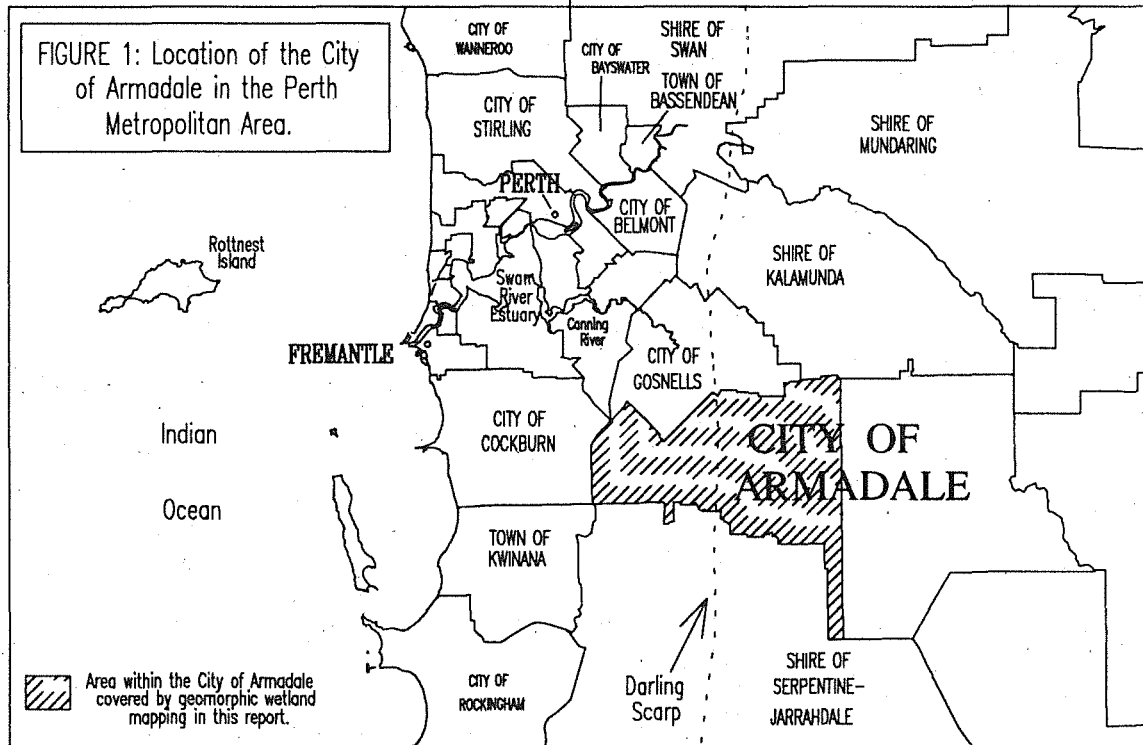
(CALM, 1992) (EPA, 1992)

Wetlands are also valued by the community for their environmental, aesthetic, recreational, cultural and agricultural values. They provide a welcome relief from the monotony of urban sprawl and are used passively for bushwalking and exercising. Many wetlands are also of significance to the Aboriginal community.

These and other values make wetlands an important part of Armadale's environment.

1.2 The City of Armadale

The City of Armadale is located approximately 25 km to the south-east of Perth city and includes parts of the Swan Coastal Plain, Pinjarra Plain and Darling Scarp (See Figure 1). It provides both urban and semi-rural environments as part of the Perth Metropolitan Area. Most urban development within the City, including the Armadale townsite, is confined to Metropolitan Area's south-east corridor at the foot of the Darling Scarp.



However, with increasing pressure for further urbanisation of the Perth Metropolitan Area, land on the Coastal Plain currently zoned rural may face changes in zonings and land use. Development to date has already changed the functioning capabilities of some wetlands, and drastically altered or destroyed others. However, relatively little is known of the wetlands that have been lost and those that remain.

1.3 About This Booklet

This booklet provides an overview of the wetlands of the City of Armadale. Those wetlands remaining have been mapped, classified and evaluated using methods discussed herein.

Section Two presents the results of mapping and classifying the City's wetlands with a discussion of the types of wetlands found within the City. Section Three addresses the evaluation of the wetlands using EPA Bulletin 374. The Bulletin is an advisory document which provides a guide to wetland management by identifying management categories and objectives. Only those basin and flat wetlands on the Swan Coastal Plain have been evaluated due to the functional and geographical limitations of Bulletin 374.

Implications of the wetland mapping, classification and evaluation work is the subject of Section Four. Wetlands of special value for conservation, educational and/or recreational purposes are also described in this section.

An extended bibliography is included for detailed information on particular wetland issues and areas. The City of Armadale may also have more detailed information on certain wetlands within the City.

2. THE WETLANDS OF THE CITY OF ARMADALE

2.1 Defining Wetlands

The term "wetland" encompasses a wide range of wet environments and not just those referred to as lakes and swamps. Wetlands have been generally accepted to be:

"areas of permanent, seasonal or intermittent inundation, whether natural or otherwise; fresh, brackish or saline; static or flowing. Typically wetlands include lakes, swamps, marshes and dams, estuaries, rivers, streams, and springs and intertidal sand flats, mud plains and mangroves." (EPA, 1990)

Wetlands therefore include areas of land which are seasonally waterlogged and where surface water may or may not be present. These waterlogged areas include damplands and palusplains which are of ecological importance in supporting flora and fauna habitats that differ from other wetland types.

This definition has been adopted by the Wetlands Advisory Committee (1977), and the V & C Semeniuk Research Group, on whose wetland mapping this booklet is based.

Wetlands may also be characterized by the occurrence of surface water, water-logged soils, vegetation typical of wet conditions (eg. paperbarks, reed beds) or hydric soils (soils that have formed in response to prevailing water inundation or waterlogging). (Hill, Semeniuk & Semeniuk, 1993, in prep.)

2.2 Mapping and Classifying Wetlands

Using this definition, the City's wetlands have been classified and mapped in greater detail than previously available. Classification places the wetlands into groups according to one or more of the wetlands attributes such as water quality, water permanence or vegetation. Wetland classification is necessary if we are to be able to adequately represent all wetland types within the conservation estate. Many wetland classification systems have been developed worldwide but few are relevant to the diversity and types of wetlands found in the Perth to Bunbury region.

Wetland mapping occurs in conjunction with classification and ensures that the entire wetland can be recognised. Each wetland is mapped according to the above definition of wetlands to include areas of seasonal waterlogging, seasonal inundation and permanent inundation. Both mapping and classification are important steps towards better management of the City's wetland resource.

In the City of Armadale, wetlands have been mapped and classified according to the classification system of C. A. Semeniuk (1987a). This classification system categorises wetlands by the permanence of inundation or waterlogging and the shape of the landform

in which they have formed. It is these two factors which are responsible for the existence of any wetland.

Three categories of water permanence are recognised, they being:

- (i) permanent inundation)
- (i) seasonal inundation) WATER PERMANENCE
- (iii) seasonal waterlogging)

with three types of wetland shape:

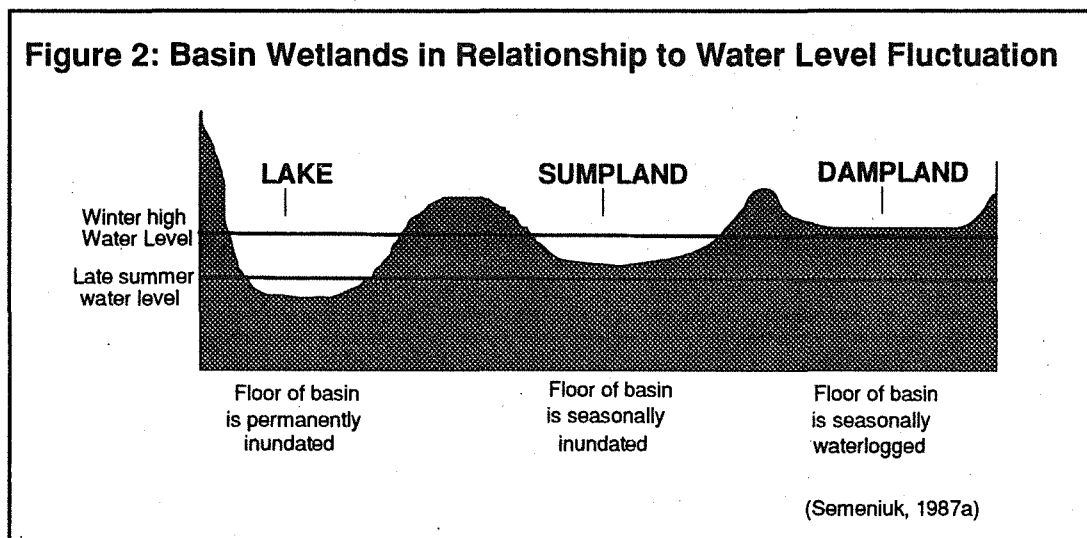
- (i) basins;)
- (ii) flats;) LANDFORM
- (iii) channels;)

In combination, these categories describe seven wetland types as is shown in the table below: lakes, sumplands, damplands, floodplains, palusplains, rivers and creeks.

TABLE 1: TERMINOLOGY USED IN THE SEMENIUK WETLAND CLASSIFICATION SYSTEM			
	BASIN	FLAT	CHANNEL
Permanently inundated	Lake	(Not common)	River
Seasonally inundated	Sumpland	Floodplain	Creek
Seasonally waterlogged	Dampland	Palusplain	(Not common)

eg. A seasonally waterlogged flat may be referred to as a palusplain

As an example, basin wetlands are shown below in relation to high and low water levels.



To apply this classification system and map wetlands, C.A. Semeniuk makes use of topographical maps, stereoscopic aerial photos, field visits and (1991) orthophotos. In this way all of the City's natural wetland areas can be identified, classified and mapped.

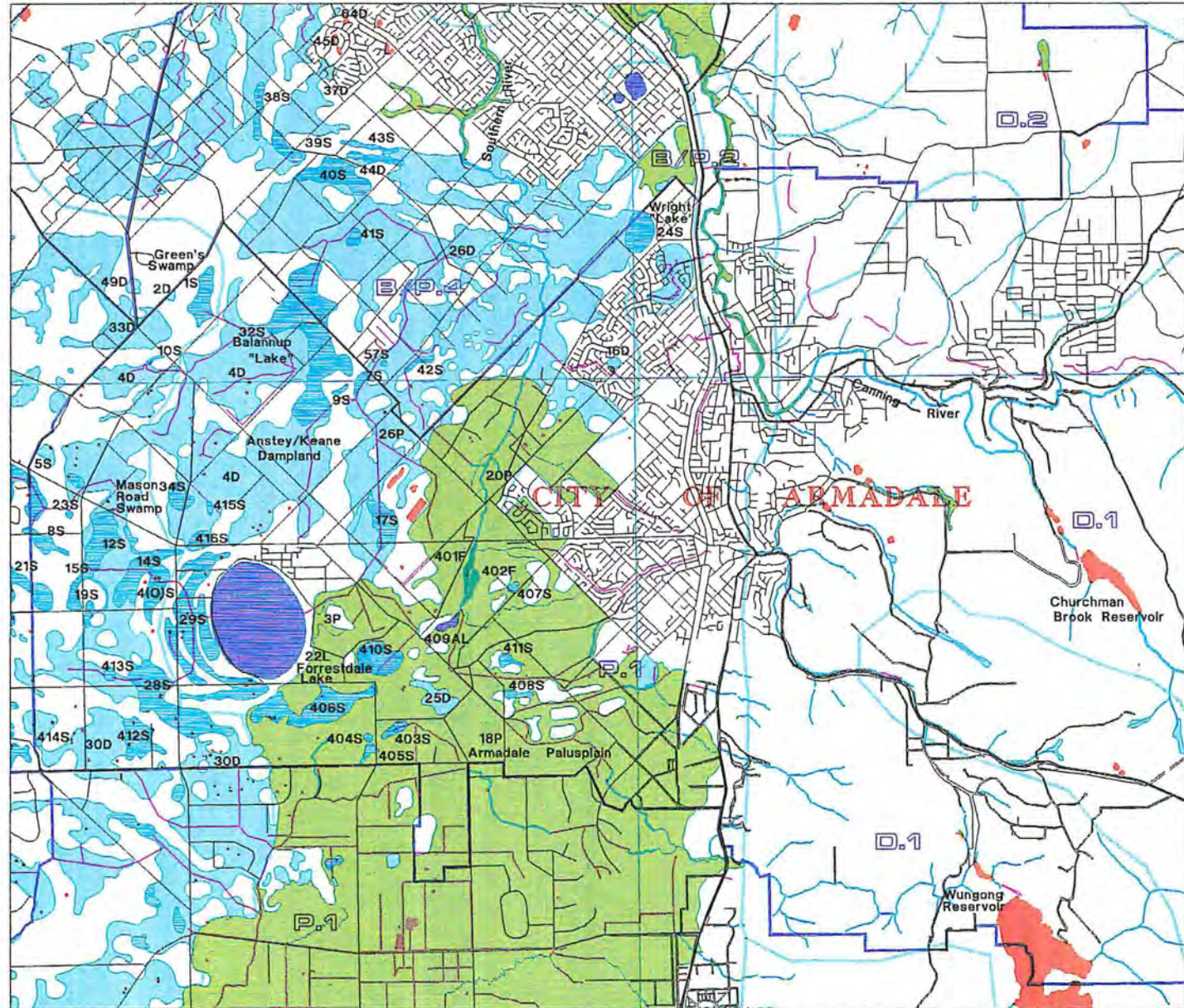
2.3 The Types of Wetlands in the City of Armadale

All seven wetland types defined by C.A. Semeniuk for the Perth to Bunbury Region can be found in the City of Armadale. This diversity of wetlands is matched only by their extent, especially across the Swan Coastal Plain. Of the area in the City covered by the wetland mapping, 20% is wetland.

Map 1 shows the extent and types of wetland coverage across the City as mapped by C.A. Semeniuk for the Water Authority of Western Australia¹. Areas covered by each wetland type are shown below in Table 2. Examples of each wetland type are included.

Wetland Type	Total Area (ha) (Basins/flats) Total Length (Channels)	% of Swan Coastal Plain part of Shire Covered by Wetland Type	Example codes are listed in Table 7
LAKE	222 ha	2.5%	Forrestdale Lake: 22L
SUMLAND	715 ha	8.5%	Green's Swamp: 1S, Balannup Lake: 32(C)(D)S
DAMPLAND	1617 ha	19%	Anstey/Keane Rds Dampland: 4(A)D
ARTIFICIAL BASINS	135 ha	1.5%	Churchman Brook Reservoir, farm dams, Minniwarra Park artificial lake
FLOODPLAIN	12 ha	<1%	Southern River floodplain: 401F
PALUSPLAIN	2429 ha	29.5%	Seasonally waterlogged pasture: 18(A)P
RIVER	36 km	-	Southern River, Canning River
CREEK	112 km	-	Wright Brook, Stony Brook
ARTIFICIAL CHANNEL (open)	78 km	-	Forrestdale Main Drain, Bailey's Branch Drain
ARTIFICIAL CHANNEL (piped)	Not Available	-	No named examples: Both open & closed artificial channels are responsible for the transport of nutrients, pollutants, plants and animals between other wetland types.
TOTAL	5130 ha	61%	

¹ Wetland mapping by C.A. Semeniuk covers that part of the City of Armadale on the Coastal Plain and parts of the Darling Scarp west of Churchman Brook and Old Albany Road. Area surrounding Canning Reservoir is not covered.



**CLASSIFICATION OF WETLANDS
ACCORDING TO
C.A. SEMENIUK (1987a).**

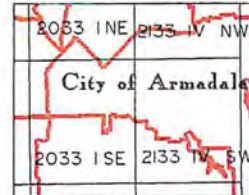
LEGEND

- | | | |
|--------------------|-------|--|
| BASINS | | |
| Lake | ----- | |
| Sumpland | ----- | |
| Dampland | ----- | |
| Artificial Basin | ----- | |
| FLATS | | |
| Floodplain | ----- | |
| Palusplain | ----- | |
| CHANNELS | | |
| River | ----- | |
| Creek | ----- | |
| Artificial channel | ----- | |
| Piped Drains | ----- | |



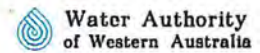
- | | |
|--|--|
| NATURAL WETLAND GROUPING
(Consonguineous Wetland Suite) | |
| SHIRE BOUNDARY | |
| MAJOR ROAD | |
| MINOR ROAD | |

Index to 1:25 000 map sheets covering shire for which Semeniuk wetland mapping exists.



BASIN and FLAT wetlands mapped by the V. & C. Semeniuk Research Group (1989-90); revised in 1992 using 1991 DOLA orthophotos and stereoscopic aerial photos.

CHANNEL wetlands reclassified from the ATSAS standard by application of C.A. Semeniuk's Wetland Classification System
ROAD capture provided by ESRIA AUSTRALIA.



WETLAND MAPPING SYSTEM

MAP 1: WETLANDS IN THE CITY OF ARMADALE

Wetland mapping confirms the extensive, interconnected nature of the City's wetlands on the Swan Coastal Plain. Apart from the ovoid Forrestdale and Wright Lakes, the City's wetlands are irregularly shaped, often abutting one another. Map 1 shows that a large part of the Coastal and Pinjarra Plains within the City is wetland (60%). In marked contrast the parts of the City in the Darling Plateau are dissected by numerous creeks and rivers but otherwise support few basin and flat wetlands. This demonstrates the importance of the landform component in determining where wetlands have formed.

2.3.1 The Damplands and Sumplands of the Swan Coastal Plain

Damplands and sumplands make up approximately half of the City's wetlands on the Swan Coastal Plain. They are located almost exclusively to the west and north of Forrestdale Lake and form a continuum with the wetlands of the southern part of the City of Gosnells.

Despite their abundance, damplands are the most poorly understood of the Perth to Bunbury Region's wetlands. As such, there has until recently been a lack of recognition of the importance of damplands as prime breeding sites for waterbirds and as areas of botanical richness. Damplands do not exhibit ponded surface water and in many instances in the past have not been recognised as wetlands. However, damplands do constitute wetlands. Standing in a dampland without shoes during its period of seasonal waterlogging clearly demonstrates its wetness. Damplands are also characterized by vegetation normally associated with wetlands such as heath and sedges.

The City's western and northern damplands are complemented by a number of sumplands which exhibit surface water for part of the year. These include Piara Reserve (Mason Road Sumpland), Balannup "Lake" and the arc-shaped wetland encircling the western half of Forrestdale Lake. The sumplands, together with damplands form a complex mosaic of wetland habitats.

2.4 Natural Wetland Groupings

Armadale's wetlands may be further described in terms of natural wetland groupings. Natural wetland groups reflect the origin, development, stratigraphy and hydrology of the wetlands such that wetlands within each group share a number of these features in common. Natural wetland groups have been identified and mapped by C.A.Semeniuk and are referred to as consanguineous suites (Del Marco, 1992). These natural groups have been mapped across the entire Perth to Bunbury Region and can be used to place Armadale's wetlands in a regional context (See Appendix E).

Six natural wetland groups cover the City of Armadale's wetlands: four groups describe coastal plain wetlands and two group Darling Plateau wetlands. Details of these groups are included in Table 3 with the boundaries of these groups shown on Maps 1 and 2.

Table 3: Natural Groups of Wetlands in the City of Armadale (After Semeluk, 1987b)					
General Wetland Area	Natural Wetland Grouping	Geomorphic Setting	Description of Wetlands	Stratigraphy	Origin of Wetlands
Western and North-western Sumplands and Damplands	JANDAKOT SUITE (B.3)	Bassendean Dunes: Low dunes and depressions	Microscale to mesoscale irregular damplands and sumplands	Peat or peaty sand or humic sand overlying quartz sand	Groundwater at or near surface in depressions to develop water table basins
Northern sumplands and damplands, Forrestdale Lake, Southern River and palusplain west of River.	BENNETT BROOK SUITE (B/P.4).	Bassendean Dunes.	Macroscale, irregular sump-lands and damp-lands microscale, meandering creeks. Macroscale, freshwater palusplains	Quartz sands or clay overlying quartz sand.	Depressions which intersect the water-table. Precipitation is ponded by clay lenses in the sub-surface.
Wright Lake	MUNGALA SUITE (B/P.2)*	Transition between Bassendean Dunes & Pinjarra Plain.	Mesoscale, round, freshwater poikilohaline lakes.	Variable: Clays to clay overlying quartz sand.	Alluvial fan distributaries terminate in Bassendean Dunes.
Palusplain to the east of Southern River including creeks & drainage channels	KEYSBROOK SUITE (P.1)	Alluvial fans & creeks of the Pinjarra Plain-gently undulating plain dissected by channels	Palusplains are macroscale freshwater. Creeks are leptoscale to microscale freshwater.	Clay overlying lateritic clay and sand	Sediment discharge to develop alluvial fans; ground-water seepage & surface runoff from the plateau; ponding of precipitation.
Darling Plateau creeks and rivers	WALYUNGA SUITE (D.1)	Steeply dissected valleys of laterite overlying Precambrian rocks	Meandering, leptoscale to microscale, freshwater creeks and rivers	Laterite or alluvium overlying Precambrian rocks	Fluvial incision, sedimentation, surface runoff channels
Darling Plateau creeks, rivers, floodplains and palusplains.	LITTLE DARDANUP SUITE (D.2)	Incised channels alternating with channels with narrow floodplains or headwaters.	Meandering, leptoscale to microscale, freshwater creeks and rivers. Microscale floodplains and palusplains.	Laterite detritus or quartz sand and gravel overlying Precambrian rocks.	Fluvial incision, surface runoff in steeply sloped areas and ponded precipitation in shallow depressions.

The concept of natural wetland groups may be used to explain differences and similarities between wetlands in a given area. For example, the hydrological response of the Gibbs Road Sumpland (B.3 Suite) may be expected to be different to that of Balannup Lake (Sumpland in B/P.4 Suite). While both wetlands are influenced by groundwater levels, wetlands of the B.3 suite respond directly to groundwater levels while B/P.4 suite wetlands are also characterized by ponding of precipitation by clay lenses in the sub-surface.

The concept of natural wetland groupings is therefore important in providing those involved in wetland research and management with a general overview of an area's wetlands before detailed studies or management practices are carried out.

3. EVALUATING THE CITY'S WETLANDS

Wetland evaluation (or assessment) identifies the values of a wetland so that they may be taken into account in future management. It builds on the information gathered from classifying and mapping the wetlands. Like wetland classification, evaluation requires a systematic approach.

3.1 Wetland Evaluation and Management Categories

The City of Armadale's wetlands were evaluated using the system of EPA Bulletin 374. This method, which takes the form of a questionnaire, was developed by the EPA over a four year period to assist in identifying objectives for which wetlands should be managed. It does this by placing wetlands into one of five preliminary management categories according to its evaluation. Appropriate management criteria for each wetland can then be directed by its management category. Table 4 describes these management categories and their objectives.

TABLE 4: WETLAND MANAGEMENT CATEGORIES AND OBJECTIVES (EPA BULLETIN 374)		
Wetland Management Cat.	General Description of Wetlands in Management Category	Management Objectives
HIGH CONSERVATION (H)	These wetlands possess a high degree of naturalness and there is a high level of interest in using the wetland for various human purposes. This category is recognised as having the highest priority for establishment and implementation as regional parks.	Active management to maintain and enhance the wetland's attributes, particularly natural attributes. Where there is no active management at present it should be put in place as a matter of highest priority. Active management requires that a detailed management plan is prepared and implemented, with significant resources to maintain or improve the wetland's current condition.
CONSERVATION (C)	These wetlands possess a high degree of naturalness.	Maintain and enhance natural attributes and functions.
CONSERVATION & RECREATION (O FOR OPEN SPACE)	These wetlands have been modified but are considered to play important roles in their urban and/or rural settings.	To provide for human uses whilst maintaining and enhancing the existing natural attributes.
RESOURCE ENHANCEMENT (R)	These wetlands have been modified and do not have clearly recognised human uses in their urban or rural settings.	To maintain and enhance the existing ecological functions.
MULTIPLE-USE (M)	Wetlands in this category are significantly degraded, with few natural attributes and limited human use interest. Despite having few natural attributes, some of these wetlands may provide valuable waterbird habitat.	Consider wetland in the context of catchment and land-use planning (esp. drainage, nutrient enrichment, surface and groundwater pollution).
NOTE: 1. Resource Enhancement and Multiple Use wetlands may still be a focus for controversy if uncontrolled developments impinge upon them. 2. No management category is of greater importance than another. All wetlands are of value regardless of the purpose for which they are managed.		

Like all evaluation systems, Bulletin 374 requires value judgements to be made through the selection of evaluation criteria and the scoring of those criteria. However, the Bulletin 374 questionnaire attempts to minimise this bias by asking questions that require quantitative answers (eg. what percentage of the wetland has been modified?). The EPA's method is also one of the few evaluation systems which are simple enough to be used by those with little wetlands expertise.

Another feature of Bulletin 374 is that it makes a distinction between a wetland's (i) natural attributes and (ii) human use attributes. This distinction can be used to assist in managing wetlands in ways which are compatible with their natural attributes. Human uses of wetlands can conflict with their natural values resulting in a reduction of the wetland's overall value to the community.

3.2 Application of Bulletin 374 in the City of Armadale

This section is a summary of the Bulletin 374 method and cannot be used in place of the EPA's report. Readers are encouraged to obtain a copy of Bulletin 374 before applying this evaluation method to any wetland. Note that the EPA's method is intended to be a 'broad-brush' evaluation of a wetland's values, and yields a preliminary management category. Use of the Bulletin does not prevent the need for subsequent more detailed investigations.

Bulletin 374 may only be applied to basin and flat wetlands on the Swan Coastal Plain between Moore River and Mandurah. Hence, channel wetlands and wetlands of the Darling Range in the City of Armadale, were not evaluated using this method. Other questionnaires or methods will need to be devised to assess these wetlands. Thorburn (1992) has developed a method to assess the channel wetlands of the Swan Coastal Plain and Darling Scarp.

The Bulletin 374 questionnaire consists of approximately twenty criteria on a wetland's:

- (i) natural attributes and
- (ii) human use attributes.

Only selected questions are answered if the wetland is a dampland or palusplain. The Bulletin refers to these wetlands as having "poorly defined" boundaries. Lakes, sumplands and floodplains are described as having "well-defined" boundaries. Questions are answered by reference to aerial photos, topographical maps and field visits and scored according to a standard scoring method (EPA, 1990). The scores for each question are then summed giving two total scores for each wetland: a naturalness value score and a human use score. These totals are used to place the wetland on a graph to determine its management category. One of two graphs is used, depending on whether the wetland has a "well-defined" or "poorly defined" boundary (See Appendix A).

Where wetlands do not clearly fall into a category a supplementary questionnaire is used to determine the most appropriate management category.

The Bulletin 374 Questionnaire and the Supplementary questionnaire are included in Appendices A and B respectively.

3.2.1 Adapting Bulletin 374 for use in the City of Armadale

Bulletin 374 was applied to the City's wetlands after they had been mapped and classified by C.A. Semeniuk (see Section 2). Difficulties were encountered in applying the questionnaire to the extensive and continuous dampland systems. This was due to large, individual wetlands having contrasting land uses, ownership and natural attributes. Evaluating these large wetlands as a whole would have devalued their ecological importance and produced inappropriate management categories.

Following direction from the Environmental Protection Authority and Water Authority, these wetlands were therefore divided into components, and the Bulletin 374 method applied to the components in turn. Component boundaries for many of the large sumplands, damplands, floodplains and palusplains were determined primarily on remnant vegetation. Where intact wetland vegetation and property boundaries approximated one another, property boundaries were used. Similarly, where wetlands extended into other shires, component boundaries were that of the shire.

3.2.2 Naming the City of Armadale's Wetlands

The City's wetlands were also provided with names as part of the evaluation process. This ensured that their existence was formally acknowledged and referenced. Where wetlands did not have an accepted name, they were described by the nearest street or intersection. In addition, all wetlands were given an identification code. Codes began with a unique number and ended with a letter representing the wetland type. For example, wetland 31D: WARTON/NICHOLSON RDS is a dampland situated near the intersection of Warton and Nicholson Roads. For wetlands which were divided into components (as discussed above), each component was given an extra letter in brackets to distinguish it from the other components. For example, wetland 34S (Mason Road Swamp) was divided for evaluation purposes into 34(A)S and 34(B)S by Nicholson Road.

3.2.3 Wetland Vegetation Assessment

In addition to Bulletin 374 evaluation of the City's wetlands, an assessment was made of the wetland's vegetation and the surrounding upland vegetation. Five categories of vegetation coverage (or status) were defined as shown in Table 5. The results of this vegetation assessment have been included in Table 7.

Vegetation Category	Wetland Vegetation	Surrounding Upland Vegetation
VV	V: natural vegetation present	V: natural vegetation present
VP	V: natural vegetation present	P: Partly modified or cleared
VC	V: natural vegetation present	C: totally cleared or modified
P_	P: Partly modified or partly cleared	Not described
C_	C: totally cleared or destroyed	Not described

(ADAPTED FROM LeProvost, Semeniuk & Chalmer, 1987)

Assessment of a wetland's vegetation and that of its surrounding upland vegetation provided a good indication of the conservation values of the wetland. Wetlands whose vegetation and buffer were intact were more likely to support a greater number of natural attributes than those wetlands whose vegetation had been cleared or modified. For example, areas of remnant vegetation often support diverse floral communities, rare species and native fauna. As shown above, the presence or absence of vegetation was a major factor in dividing a wetland before application of Bulletin 374.

The orthophoto aerial image showing a portion of the City of Armadale (Figure 3) provides an indication of the extent of remnant vegetation on the Swan Coastal Plain within the City. Notable wetland remnant vegetation features include the Gibbs Rd Sumpland (14S), Piara Reserve off Nicholson Road (34(A)S) and the heath vegetation of the Anstey/Keane Rd dampland. The internationally recognised Lake Forrestdale can be seen to have a relatively narrow buffer of upland remnant vegetation.

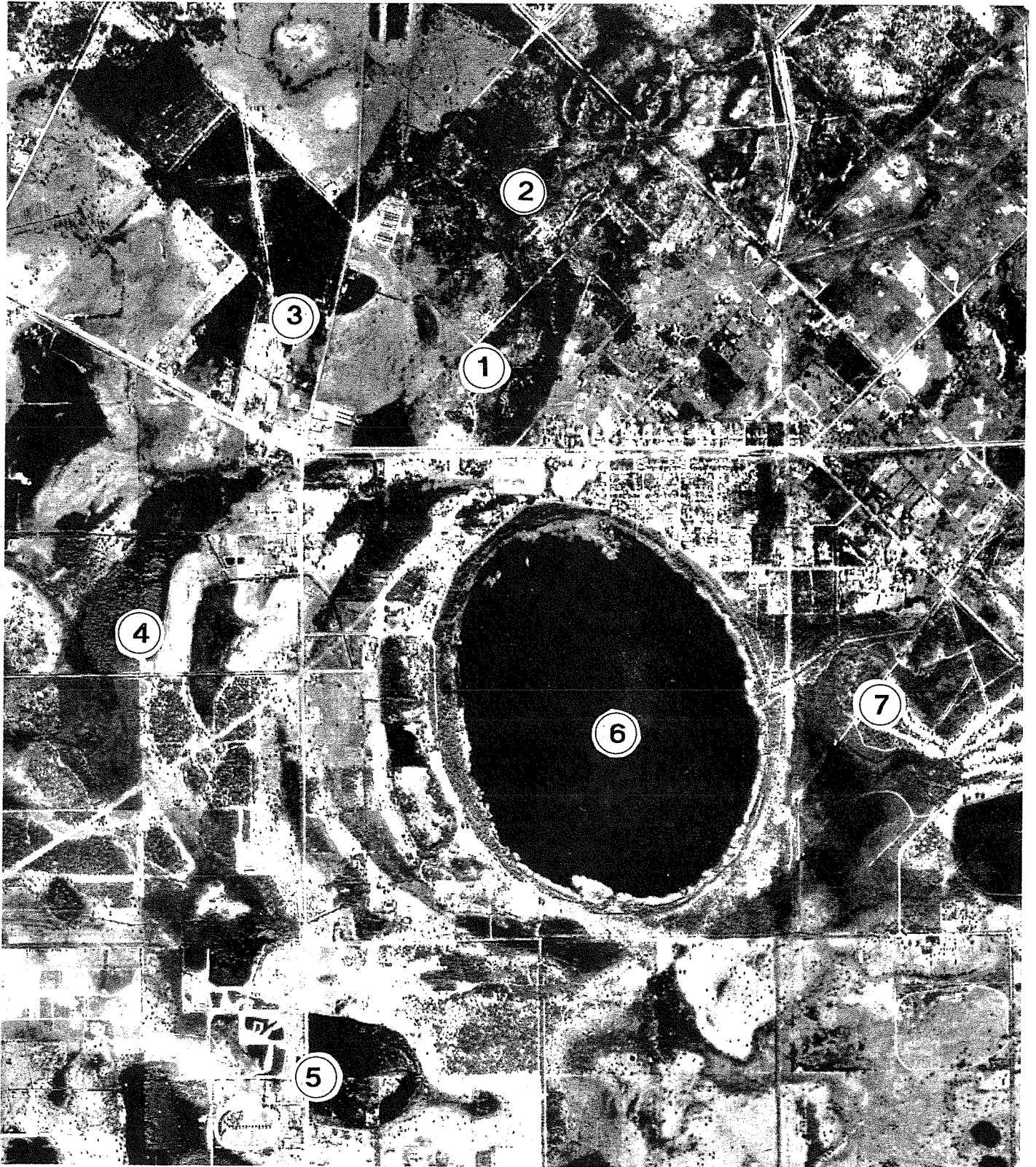
Similar photo images of the entire Swan Coastal Plain reveal that very little of the seasonally waterlogged and inundated areas of the region remain vegetated. In fact, the palusplain which extends north-south along the Coastal Plain between Gingin and Bunbury and makes up a large part of the City of Armadale (wetland 18(A)P) has been almost totally cleared. The protection of Armadale's dampland, sumpland and palusplain remnant vegetation is therefore of regional importance.

Key to Locations on Figure 3: Orthophoto Image of the Forrestdale area.

PHOTO	WETLAND AND NOTES
1	4(D)D: Forrest/Anstey Dampland, Man Cat: Conservation
2	4(A)D: Anstey/Keane Dampland, Man Cat: High Conservation, high biodiversity,
3	34(A)S: Piara Reserve (Mason Road Sumpland), Man Cat: Conservation; proposed for inclusion in Jandakot Botanical Park, partly covered by EPA Lakes EPP
4	14S: Gibbs Road Sumpland, Man Cat: Conservation; proposed for inclusion in Jandakot Botanical Park, partly covered by EPA Lakes EPP
5	28S: Nicholson Rd Sumpland, Man Cat: Resource Enhancement; partly covered by Lakes EPP.
6	22L: Forrestdale Lake, Man Cat: High Conservation; covered by EPA Lakes EPP
7	3P: Reserve 27165 Palusplain, Man Cat: High Conservation, rare species.

FIGURE 3: ORTHOPHOTO AERIAL IMAGE OF BALANNUP/SOUTHERN RIVER AREA

- Scale 1:25 000 ; Date of Photography: August, 1991
- See table above for key to location numbers)
- Areas of remnant vegetation and/or inundation are evident by the darker photo tones.



3.3 Management Categories for the City's Wetlands

Evaluation of the City's wetlands has shown that a number of wetlands have significant natural values. One fifth of the City's wetlands were evaluated as having either High Conservation (H), Conservation (C) or Open Space (O) preliminary management categories as shown in Table 6 and Map 2.

TABLE 6: SUMMARY OF MANAGEMENT CATEGORIES
FOR EACH OF THE CITY'S WETLAND TYPES

Wetland Type	H High Cons.		C Cons.		O Open Space		R Resource Enhncmt		M Multiple Use		Area Not Evaluated	TOTAL	
	No	Area (ha)	No	Area (ha)	No	Area (ha)	No	Area (ha)	No	Area (ha)	Area (ha)	No	Area (ha)
LAKE	1	222										1	222
SUMLAND	1	23	9	257	1	58	14	237	7	76	64	32	715
DAMPLAND	3	136	7	302			16	1024	3	65	90	29	1617
ARTIFICIAL LAKE											135		135
FLOODPLAIN											12	2	12
PALUSPLAIN	1	12			1	9			1	2190	218	3	2429
TOTAL	6	393	16	559	2	67	30	1261	11	2331	519	69	5130

(Those wetlands not evaluated are in the Darling Range)

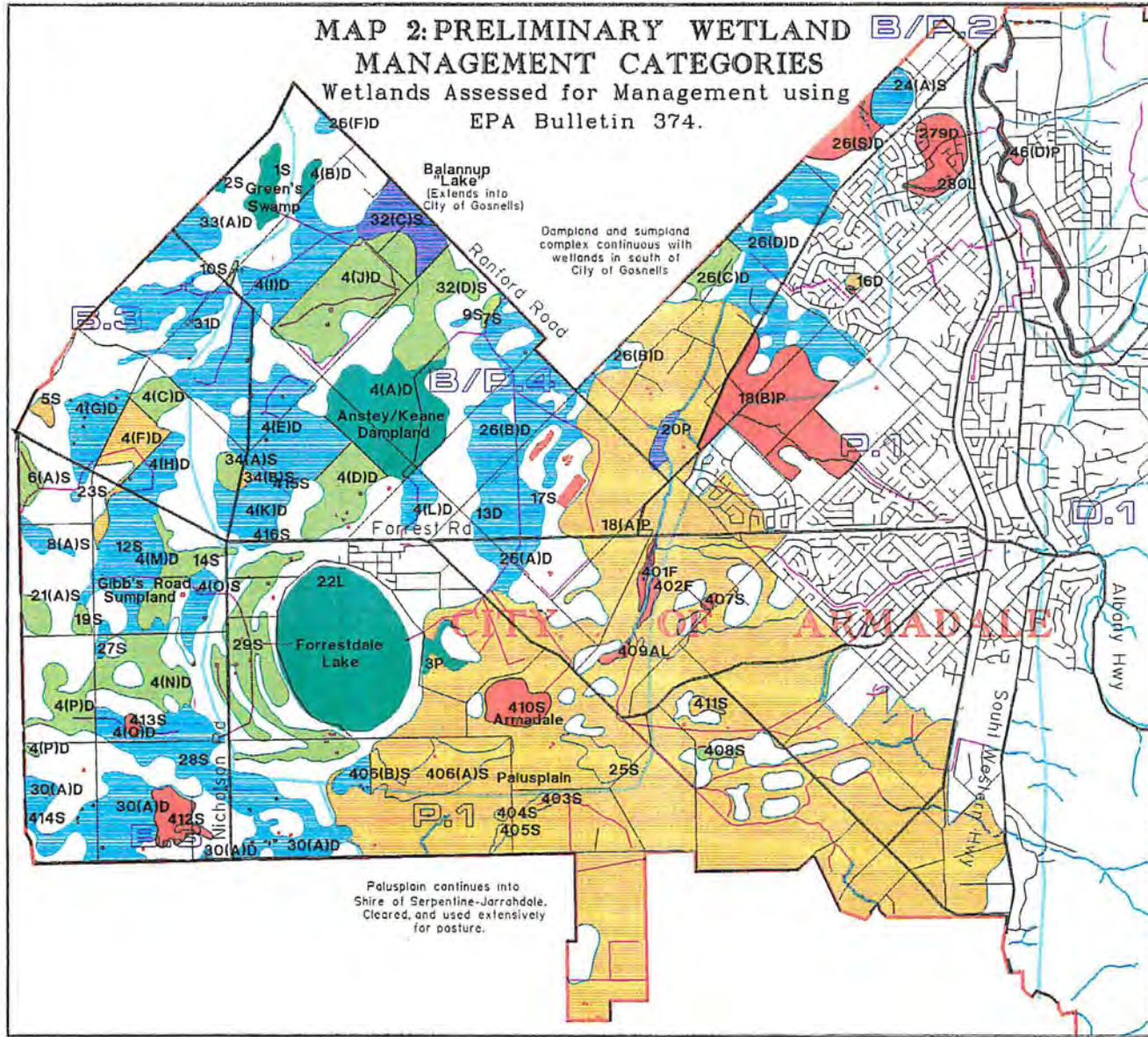
Individual wetland components are listed in numerical order in Table 7 with information on their type, management category, vegetation status, natural group and area. This information is also presented in Appendix C, where wetlands are grouped by type and sub-grouped by management category. Map 2 shows the location of these wetland components and the approximate boundaries between each component.

3.3.1 High Conservation Wetlands

Six High Conservation wetlands with a total area of 390 hectares have been evaluated within the City of Armadale. All supported significant stands of remnant vegetation. Three of these wetlands were located in the Green's Swamp area (wetlands 1S, 2D, 4(B)D), two were part of the Forrestdale Lake area (the Lake and palusplain 3P to the east) and another was located near the Anstey/Keane Roads junction (wetland 4(A)D). These wetlands covered the full spectrum of water regimes ranging from the seasonally waterlogged damplands of the Green's Swamp and Anstey/Keane areas to the permanently inundated Forrestdale Lake. Information on each of these High Conservation wetlands can be found in Section 4.2.

MAP 2: PRELIMINARY WETLAND MANAGEMENT CATEGORIES

Wetlands Assessed for Management using
EPA Bulletin 374.



KEY TO WETLAND MANAGEMENT CATEGORIES

H	High Conservation	
C	Conservation	
O	Open Space (Conservation & Recreation)	
R	Resource Enhancement	
M	Multiple-use	
NA	Not Evaluated	

MAJOR ROADS	
MINOR ROADS	
SHIRE BOUNDARY	
CONSANGUINEOUS WETLAND SUITE D.1	
WETLAND NUMBER (See Table 7)	

Sources of Information

BASIN WETLANDS (lakes, sumplands and damplands) and FLAT WETLANDS (floodplains and palusplains) mapped by VBC Semeniuk Research Group (1989-90) and revised using DOLA 1991 orthophotos and stereoscopic aerial photos for the Water Authority of Western Australia.


Wetlands assessed by Joan Payne and Jan Rodda for the Water Authority of Western Australia.

Road capture provided by ESRI Australia.

Notes

1. Wetland assessment carried out using 1989-90 Semeniuk wetland mapping. Assessments have been revised in accordance with the editing of wetland mapping and classification in 1991.
2. Assessment of High Conservation and Conservation wetland components has been based on the presence and condition of remnant vegetation.
3. Only those components of damplands within the City of Gosnells have been shown. See Map 1 for the extent of damplands adjacent to the City of Gosnells' boundary.
4. Sumplands which straddle the City's boundary are shown in their entirety.
5. Damplands and palusplains of the Darling Scarp were not assessed. Refer to Thorburn (1992) for a method to assess these and other wetlands.

Palusplain continues into
Shire of Serpentine-Jarrahdale.
Cleared, and used extensively
for pasture.

 **Water Authority
of Western Australia**
WETLAND MAPPING SYSTEM

**TABLE 7: WETLANDS IN THE CITY OF ARMADALE
(Listed by Wetland Number)**

KEY TO SYMBOLS USED IN TABLE 7		
WETLAND TYPE	MANAGEMENT CATEGORY	NATURAL GROUP
L=Lake S= Sumpland D = Dampland AL = Artificial Lake F= Floodplain P = Palusplain R = River	H = High Conservation C = Conservation O = Open Space R = Resource Enhancement M = Multiple Use NE = Wetland Not Assessed/Evaluated	B.3: JANDAKOT SUITE (Bassendean Dunes) B/P.2: MUNGALA SUITE (Bassendean Dunes/Pinjarra Plain Transition) B/P.4 BENNETT BROOK SUITE(Bassendean Dunes/Pinjarra Plain Transition) P.1: KEYSBROOK SUITE(Pinjarra Plain) D.1: WALYUNGA SUITE (Darling Plateau) D.2: LITTLE DARDANUP SUITE (Darling Plateau)

WETLAND NAME/CODE	WET. TYPE	MAN CAT	VEG STAT.	NATURAL GROUP	WETLAND AREA (ha)
1S GREEN'S SWAMP	S	H	VV	B.3	22.8
2D WARTON/RANFORD/NICHOLSON	D	H	VV	B.3	1.4
3P RES 27165 FORRESTDAL	P	H	VV	B/P.4	11.8
4(A)D ANSTEY/KEANE JUNCTION	D	H	VV	B/P.4	128.9
4(B)D WRIGHT/RANFORD/WARTON	D	H	VV	B/P.4	5.8
4(C)D WRIGHT/MASON RDS	D	C	VP	B.3	19.0
4(D)D FORREST/ANSTEY RDS	D	C	VP	B/P.4	53.3
4(E)D ANSTEY RD	D	R	P-	B/P.4	100.3
4(F)D WRIGHT/FORREST RDS	D	M	C-	B.3	41.5
4(G)D FORREST/WRIGHT RDS	D	R	P-	B.3	43.9
4(H)D WRIGHT/MASON/FORREST D	D	R	C-	B.3	26.3
4(I)D NICHOLSON/WRIGHT RD	D	R	C-	B/P.4	142.1
4(J)D HALE RD	D	C	P-	B/P.4	121.7
4(K)D FORREST/NICHOLSON RD	D	R	C-	B/P.4	40.8
4(L)D ARMADALE DAMPLAND	D	R	P-	B/P.4	18.6
4(M)D FORREST/TAYLOR RDS	D	R	P-	B.3	42.6
4(N)D GIBBS/TAYLOR RDS	D	C	VV	B.3	51.0
4(O)S GIBBS/NICHOLSON RDS	D	R	C-	B.3	21.9
4(P)D ANSTEY/KEANE RDS	D	C	VP	B.3	35.5
4(Q)D ARMADALE DAMPLAND	D	R	P-	B.3	28.8
5S WARTON/FORREST RDS	S	M	P-	B.3	5.9
6(A)S FORREST/WARTON RDS	S	C	VV	B.3	13.4
7S RANFORD RD	S	C	VP	B/P.4	4.3
8(A)S BORONIA/WARTON RDS	S	R	P-	B.3	11.2
9S RANFORD/ANSTEY RDS	S	R	VP	B/P.4	1.9
10S KEANE/WRIGHT RDS	S	R	VC	B.3	1.4

WETLAND NAME/CODE	TYPE	MAN	VEG	GROUP	AREA (ha)
11D WRIGHT/KEANE RDS	D	C	VC	B/P.4	1.9
12S TAYLOR/FORREST RDS	S	R	P-	B.3	46.6
13D ALLEN RD/BALANNUP SPRING	D	R	P-	B/P.4	4.8
14S GIBBS RD SUMPLAND	S	C	VV	B.3	38.3
16D WESTFIELD RD	D	M	C-	B/P.4	3.4
17S ALLEN/ARMADALE RDS	S	R	P-	B/P.4	25.7
18(A)P ARMADALE PALUSPLAIN	P	M	C-	P.1	2189.9
18(B)P ARMADALE PALUSPLAIN	P	NE		B/P.4	146.2
19S TAYLOR/GIBBS RDS	S	C	VP	B.3	6.2
20P RANFORD/WESTFIELD RDS	P	O	VP	B/P.4	9.3
21(A)S GIBBS/WRIGHT RDS	S	C	VV	B.3	12.5
22L FORRESTDAL LAKE	L	H	VP	B/P.4	221.9
23S FORREST/TAYLOR RDS	S	R	VP	B.3	1.1
24(A)S WRIGHT 'LAKE'	S	R	P-	B/P.2	22.5
25D KARGOTICH/FORREST RDS	D	M	C-	B/P.4	20.2
26(A)D ALLEN/FORREST RDS	D	R	VC	B/P.4	42.3
26(B)D ALLEN/RANFORD RDS	D	R	C-	B/P.4	141.7
26(C)D ALLEN RD/SOUTHERN R.	D	C	VV	B/P.4	19.3
26(D)D WESTFIELD RD/SOUTHERN R.	D	R	P-	B/P.4	133.2
26(S)D ARMADALE DAMPLAND	D	NE		B/P.4	4.5
26(T)D RANFORD/WARTON RDS	D	R		B/P.4	29.5
27S GIBBS/TAYLOR RDS	S	R	P-	B.3	4.6
28S OXLEY/NICHOLSON RDS	S	R	VC	B.3	75.1
29S FORRESTDAL SUMPLAND	S	C	P-	B/P.4	120.2
30(A)D ROWLEY/NICHOLSON RDS D	D	R	P-	B.3	133.9
31D WARTON/NICHOLSON RDS	D	R	C-	B.3	65.4
32 (D)S BALANNUP 'LAKE'	S	C	P-	B/P.4	46.5
32(C)S BALANNUP 'LAKE'	S	O	P-	B/P.4	58.4
33(A)D ACOURT/WARTON RDS	D	R	C-	B.3	29.5
34(A)S PIARA RESERVE, MASON RD	S	C	VV	B/P.4	10.8
34(B)S MASON RD SUMPLAND	S	M	C-	B/P.4	2.7
46(D)P CANNING R. PALUSPLAIN	P	NE		R.2	35.6
279D WESTFIELD PK SCH DAMPLAND	D	NE		B/P.2	44.5
280AL WESTFLD PK SCH ART.LKE	L	NE		B/P.2	1.7
281P DARLING RANGE WETLAND	P	NE		D.1	7.6
282D DARLING RANGE WETLAND	D	NE		D.2	1.4
283D DARLING RANGE WETLAND	D	NE		D.2	8.7
284D DARLING RANGE WETLAND	D	NE		D.2	1.3
285D DARLING RANGE WETLAND	D	NE		D.2	3.0
286D DARLING RANGE WETLAND	D	NE		D.2	2.7
287D DARLING RANGE WETLAND	D	NE		D.2	4.5
288D DARLING RANGE WETLAND	D	NE		D.2	1.5
289D DARLING RANGE WETLAND	D	NE		D.2	0.9

WETLAND NAME/CODE	TYPE	MAN	VEG	GROUP	AREA (ha)
290P DARLING RANGE WETLAND	P	NE		D.1	14.0
291D DARLING RANGE WETLAND	D	NE		D.2	5.2
292D DARLING RANGE WETLAND	D	NE		D.2	1.6
293D DARLING RANGE WETLAND	D	NE		D.2	3.9
294D DARLING RANGE WETLAND	D	NE		D.2	3.3
295D DARLING RANGE WETLAND	D	NE		D.2	1.2
296P DARLING RANGE WETLAND	P	NE		D.2	2.8
297D DARLING RANGE WETLAND	D	NE		D.2	1.2
298D DARLING RANGE WETLAND	D	NE		D.2	1.1
299P DARLING RANGE WETLAND	P	NE		D.2	11.9
401F SOUTHERN R.FP, TWELTH RD	F	NE	VC	B/P.4	6.9
402F SOUTHERN R FP, TWELTH RD	F	NE	VC	B/P.4	5.1
403S ROWLEY RD SUMPLAND	S	M	C-	P.1	5.7
404S ROWLEY RD SUMPLAND	S	M	C-	P.1	1.5
405S ROWLEY RD SUMPLAND	S	M	C-	P.1	3.8
406(A) OXLEY RD SUMPLAND	S	M	C-	B/P.4	51.7
406(B) OXLEY RD SUMPLAND	S	R	P-	B/P.4	12.0
407S SEVENTH AVE SUMPLAND	S	NE	P-	P.1	2.3
408S HILBERT RD SUMPLAND	S	C	VP	P.1	4.7
409AL TWELTH/FORREST RD	AL	NE	P-	B/P.4	4.5
410S STIRLING/OXLEY RD	S	NE	P-	B/P.4	31.5
411S FORREST/ELEVENTH RD	S	M	C-	P.1	4.7
412S FREEMAN RD SUMPLAND	S	NE	P-	B.3	26.7
413S TAYLOR RD SUMPLAND	S	NE	VP	B.3	3.6
414S WOLFE RD SUMPLAND	S	R	P-	B.3	1.5
415S FORREST/NICHOLSON R	S	R	P-	B/P.4	1.9
416S FORREST/NICHOLSON RD	S	R	P-	B/P.4	9.8
Total Area of other Artificial Basin Wetlands					29
Total Area of Armadale's Basin and Flat Wetlands (hectares)					5130.5

Wetlands with a High Conservation management category differ from "Conservation" wetlands in having a high number of human use attributes in addition to the wetland's high natural attributes. Active, protective management is therefore necessary to minimise the impacts of any conflicting uses and enhance the wetland's overall attributes. "High Conservation" wetlands are also recognised as having the highest priority for establishment and implementation as regional park wetlands (EPA, 1990).

Five of the City's six High Conservation wetlands supported Rare and Endangered fauna and/or flora as shown in Table 8. Other rare and priority listed flora associated with wetlands in the City of Armadale include Eryngium pinnatifidum, Grevillea thelemanniana (subsp. thelemanniana), Gonocarpus pithyoides and Restio stenostachyus (Kelly et al, 1993). Each of these floral species are associated with seasonally inundated or waterlogged sites rather than the permanently inundated wetlands such as Forrestdale Lake.

TABLE 8: RARE FLORA AND FAUNA SUPPORTED BY HIGH CONSERVATION WETLANDS IN THE CITY OF ARMADALE.

1S	Green's Swamp	<u>Stictonetta naevosa</u> Freckled Duck * <u>Caladenia leigiana</u> #
2D	Warton/Ranford/Nicholson Dampland	<u>Stictonetta naevosa</u> Freckled Duck* <u>Caladenia leigiana</u> #
4(B)D	Wright/Ranford/Warton Dampland	<u>Stictonetta naevosa</u> Freckled Duck * <u>Caladenia leigiana</u> #
3P	Forrestdale Res.27165 Palusplain	<u>Diuris purdiei</u> (Purdey's Donkey Orchid) <u>Isoodon obesulus</u> (Southern Brown Bandicoot/Quenda)*
4(A)D	Anstey/Keane Road Dampland	<u>Diuris purdiei</u> (Purdey's Donkey Orchid)# <u>Isoodon obesulus</u> (Southern Brown Bandicoot/Quenda)*
NOTE: 1. This list is not exhaustive. Further studies are required to locate other rare species associated with wetlands in the City of Armadale. 2. *=Declared Rare Fauna; #=Declared Rare Flora; ^=Priority Listed Flora 3. The above wetlands are discussed further to Section 4.2.		

Utilization of wetland habitats by the Southern Brown Bandicoot or Quenda, a Declared Rare and Endangered species has the potential to change the preliminary management categories of a number of the City's wetlands. Bandicoot sightings made by members of the public and logged with CALM between April 1991 and December 1992 show that a number of wetlands in the City of Armadale support the Southern Brown Bandicoot (Glenn Collis, CALM, pers. comm.). The details of these sightings, the majority of which have been made in Forrestdale on the coastal plain and Roleystone in the Darling Range, are listed in Appendix D.

3.3.2 Conservation and Open Space Wetlands

Sixteen dampland and sumpland components within the City were evaluated as having a Conservation preliminary management category. "Conservation" dampland components are especially important as the majority of dampland areas in the Perth Metropolitan Area have been lost or severely degraded. Those closer to Perth have become urbanised whilst those to the south have been cleared for grazing and other rural purposes. Only one quarter of Armadale's remaining damplands support remnant vegetation and have been assigned management categories of Conservation or High Conservation. Management of these vegetated dampland areas must be addressed as a priority.

Part of Balannup "Lake" and a small palusplain fringing the Southern River were the only wetlands evaluated within the City to obtain a management category of Open Space. The Ranford/Westfield Rd palusplain (20P) on the Southern River supports remnant riparian vegetation which has been removed from most of the City's other coastal plain channel wetlands. Two other recently mapped floodplains on the Southern River south of wetland 20P are similarly well vegetated.

TABLE 9: "CONSERVATION" AND "OPEN SPACE" WETLAND COMPONENTS IN THE CITY OF ARMADALE
See Table 7 for key to wetland types, management categories and natural groups.

WETLAND NAME/CODE	TYPE	MAN	VEG.	GROUP	AREA (ha)
6(A)S FORREST/WARTON RDS	S	C	VV	B.3	13.4
21(A)S GIBBS/WRIGHT RDS	S	C	VV	B.3	12.5
19S TAYLOR/GIBBS RDS	S	C	VP	B.3	6.2
14S GIBBS RD SUMPLAND	S	C	VV	B.3	38.3
29S FORRESTDAL E SUMPLAND	S	C	P-	B/P.4	120.2
34(A)S PIARA RESERVE (Mason Rd Sumpland)	S	C	VV	B/P.4	10.8
7S RANFORD RD	S	C	VP	B/P.4	4.3
32 (D)S BALANNUP 'LAKE'	S	C	P-	B/P.4	46.5
408S HILBERT RD SUMPLAND	S	C	VP	P.1	4.7
32(C)S BALANNUP 'LAKE'	S	O	P-	B/P.4	58.4
4(N)D GIBBS/TAYLOR RDS	D	C	VV	B.3	51.0
11D WRIGHT/KEANE RDS	D	C	VC	B/P.4	1.9
4(P)D ANSTEY/KEANE RDS	D	C	VP	B.3	35.5
4(C)D WRIGHT/MASON RDS	D	C	VP	B.3	19.0
4(D)D FORREST/ANSTEY RDS	D	C	VP	B/P.4	53.3
4(J)D HALE RD	D	C	P-	B/P.4	121.7
26(C)D ALLEN RD/SOUTHERN R.	D	C	VV	B/P.4	19.3
20P RANFORD/WESTFIELD RDS	P	O	VP	B/P.4	9.3

3.3.3 Resource Enhancement and Multiple Use Wetlands

Many of the City's wetlands were evaluated to have Resource Enhancement or Multiple Use management categories. Whilst these wetlands are in many cases significantly modified or degraded, they can still support a number of natural and human use attributes and fulfil a number of important functions. Resource Enhancement dampland components for example are habitat to a variety of species and provide important linkages between more pristine wetlands and woodlands. (eg. dampland components 4(L)D and 4(M)D north of Forrestdale Lake).

Multiple Use wetlands also provide a significant number of ecological, hydrological and social functions which must be considered in the context of sustainable catchment and land use planning. The large Armadale palusplain (wetland 18(A)P, 2311 ha) is one such wetland. Although extensively cleared, parts of this seasonally waterlogged flat provide valuable feeding sites for a variety of waterbirds, including ibis, egrets and herons. The cleared palusplain is also important for providing green pasture well into the summer.

3.4 THE IMPORTANCE OF DAMPLANDS AND PALUSPLAINS

Vegetated damplands and palusplains are as important as Perth's other more well known and studied wetlands such as Lake Monger and Thomsons Lake. Their importance stems from their high genetic diversity, presence of rare species, waterbird breeding habitat and floristic displays.

Damplands and palusplains are those wetlands characterized by waterlogged soils in the wetter months. This is referred to as seasonal waterlogging. While they may occasionally exhibit surface water for a few days or weeks it is seasonal waterlogging which is the regular, prevailing feature which influences their soils and vegetation.

Habitat for Native Flora

Damplands and palusplains are more botanically rich than other wetland types. This follows the Australia-wide trend that the most botanically diverse wetlands are those which are only subject to temporary water excess (CSIRO, 1985). In Perth, the floristic diversity of the seasonally waterlogged wetlands is well supported by studies of the Brixton Street area in the City of Gosnells and the Anstey/Keane Road Dampland in the City of Armadale.

Surveys of the Brixton Street palusplain have shown that the area supports 258 species of plants (Keighery & Keighery, 1991). Initial studies of the 150ha Anstey/Keane Road Dampland site have recorded 293 plant species, including 28 native orchid species making it more diverse than Kings Park (400ha - 275 species) or Bold Park (321ha - 226 species) (Weston, 1991). Such floristic diversity is made apparent by a walk through these areas in spring when an array of wildflowers can be seen, including species of kangaroo paw and native orchids.

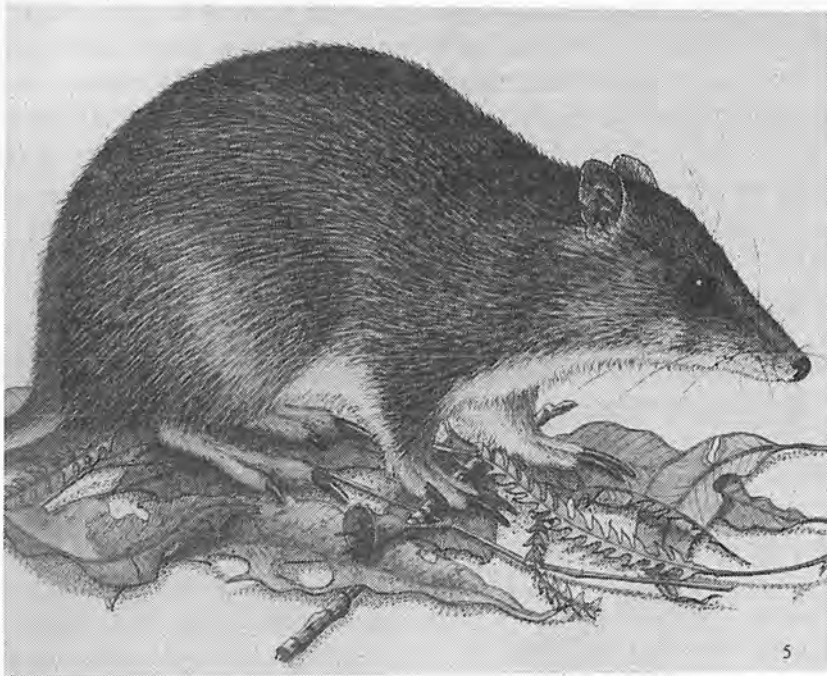
Habitat for Native Fauna

Perth's damplands also provide habitat for the Rare and Endangered Southern Brown Bandicoot or Quenda, *Isoodon obesulus*. The Quenda is able to sustain a higher population density in the productive dampland and palusplain environments than is possible in other, drier habitats. This is partly attributed to the dense heathland vegetation of seasonally waterlogged wetlands which allow the Quenda to cope to a greater extent with predation by cats and foxes (Friend, 1991). As a result this marsupial species has been able to survive in urban bush remnants in suburbs such as Gosnells, Armadale, Belmont and Kalamunda. However, these populations are precariously placed as their habitat is lost and fragmented by clearing and bushland degradation and individuals are further stressed by well-intentioned translocation programs and predation by cats, dogs and foxes.

Seasonally waterlogged areas are also recognised as prime breeding areas for waterbirds. Much of the Swan Coastal Plain's waterlogged pastures are used by nomadic avifauna and other waterbirds for breeding and feeding during the winter months. Scopewest, a study of the waterbird usage of wetlands on the Swan Coastal Plain, found that for Grey Teal, 55% of individuals and 86% of breeding activity occurred on damplands and floodplains (Storey et al, 1993). For the Pacific Black Duck, 60% of individuals and 55% of breeding activity occurred on these wetland types. Specific reptiles and invertebrates also find damplands and palusplains excellent habitat.

Damplands and palusplains are therefore an important part of the spectrum of wetland types. With sumplands, damplands probably support more aquatic flora and fauna than lakes (Balla & Davis, 1992). However seasonally waterlogged wetlands are being lost at a faster rate than other wetland types due to their less conspicuous wetland characteristics and the traditional approach to land development.

The lack of understanding of damplands and palusplains has also meant that they have are not as well represented in the conservation estate as the other wetland types. While Perth has experienced the loss or degradation of approximately 70% of its wetlands, it has probably lost 80-90% of its seasonally waterlogged areas. Conservation of vegetated damplands and palusplains is essential if we are to maintain the variety of Perth's wetlands and the diversity of species they support.



The Declared Rare and Endangered Southern Brown Bandicoot or Quenda (Isoodon Obesulus) Drawing by Susan Tingay (Tingay & Tingay, 1982).

4. IMPLICATIONS FOR MANAGEMENT

Wetland evaluation using Bulletin 374 provides a guide as to how wetlands should be managed by identifying preliminary management categories and objectives. It has highlighted the values of certain wetlands and the specific management issues which must be addressed. Other, wider management considerations have also become evident through the field and data research work that has been undertaken to assess the City's wetlands.

4.1 Management Objectives for Armadale's Wetlands

Many of the City's wetlands retain substantial natural attributes which must be taken into account in planning for the City's growth. Evaluation has identified high natural attribute wetlands by assigning them preliminary management categories of High Conservation and Conservation. These wetlands support substantial areas of remnant vegetation and will require protective management to maintain their high degree of naturalness. They include the Anstey/Keane Dampland, Gibbs Road Sumpland and part of Balannup "Lake".

Other wetlands with relatively fewer natural attributes and/or human use attributes have been assigned "Resource Enhancement" and "Multiple Use" management categories. Management of these areas will be required to maintain and enhance the wetland's ecological functions and consider the wetland in the context of catchment and land use planning (EPA, 1991).

All of the City's wetlands are important. It is well documented in Western Australia that rehabilitation and proper management can readily alter the condition and management category of a wetland.

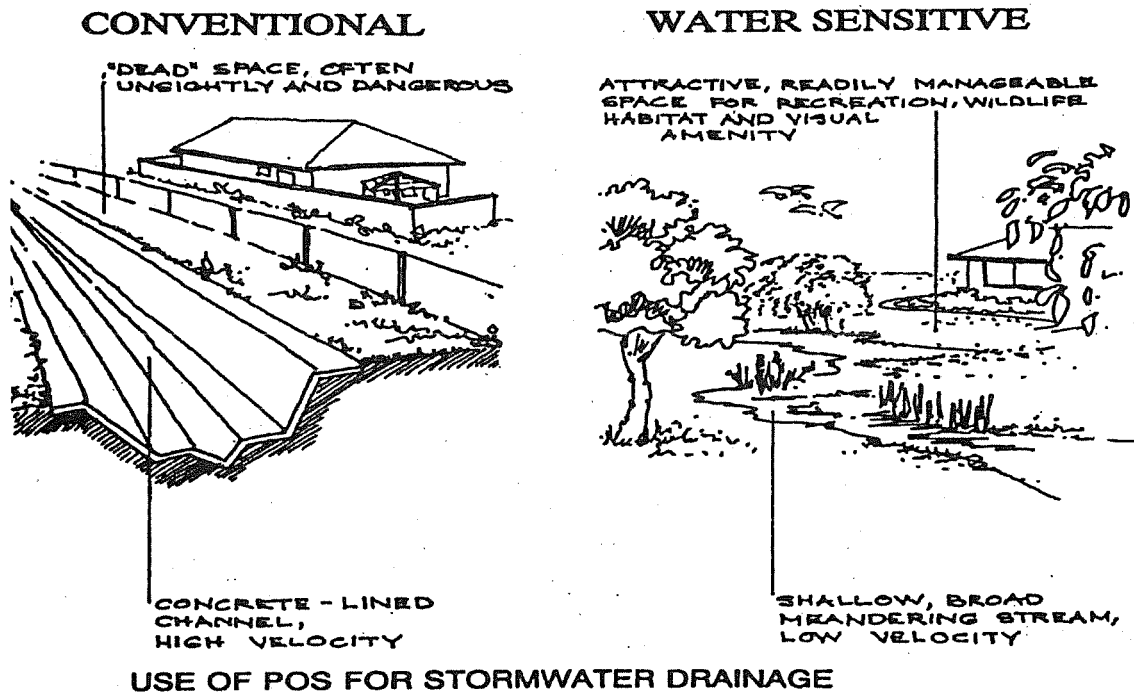
4.2 Managing the Wetland Water Resource

Wetlands are complex ecosystems which need to be managed in concert with their catchment and other wetlands. This is particularly appropriate to the wetlands of the City of Armadale on the Coastal Plain as they are often extensive, inter-connected areas which are further linked by a network of creeks and artificial channels.

An integrated approach to catchment management and the introduction of Water Sensitive Design (WSD) techniques are considered the most effective ways of protecting the valuable wetlands which remain. Both processes seek to integrate water resource management with land use planning activities. Whilst integrated catchment management addresses issues such as drainage and land-use activities at the catchment level (as in the Bayswater Main Drain Catchment Group), Water Sensitive Design provides the "hands-on" planning and management guidelines and techniques to meet wetland water balance and quality objectives (Water Sensitive Urban Design Steering Committee, 1993). WSD has the objectives of designing for water balance, water quality, water conservation and the maintenance of water related environmental, recreational and cultural values.

Figure 4 is an example of the application of water sensitive design. Instead of a straight, fenced drain which is often unsightly and dangerous, a water sensitive approach has stormwater flowing along an artificial, shallow, vegetated stream within public open space. Helping to improve the quality of drainage waters and keep water levels within a more natural regime, this approach might be appropriate on various drains in the City of Armadale.

FIGURE 4: AN APPLICATION OF WATER SENSITIVE DESIGN TO STORMWATER DRAINAGE



(Water Sensitive Urban Design Steering Committee, 1993)

While management of the City's drains needs to be improved, (Pawluk et al, 1992) "improvement" requires a water-sensitive rather than a water-export approach. This will ensure that the maximum benefit is obtained from minimising fertilizer use and protecting and re-establishing native vegetation.

The management of existing wetland water levels is another important objective of water sensitive design. This is particularly important for the vegetated damplands, sumplands and palusplains whose vegetation is dependant upon the existing regime of inundation or waterlogging. In the case of damplands, raised water levels would lead to the seasonal inundation of the basins and to large changes in the dampland's vegetation. Alternatively, drainage of an area or excessive abstraction of groundwater may lead to a dampland's vegetation being gradually succeeded by upland vegetation.

4.3 Regional Management Considerations

In addition to managing wetlands at the catchment level, a given wetland must be recognised and managed as part of a regional network of sites. Therefore, whilst particular wetlands may be of special significance, all wetlands should be valued as part of an inter-related network. (See Figure 5).

For instance, while many of the City's wetlands are of importance in their own right, they have a regional role in acting as natural wildlife corridors between more well known wetlands such as Forrestdale Lake and the Canning River. One such well-vegetated wildlife corridor is formed by the Anstey/Keane Dampland, Balannup Lake and the Balfour/Furley Road Dampland in the City of Gosnells.

Isolated wetlands/woodlands protected by the creation of the Jandakot Botanical Park also require wildlife corridors if they are to be effective conservation areas. Dampland 4(D)D is one such example of a wetland which could be protected to link the important Anstey/Keane Dampland with Forrestdale Lake.

Channel wetlands-rivers, creeks and artificial channels-also form important corridors for wildlife movement and open space. One such channel wetland, the Southern River has already been recognised as open space of regional significance and recommended for inclusion into a regional park (See Figure 6)(Dept. Cons. & Env. 1983). Other channel wetlands, many of which have become degraded through clearing and training, require further attention. With good design and management many of these wetlands have the potential to enhance areas of Public Open Space and act as wildlife corridors.

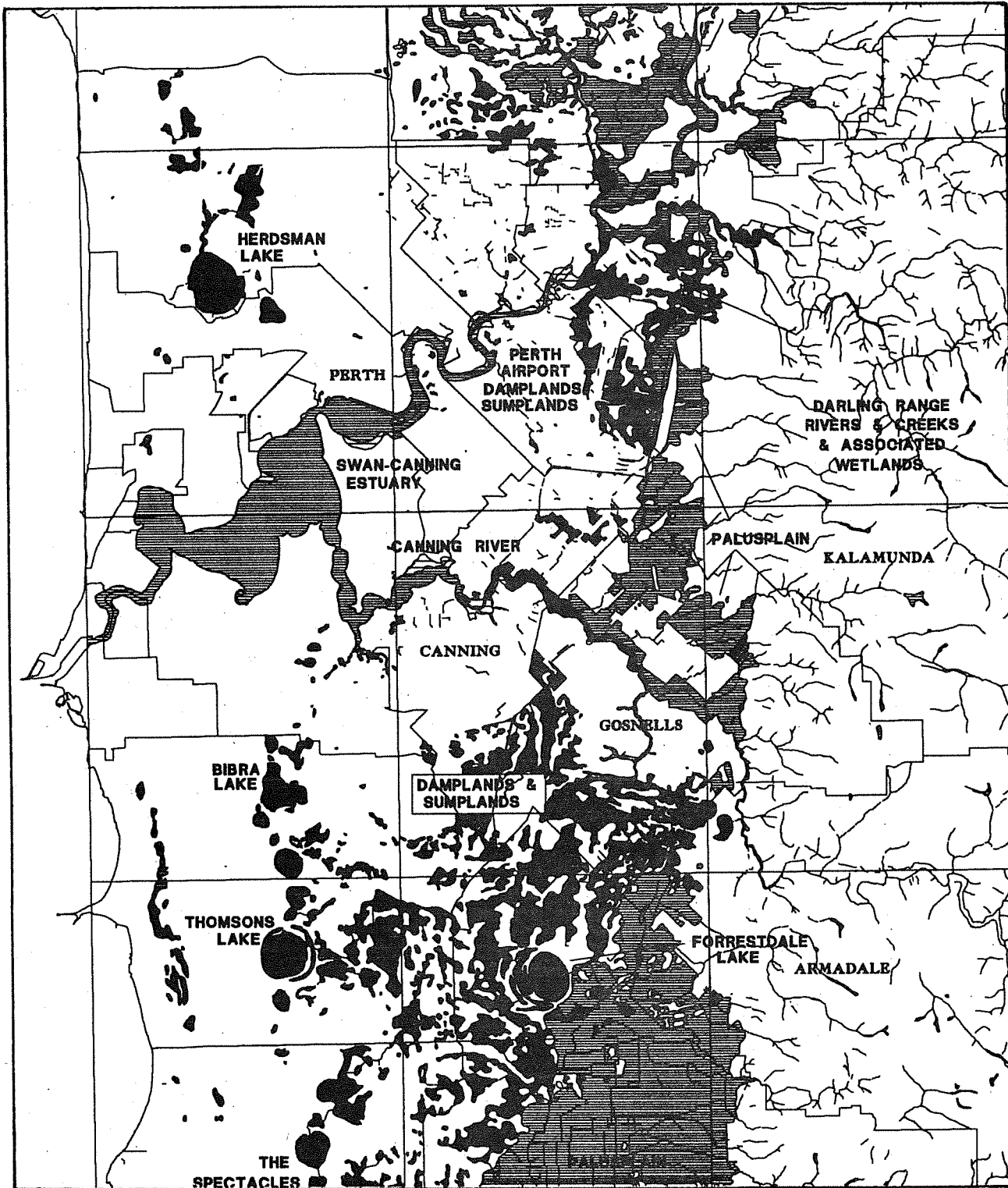
Better management of the City's channel wetlands may begin with the re-establishment of a suitable buffer of native riparian vegetation as recommended in part by the Armadale Rural Strategy (Pawluk et al, 1992). A 50m buffer on each side of the river, creek or artificial channel is the minimum recommended for the Region's channel wetlands (Hussey, 1991) (Thorburn, 1992) (Water Sensitive Urban Design Committee, 1993). This would ensure that the channel wetland would be truly multipurpose: improving water quality, stormwater management, water balance, recreational usage and use as a wildlife corridor.

4.4 Conservation of Damplands, Palusplains and Rare Species

Seasonally waterlogged areas are the most predominant wetland features of the cities of Gosnells and Armadale and should be conserved to maintain the area's character. Vegetated damplands and palusplains are regionally important as most of Perth's other seasonally waterlogged areas have been lost, cleared or severely degraded by development. Whilst parts of the Kenwick palusplain have been set aside for conservation, few dampland areas within the City of Armadale and Perth Metropolitan Area are represented within the conservation estate.

FIGURE 5: ARMADALE'S WETLANDS IN A REGIONAL PERSPECTIVE

Armadale's wetlands are part of an important north-south system of wetlands, both on the Coastal Plain and Darling Scarp. This figure shows the damplands, sumplands and palusplains which extend from the Perth Airport area through the City of Armadale to the Shires of Serpentine-Jarrahdale and Murray. To the east, creeks and rivers line the valleys of the Darling Scarp, providing important wildlife habitat and corridors for species such as the Southern Brown Bandicoot. It is important to plan to retain these wetlands as wildlife corridors, linking the permanently inundated wetlands and to provide areas for the breeding and feeding of native fauna.



Damplands must be recognised and conserved as areas of high genetic diversity which support very unique, diverse floral communities. Vegetated damplands support populations of the Rare and Endangered Southern Brown Bandicoot and are recognised as prime breeding areas for waterbirds. Their existence is threatened by further clearing, expansion of the metropolitan area and altered water levels.

Conservation of dampland, sumpland and palusplain habitats within the City will play a large part in ensuring the survival of the Region's wetland dependant rare flora and fauna. All of the City's rare and endangered wetland dependant species were found in these wetland types rather than the permanently inundated wetlands (see Table 8). It is therefore essential that use of wetlands by these species is acknowledged and accommodated into the City's development. Protection of the habitat of the Freckled Duck, such as the Gibbs Road sumpland, has already been recommended by the City's Rural Strategy (Pawluk, 1992).

Habitat protection is the most effective and efficient means of protecting rare species and has been recognised by State Government agencies in a recent green discussion paper (Dept. of CALM, 1992a). The protection of rare species is also fundamental to one of the State's key environmental protection goals: "to preserve genetic diversity" and the state's Environmental Charter (Dept. Conservation & Environment, 1987).

4.5 Wetland Conservation and the Jandakot Botanical Park

The conservation of a number of sumplands and damplands in the City of Armadale will be achieved through the creation of the proposed Jandakot Botanical Park. In addition to conserving separate core areas of wetland and woodland, the Park will endeavour to link these areas by protecting other environmental features to form contiguous conservation areas (Dept. Planning & Urban Development, 1992). At present four isolated core areas have been identified for inclusion into the Park. These areas cover Green's Swamp (1S), Piara Reserve (Mason Road Sumpland: 34(A)S), a small part of the Anstey/Keane Dampland (4(A)D) and an area to the east of Forrestdale Lake including parts of the Gibbs Road Sumpland and dampland 4(N)D.

4.6 Wetland Conservation and the EPA Lakes EPP

Lakes, and to a lesser extent sumplands, are relatively well protected and represented in the conservation estate. Protection of Perth's lakes has been recently strengthened by the proclamation of the Environmental Protection (Swan Coastal Plain Lakes) Policy Approval Order 1992, otherwise known as the Lakes EPP. The Policy defines lakes as areas of standing water of 1000 square metres or more as at 1 December, 1991 and prevents their destruction and degradation by prohibiting filling, excavation, mining, effluent disposal and drainage² (Environmental Protection Act, 1986). Lakes covered by the policy have been identified on Department of Land Administration Miscellaneous Plan No. 1815.

²The boundaries of these lakes covered by the EPA's Lakes EPP differ from those mapped by the V&C Semeniuk Research Group for the Water Authority of Western Australia.

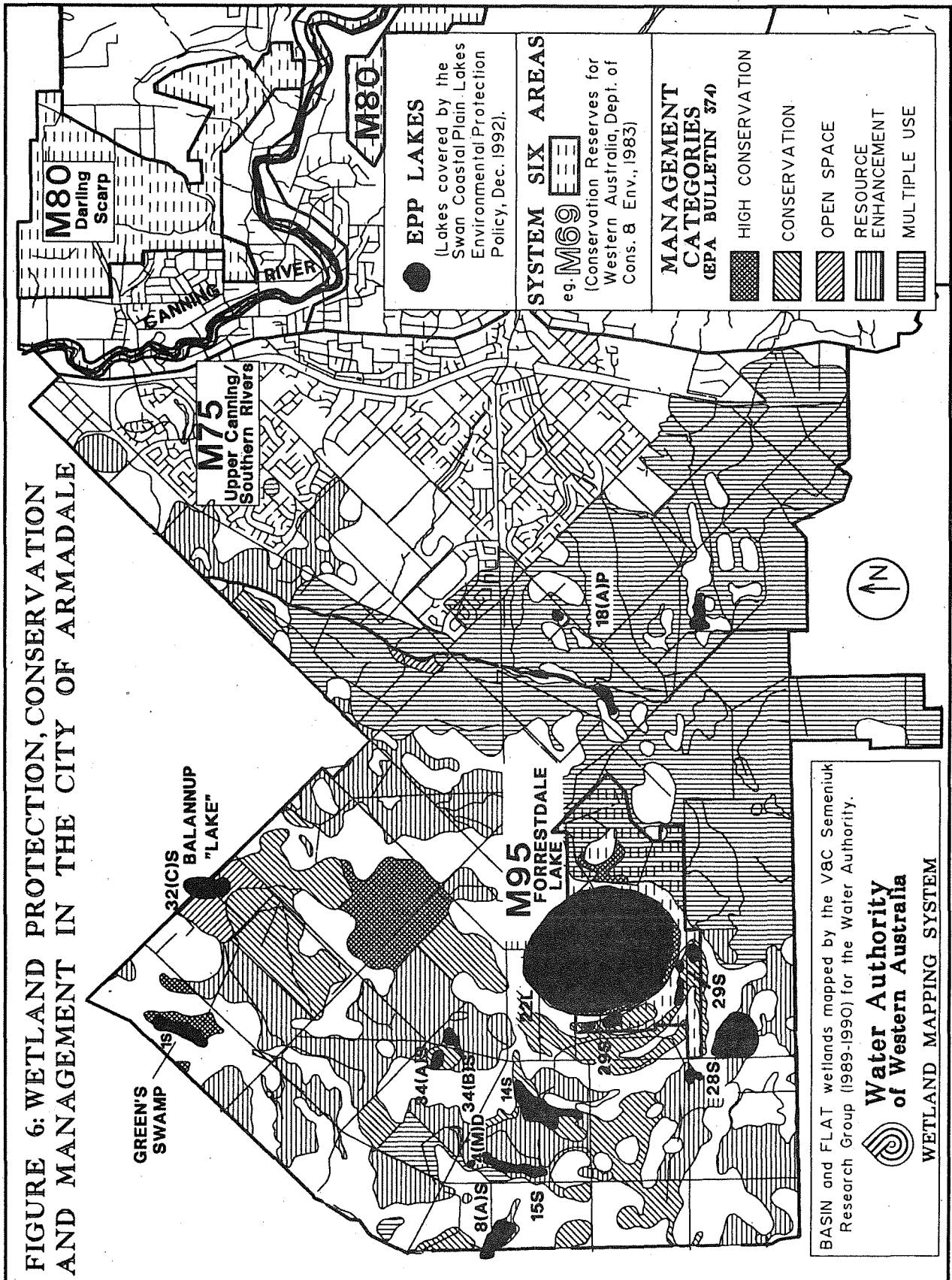


Figure 6: System Six areas and "lakes" covered by the Swan Coastal Plain Lakes Policy have been shown over the City's wetland resource. System Six areas in the City which incorporate wetlands include Forrestdale Lake (M95) and the upper Canning and Southern Rivers (M75). Twenty "lakes" of total area 314 hectares are covered by the Lakes EPP in the City of Armadale. These include parts of Green's Swamp (1S), the Nicholson/Oxley Road Sumpland (28S) and the Hilbert Road Sumpland (408S). A large part of the City's "High Conservation" and "Conservation" wetlands are outside of these protective areas and are of high priority for conservation.

The Swan Coastal Plain Lakes Policy is a statutory document and automatically protects nominated Lakes from unauthorized filling, mining, changes to drainage or direct effluent discharge regardless of their Bulletin 374 management category. Bulletin 374 on the other hand, is an advisory document which provides a framework for the identification of management objectives for wetlands to ensure their natural and human use values are maintained or enhanced.³

4.7 Wetland Buffers

The management of adjoining vegetation is of major importance for the effective conservation of all wetland types. Evaluation has shown that wetlands buffered by native vegetation were more likely to be in a near-pristine condition and worthy of conservation (See Appendix C: Listing of Wetlands by Management Category).

Mapping presented in this booklet can be used to identify wetland buffers as the wetlands have been described in their entirety. Figure 7 shows how each lake is mapped to include its zone of seasonal waterlogging, seasonal inundation and permanent inundation. Similarly, a sumpland is mapped to include its zone of seasonal waterlogging and seasonal inundation. An effective buffer of upland vegetation should be retained or rehabilitated to cover an area of at least 50m from the edge of this seasonally waterlogged zone.

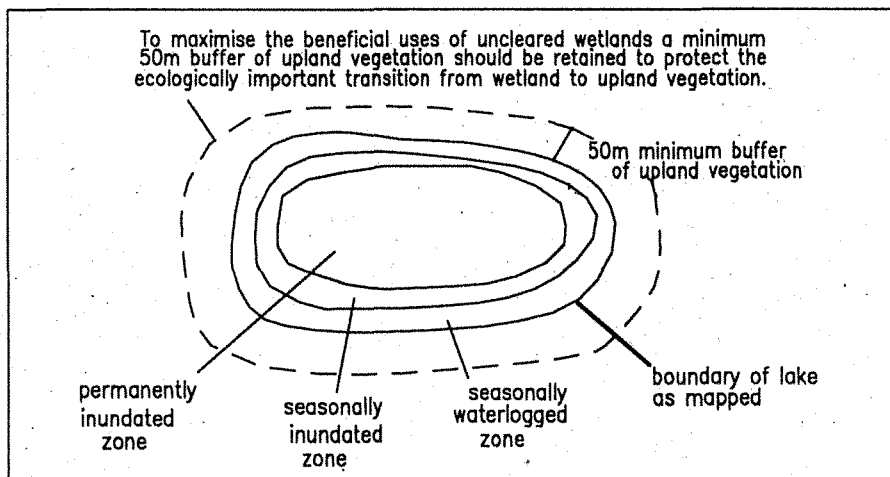


FIGURE 7: WETLAND BUFFERS

Each lake is mapped to include the wetland's zones of permanent inundation, seasonal inundation and seasonal waterlogging. The minimum 50m buffer of upland vegetation should then be planned to protect the entire wetland.

Buffers reduce nutrient enrichment, midge and odour problems as surrounding areas are developed. They also lessen the impact of people pressures on the wetland and minimise the cost of management and maintenance measures.

³Bulletin 374 is only applicable to wetlands of the Swan Coastal Plain from Gingin Brook in the north to the Murray River in the south.

The impact of human use may also be minimised by fencing, signposting and community management and policing of wetlands. This eliminates much of the rubbish dumping, off-road vehicles and unnecessary access which is degrading many of the City's wetlands, especially the damplands. Community management of natural areas as in the Armadale Settlers Common and the Hume Road Wildlife Reserve in the City of Gosnells are particularly encouraging. Other pro-active strategies, such as the use of Water Sensitive Design, could also be used to improve the amenity of the City's wetlands.

4.8 Wetlands Of Special Note in the City of Armadale

Wetland evaluation has identified that a number of wetlands in the City of Armadale are of special interest for conservation and recreation purposes. Some of these are described below.

4.8.1 GREEN'S SWAMP AND WOODLANDS: 1S

Management Category: High Conservation Wetland Area: 22.8 ha

Wetland 1S is known locally as Green's Swamp. It has been identified as regionally to internationally significant in the study into the environmental significance of wetlands in the Perth to Bunbury Region (Wright Road Wetland) (LeProvost, Semeniuk & Chalmer, 1987).

This wetland's outstanding conservation values are due to its diversity in vegetation types and the near-pristine condition of the vegetation. Green's Swamp has a heterogeneous zoned vegetation cover and a healthy banksia woodland buffer. Two nearby vegetated damplands also add to the area's habitat diversity.

Banksia woodland in association with ephemeral wetlands such as Green's Swamp has become uncommon habitat on the Swan Coastal Plain. This type of woodland is botanically diverse and internationally known for its abundance of wildflowers, some of which have become symbols of Western Australia, such as the kangaroo paw and banksia. Both Green Swamp and the surrounding banksia woodland are poorly represented in the conservation estate.

Green's Swamp supports Declared Rare Flora and Fauna and is considered to be a potential breeding site for the Declared Rare and Endangered Freckled Duck. The Swamp also acts as an important linkage between other wetlands. Together with the Balfour/Furley Dampland and Holmes/Balfour Sumpland to the north in the City of Gosnells and Balannup "Lake" to the east, it forms part of a series of linked sites which provide vital habitat for fauna, particularly waterbirds.

Well-buffered wetlands such as Green's Swamp tend to be more resilient and capable of withstanding urban pressures. This wetland and the surrounding woodland should be afforded the highest protection, and managed accordingly. It is currently in private ownership but has been nominated for inclusion in the Jandakot Botanical Park (Department of Planning and Urban Development, 1992). Green's Swamp is also protected by the EPA's Lakes Environmental Protection Policy.

4.8.2 ANSTEY/KEANE DAMPLAND: 4(A)D

Management Category: High Conservation Wetland Area: 129ha

The Anstey/Keane wetland supports a significant area of remnant dampland vegetation and should be given the highest level of protection. It is part of an extensive dampland found throughout much of the Shire of Armadale which has been largely cleared for grazing. Studies have already shown that this wetland is of regional significance (Keighery, 1991).

Two hundred and ninety three species of native flora have been recorded from the 150ha covering this wetland and its buffer making it more diverse than Kings Park (400ha - 275 species) or Bold Park (321ha - 226 species)(Weston, 1989). This may be increased to around 350 species with further studies (Keighery, 1991).

The Anstey/Keane Dampland contains Rare and Endangered flora including Diuris purdiei (Purdey's Donkey Orchid) and Drosera occidentalis and five Priority listed species. It is the last significant site for the Donkey Orchid and supports over 28 other orchid species.(Keighery, 1991). Each of the vegetation communities present on this dampland (Melaleuca, Swamp Cypress, Sedge Savannah, Pericalymma and Regelia heath) are all uncommon communities within the metropolitan area.

Despite being severely damaged by fire in the summer of 1991, there are now signs of healthy regeneration. Only a small part of the dampland has been recommended for inclusion into the Jandakot Botanical Park.

4.8.3 GIBBS ROAD SUMPLAND: 14S

Management Category: High Conservation Wetland Area: 38.3ha

This wetland, is a valuable breeding area for waterbirds, and has been confirmed as a breeding site for the freckled duck. (David James, Pers. comm.) It is a very attractive wetland with intact vegetation and provides excellent feeding and breeding habitat for a wide range of birds.

The Gibbs Road Sumpland is protected by the EPA Lakes Environmental Protection Policy and has been nominated for inclusion in the Jandakot Botanical Park (Dept. Planning & Urban Development, 1992). The northern part of the wetland is in private ownership whilst the southern part is owned by Homeswest and CALM.

4.8.4 FORRESTDALE LAKE (22L) Forrestdale Lake Nature Reserve:

Management Category: High Conservation Wetland Area: 222 ha

Forrestdale Lake is a wetland of international significance. It meets the stringent criteria required for listing under the Ramsar Convention and supports large numbers of waterbirds, including wading birds which are protected under several international treaties. The Lake is included in an 'A' Class Nature Reserve which is managed by the Department of CALM. This reserve is for the Protection of Flora and Fauna and Recreation.

Forrestdale Lake was also the subject of System 6 Area Recommendation M95 which recommended that the "seasonal swamps" to the west and south west be included within the Forrestdale Lake reserve. These seasonal swamps equate to the large sumpland encircling part of the Lake, 29S, which has been assigned a Conservation management category. Inclusion of this sumpland within the Nature Reserve would help safeguard the area's diverse wildlife and waterfowl breeding habitats. (Dept. of Cons. and Env., 1983).

4.8.5 PALUSPLAIN 3P: Reserve 27165 Forrestdale

Management Category: High Conservation Wetland Area: 12 ha

The palusplain 3P to the south of Forrestdale Lake is included within Reserve No. 27165 and supports rare flora. The area has recently been added to the Forrestdale Lake Nature Reserve as recommended in the Forrestdale Lake Management Plan (1987-1992). The area is unfenced and unmanaged and unless action is taken soon this fragile area will become damaged through misuse.

4.8.6 BALANNUP LAKE 32:(C)S and 32 (D)S

32(C)S

32(D)S

Management Category: Open Space

Management Category: Conservation

Wetland Area: 46 ha

Wetland Area: 58 ha

Balannup "Lake" is a sumpland which extends into the City of Gosnells and is intersected by Ranford Road. It was evaluated as two wetland components in the City of Armadale due to marked changes in vegetation and landuse.

Part of the wetland in the City of Armadale from Hale Road to Balannup Road is now vested in the National Parks and Conservation Authority to be managed by the Department of CALM. Balannup Lake (32(C)S) is also protected by the EPA Lakes Environmental Protection Policy.

Balannup Lake has ongoing problems with rubbish dumping, and more public awareness is needed to prevent this harmful and irresponsible practice. Severe and repeated fires in the summer of 1990/91 have adversely affected 32(D)S, south of Balannup Road, promoting the growth of fire-prone introduced grasses. Careful management and fire prevention measures are needed to prevent long-term degradation of this wetland and its woodland buffer. Any widening of Ranford Road would also severely impact on this wetland, and it is recommended that with increased traffic the road be re-routed around the sumpland with an adequate buffer.

4.8.7 PIARA RESERVE (MASON ROAD SWAMP): 34(A)S

"Piarra" is the Aboriginal word for "place of the Banksia attenuata".

Management Category: Conservation Wetland Area: 11 ha

This wetland is intersected by Nicholson Road. The western part, Reserve 36594 comprising Lot 606 of approximately 40 ha, is managed by the Department of CALM for

conservation of flora and fauna and has been nominated for inclusion in the Jandakot Botanical Park (Dept. Planning & Urban Development). It is considered an important waterbird breeding area.

The remainder of the Mason Road Sumpland on the eastern side of Nicholson Road, is privately owned, cleared, and used for grazing purposes when not inundated. This area, 34(B)S has been evaluated as a Multiple Use area. Like other cleared wetlands it is used by waterbirds and nomadic avifauna such as ibis for feeding and loafing. Both 34(A)S and 34(B)S are protected by the EPA Lakes Environmental Protection Policy from filling, excavation, mining, effluent disposal and drainage (Environmental Protection Act, 1986).

4.9 Where to from Here

The results presented in this report provide information that encourages a change in the way we value wetlands and plan for development. They show that many wetland values, such as the presence of rare species and habitats, pose significant challenges to the land and water planning process.

The Water Authority, the City of Armadale and other government agencies can now use the results of mapping, classifying and evaluating the City's wetlands as the basis for more environmentally sound and "wetland-sensitive" planning and development decisions. The management categories can be used to determine priorities for wetland conservation and management within the City. Wetland evaluation in particular, has flagged the values and management objectives of each of the City's wetlands regardless of the wetland being within a conservation reserve or protected by the Lakes EPP.

The management categories should be of use in determining priorities for conservation of wetlands not protected by other mechanisms such as the Jandakot Botanical Park, other conservation reserves or Lakes EPP. However, more detailed work will be required to consolidate these preliminary management categories, assess the City's channel wetlands and further improve our knowledge of the many values of Armadale's wetlands.

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6. GLOSSARY

Consanguineous wetlands (natural groupings)	wetlands that are distinctly related because of similarity in size, shape, soils, water, setting and origin (LSC, 1987)
Creek	seasonally inundated channel wetland
Dampland	seasonally waterlogged basin wetland
Floodplain	seasonally inundated flat wetland
Fresh (water)	salinity less than 1000 mg/L
Geomorphic	the form of the earth or its surface features
Groundwater	subsurface water in the zone of saturation
Lake	permanently inundated basin wetland
Leptoscale	wetlands smaller than a frame of reference 100m x 100m
Macroscale	Large scale wetlands encompassed by a frame of reference 1000m x 1000m to 10km x 10km
Megascale	very large scale wetlands larger than a frame of reference 10km x 10km
Mesoscale	Medium scale wetlands encompassed by a frame of reference 500m x 500m to 1000m x 1000m
Mesosaline	salinity 20,000 to 50,000 mg/L TDS
Microscale	small scale wetlands encompassed by a frame of reference 100m x 100m to 500m x 500m
Palusplain	seasonally waterlogged flat wetland
Poikilohaline	water of variable salinity, fluctuating from one salinity field to another
River	permanently inundated channel wetland
Salinity	the total quantity of dissolved salts in water
stasohaline	water of relatively constant salinity, remaining in a given salinity field (cf. Poikilohaline)
Stratigraphy	geological study of strata and their succession
Subhaline	salinity 1000-3000 mg/L
Sumpland	seasonally inundated basin wetland
Waterlogged	area in which water stands near or at the land surface
Wetland	areas of permanent, seasonal or intermittent inundation, whether natural or otherwise; fresh, brackish or saline; static or flowing.

7. APPENDICES

- APPENDIX A:** EPA Bulletin 374 Field Questionnaire and Management Category Graphs
- APPENDIX B:** EPA Bulletin 374 Supplementary Questionnaire
- APPENDIX C:** Wetlands in the City of Armadale grouped by wetland type and management category.
- APPENDIX D:** Southern Brown Bandicoot observations made by the public and logged with the Department of CALM.
- APPENDIX E:** A regional perspective of Armadale's wetlands

APPENDIX A: FIELD QUESTIONNAIRE AND SCORE SHEET

A. RESOURCE DATA

WETLAND NAME _____
 IS THE BOUNDARY WELL DEFINED OR POORLY DEFINED? (underline correct response)
 LOCATION (nearest road or junction) _____

DATE(S) VISITED _____ FIELD WORKER _____
 LOCAL GOVERNMENT AUTHORITY _____
 MAP REFERENCE _____
 AERIAL PHOTOGRAPH RUN _____ NUMBER _____

B. NATURAL ATTRIBUTES **SCORE**

***1. Environmental geology classification**

Geology _____ Soil type _____ Distribution restricted? Yes/No

***2a ADJACENT WETLANDS**

Are there wetlands within a 2 km radius? Yes/No

2b HABITAT DIVERSITY

Is the composition and structure of the vegetation significantly different to that found at nearby wetlands? (refer to Q5) YES/NO

3. DROUGHT REFUGE

Is the wetland important as a drought refuge for water birds? (Tick appropriate box)
 Major [] Minor [] None []

4. AREA OF WETLAND

Estimate the diameter of the wetland [] m
 and/or its length [] m and breadth [] m,
 or calculate the area of the wetland, and tick the appropriate box.
 0-10 ha [] 10-25 ha [] 25-50 ha [] 50-100 ha [] >100 ha []

***5. HABITAT TYPE**

No. of habitat types visible from the aerial photo _____

Tick the appropriate boxes for habitat types present.

a. Vegetation over one hectare in area

Large paperbarks (>2.5 m tall) in dense clumps [] Paperbark fringe []
 Low thickets of *Melaleuca*, *Kunzea* or *Astartea* spp. [] *Typha* []
 Extensive inlake beds of sedges [] Extensive beds of *typha* or sedges []
 Scattered clumps of rushes or sedges [] Fringing rushes and sedges []

b. Other Habitats

SCORE

Samphire or saltmarsh [] Flooded grasslands in winter/spring []
 Mud flats or seasonally dry open water [] Islands - natural or human made []
 Permanent shallow open water (>0.5 m deep) [] Scattered paperbarks []
 Permanent deep open water (>0.5 m deep) [] Fringing woodland or heath []

6. EMERGENCY VEGETATION

How much of the wetland is covered with emergent vegetation?

Calculate $\frac{\text{AREA OF EMERGENT VEGETATION} \times 100}{\text{AREA OF WETLAND}}$

Tick the appropriate box 40-60% [] 30-40% or 60-70% [] 20-30% or 70-80% []
 10-20% or 80-90% [] <10% or >90% []

7. ADVERSE WATER QUALITY

Have any of the following been observed/recorded by field workers or locals?

Algal blooms (free-floating) [] Algal mats (filamentous) []
 High nutrient levels [] Pollution slicks []
 Botulism []

***8. DRAINAGE**

Are there any drains coming in or out? (circle correct response)

Drains in Drains out No drains

If drains come into the wetland what is the catchment area for that/those drain(s)? ha

9. ADJACENT NUTRIENT SOURCES

Note the presence of any of the following:

Septic tanks within 100 m [] Unbunded rubbish tips/landfill []
 Seasonally fertilised lawns or grazing areas [] Agriculture with high nutrient output []

10. AREA OF WETLAND MODIFIED

What percentage of the wetland and buffer has been modified within the boundaries you have chosen? To determine this you may need to calculate

$\frac{\text{TOTAL AREA MODIFIED} \times 100}{\text{AREA OF WETLAND} + \text{BUFFER}}$

Tick the appropriate box 0-10% [] 11-20% [] 21-30% []
 31-40% [] >40% []

11. RESERVE AREA

SCORE

Wetland area (refer to question 10) _____

Calculate the area of reserved land containing the wetland, AND/OR

area of private land allocated to the wetland by the landowner(s) _____

(Show calculation in margin)

12. NATIVE VEGETATION BUFFER

What is the total perimeter of the wetland? _____ m

What percentage of the property boundary chosen is at least 50 m from the wetland edge and is covered with native vegetation?

100-90% [] 79-70% [] 59-50% []
 89-80% [] 69-60% [] <50% []

C. HUMAN USE

***13. AESTHETICS**

Record any of the following aspects related to aesthetics:

- Little if any artificial noise [] Steep ridge visible as part of scenery []
 Ridge accessible giving view of wetland [] Wetland is a lake & open water easy to view []
 Understorey mostly intact [] Few or no roads or buildings obvious from wetland []
 A section of wetland exists where few people visit []

***14. HISTORICAL/ARCHAEOLOGICAL FEATURES**

Note the presence of any of the following:

Aboriginal site [] Pioneer relics []
 National Trust site [] National Estate listing []

***15. SECURITY OF WETLAND**

Total No. of owners _____

Using the codes below list the owner types.
 PO - private; LA - local authority; VA - vested res or DPUD land; CL - vacant Crown land

Owner 1 _____ Owner 2 _____ Owner 3 _____

Major owner _____

Reserve class and number _____

Reserve purpose:

a In full

b Summary: tick the appropriate box.

A Class Reserve for conservation/recreation []
 MRS owned by local authority or government department []
 Other vested reserve []
 Other (eg private or vacant Crown land) []

System 6 Recommendation No. MRS Zone (use codes below)
 PAR - parks & recreation; PUB - public purposes; RRL - rural; SF - State Forest;
 IND - industry & special industry; TRS - transport (road and rail); URB - urban, urban deferred,
 civic and cultural

***16. PROTECTION GROUPS**

SCORE

Are there active protection groups for this wetland? Yes/No
 If yes, give the details below.

NAME(S) _____

CONTACT PERSON(S) _____

ADDRESS(ES) _____

PHONE NUMBER(S) _____

***17. PASSIVE RECREATION**

Is the wetland used or has it facilities for the following - tick the appropriate box(es)?

- nature study/bird watching [] education (school <500 m) []
 picnic/barbecue facilities [] recognised tourist venue []
 conservation of flora [] conservation of fauna []
 recognised research site [] protection/preservation of other attributes []

***18. ACTIVE RECREATION**

Is the wetland used or has it facilities for any of the following active recreation pursuits:

- walking, jogging or cycling [] horse riding [] trail bike []
 playground [] oval [] other []

***19. OTHER HUMAN USES**

Is the wetland used for any of the following? tick box(es)

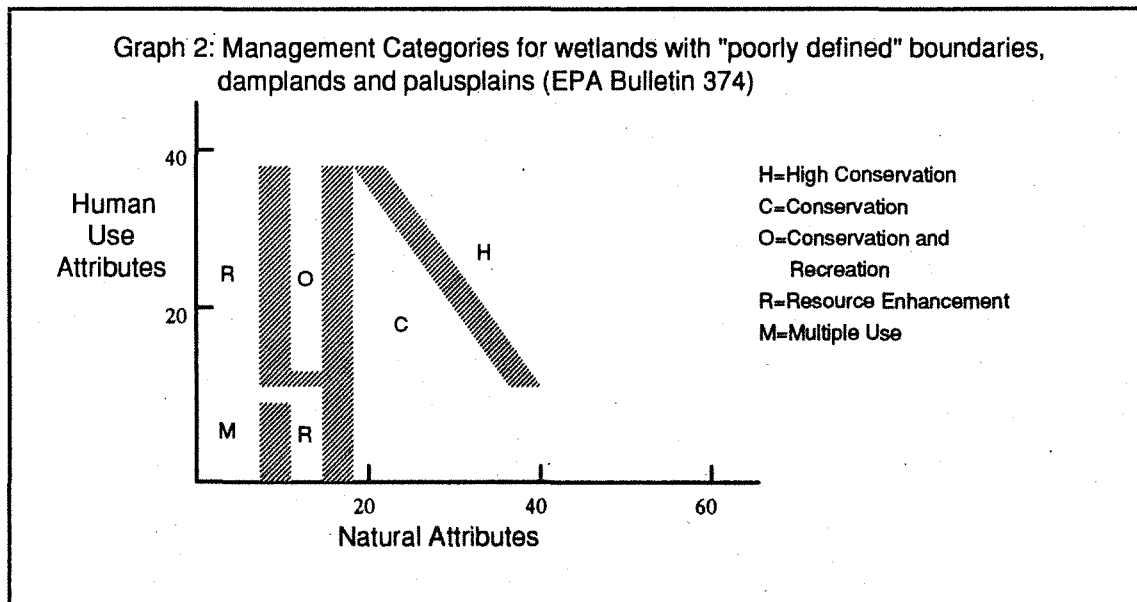
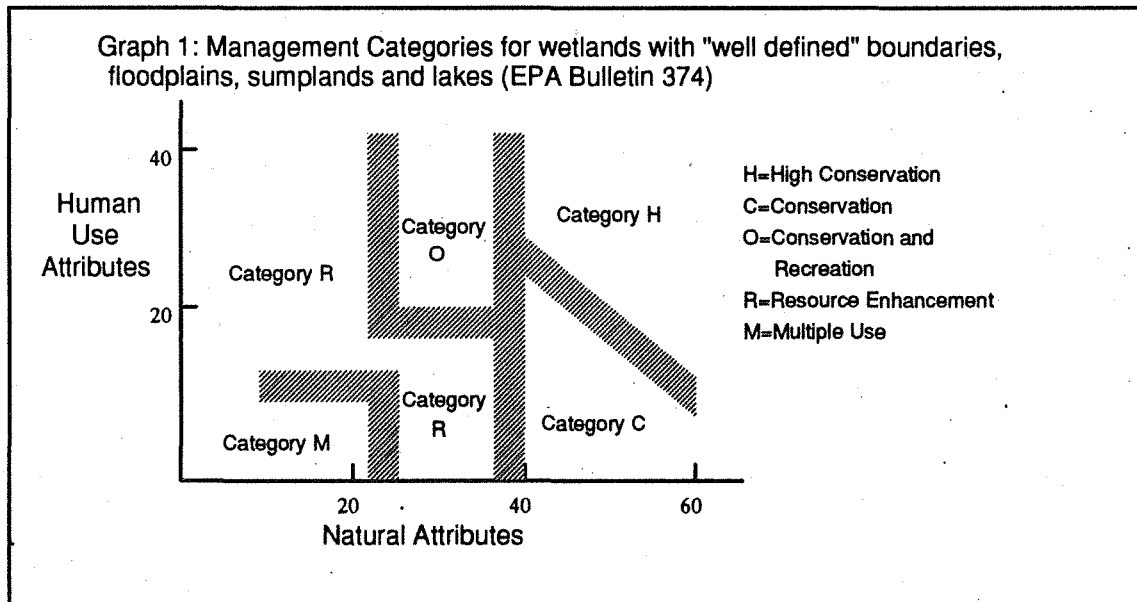
agriculture []
 mining (check for mining leases) []
 water supply []
 existing/proposed service corridors (roads, SEC) []
 proposed urban/housing []
 private purposes other than above []

***20. MAKE A ROUGH SKETCH OF THE AREA, BELOW OR ATTACHED, INCLUDING IF YOU CAN THE BOUNDARIES YOU CHOSE, DIMENSIONS, NORTH DIRECTION, RESERVES, WATERBODY, VEGETATION ZONES, TRACKS, ROADS, FENCES, ETC.**

MISCELLANEOUS COMMENTS

Appendix A: EPA Bulletin 374 Management Category Graphs

The graphs below are used to determine the management category of wetlands using the Bulletin 374 questionnaire. This is done by plotting the natural attributes and human use attributes totals on the Y and X axes respectively, which results in the wetland being placed in one of the five management categories. If the wetland falls into one of the transition zones (hatched areas) then the Supplementary Questionnaire is answered (See Appendix B).



APPENDIX B

ENVIRONMENTAL PROTECTION AUTHORITY BULLETIN 374

A Guide to Wetland Management in Perth

SUPPLEMENTARY QUESTIONNAIRE

The Bulletin 374 supplementary questionnaire is used to determine the most appropriate management category for a wetland where the natural and human use attribute scores fall in the transition zones in the management category graph.

If the answer is YES in question (i) the wetland should be moved to the management category to the right. If NO, move to the left.

If the answer to either (ii) or (iii) is YES, move upwards, if NO move downwards.

NOTE: The presence of Gazetted Rare and Endangered species in a wetland automatically places that wetland in the "High Conservation" management category.

(i) Species rarity

Are rare species of animals or plants present or are there communities represented which have a limited distribution?

Source: Department of Conservation and Land Management, local government authorities, conservation groups, literature searches.

Management Notes: Wetlands supporting rare and endangered species should be given priority when allocating resources for the formulation of management plans and implementation of field works.

(ii) Effect on land values

Does the wetland significantly enhance real estate values and land rates around it? ie. Does the wetland add more than 10% to the value of nearby houses?

Source: local government authorities, real estate agents.

Management Notes: The enhancement of real estate values is a legitimate reason for increased expenditure on the active management of a wetland.

(iii) Human use

Do more than 100 people visit the wetland each week?

Source: Extended field surveys, State and local government recreation departments.

Management Notes: This question provides a good measure of the need for human use management.

APPENDIX C: WETLANDS IN THE CITY OF ARMADALE
(Grouped by Wetland Type, Sub-grouped by Management Category)

KEY TO SYMBOLS USED IN APPENDIX C		
WETLAND TYPE	MANAGEMENT CATEGORY	NATURAL GROUP
L=Lake S=Sumpland D=Dampland AL=Artificial Lake F=Floodplain P=Palusplain R=River	H = High Conservation C = Conservation O = Open Space R = Resource Enhancement M = Multiple Use NE = Wetland Not Assessed/Evaluated	B.3: JANDAKOT SUITE (Bassendean Dunes) B/P.2: MUNGALA SUITE (Bassendean Dunes/Pinjarra Plain Transition) B/P.4 BENNETT BROOK SUITE(Bassendean Dunes/Pinjarra Plain Transition) P.1: KEYSBROOK SUITE(Pinjarra Plain) D.1: WALYUNGA SUITE (Darling Plateau) D.2: LITTLE DARDANUP SUITE (Darling Plateau)

WETLAND NAME/CODE	WET. TYPE	MAN CAT	VEG. STAT	WETLAND AREA (ha)	NATURAL GROUP
LAKES					
High Conservation Lakes					
22L FORRESTDALE LAKE	L	H	VP	221.9	B/P.4
Total: High Conservation Lakes				221.9	
TOTAL LAKES				221.9	
SUMLANDS					
High Conservation Sumplands					
1S GREEN'S SWAMP	S	H	VV	22.8	B.3
Total High Conservation Sumplands				22.8	
Conservation Sumplands					
6(A)S FORREST/WARTON RDS	S	C	VV	13.4	B.3
21(A)S GIBBS/WRIGHT RDS	S	C	VV	12.5	B.3
19S TAYLOR/GIBBS RDS	S	C	VP	6.2	B.3
14S GIBBS RD SUMLAND	S	C	VV	38.3	B.3
29S FORRESTDALE SUMLAND	S	C	P-	120.2	B/P.4
34(A)S PIARA RESERVE (Mason Rd Sumpland)	S	C	VV	10.8	B/P.4
7S RANFORD RD	S	C	VP	4.3	B/P.4
32 (D)S BALANNUP 'LAKE'	S	C	P-	46.5	B/P.4
408S HILBERT RD SUMLAND	S	C	VP	4.7	P.1
Total: Conservation Sumplands				256.7	
Open Space Sumplands					
32(C)S BALANNUP 'LAKE'	S	O	P-	58.4	B/P.4
Total: Open Space Sumplands				58.4	
Resource Enhancement Sumplands					
8(A)S BORONIA/WARTON RDS	S	R	P-	11.2	B.3

23S FORREST/TAYLOR RDS	S	R	VP	1.1	B.3
27S GIBBS/TAYLOR RDS	S	R	P-	4.6	B.3
10S KEANE/WRIGHT RDS	S	R	VC	1.4	B.3
12S TAYLOR/FORREST RDS	S	R	P-	46.6	B.3
28S OXLEY/NICHOLSON RDS	S	R	VC	75.1	B.3
4(O)S GIBBS/NICHOLSON RDS	S	R	C-	21.9	B.3
9S RANFORD/ANSTEY RDS	S	R	VP	1.9	B/P.4
17S ALLEN/ARMADALE RDS	S	R	P-	25.7	B/P.4
24(A)S WRIGHT 'LAKE'	S	R	P-	22.5	B/P.2
415S FORREST/NICHOLSON RD	S	R	P-	1.9	B/P.4
414S WOLFE RD SUMPLAND	S	R	P-	1.5	B.3
416S FORREST/NICHOLSON RD	S	R	P-	9.8	B/P.4
406(B) OXLEY RD SUMPLAND	S	R	P-	12.0	B/P.4
Total: Resource Enhancement Sumplands				237.2	
Multiple Use Sumplands					
5S WARTON/FORREST RDS	S	M	P-	5.9	B.3
34(B)S MASON RD SWAMP	S	M	C-	2.7	B/P.4
403S ROWLEY RD SUMPLAND	S	M	C-	5.7	P.1
404S ROWLEY RD SUMPLAND	S	M	C-	1.5	P.1
405S ROWLEY RD SUMPLAND	S	M	C-	3.8	P.1
406(A) OXLEY RD SUMPLAND	S	M	C-	51.7	B/P.4
411S FORREST/ELEVENTH RD	S	M	C-	4.7	P.1
Total: Multiple Use Sumplands				75.9	
Sumplands Not Assessed/Evaluated					
407S SEVENTH AVE SUMPLAND	S	NA	P-	2.3	P.1
410S STIRLING/OXLEY RD	S	NA	P-	31.5	B/P.4
412S FREEMAN RD SUMPLAND	S	NA	P-	26.7	B.3
413S TAYLOR RD SUMPLAND	S	NA	VP	3.6	B.3
Total: Sumplands Not Assessed				64.1	
TOTAL SUMPLANDS				715.1	
DAMPLANDS					
High Conservation Damplands					
2D WARTON/RANFORD/NICHOLSON	D	H	VV	1.4	B.3
4(B)D WRIGHT/RANFORD/WARTON	D	H	VV	5.8	B/P.4
4(A)D ANSTEY/KEANE JUNCTION	D	H	VV	128.9	B/P.4
Total: High Conservation Damplands				136.1	
Conservation Damplands					
4(N)D GIBBS/TAYLOR RDS	D	C	VV	51.0	B.3
11D WRIGHT/KEANE RDS	D	C	VC	1.9	B/P.4
4(P)D ANSTEY/KEANE RDS	D	C	VP	35.5	B.3
4(C)D WRIGHT/MASON RDS	D	C	VP	19.0	B.3
4(D)D FORREST/ANSTEY RDS	D	C	VP	53.3	B/P.4

4(J)D HALE RD	D	C	P-	121.7	B/P.4
26(C)D ALLEN RD/SOUTHERN R.	D	C	VV	19.3	B/P.4
Total: Conservation Damplands				301.8	
Resource Enhancement Damplands					
4(G)D FORREST/WRIGHT RDS	D	R	P-	43.9	B.3
31D WARTON/NICHOLSON RDS	D	R	C-	65.4	B.3
33(A)D ACOURT/WARTON RDS	D	R	C-	29.5	B.3
4(I)D NICHOLSON/WRIGHT RD	D	R	C-	142.1	B/P.4
26(T)D RANFORD/WARTON RDS	D	R	-	29.5	B/P.4
30(A)D ROWLEY/NICHOLSON RD	D	R	P-	133.9	B.3
4(Q)D ARMADALE DAMPLAND	D	R	P-	28.8	B.3
4(M)D FORREST/TAYLOR RDS	D	R	P-	42.6	B.3
4(H)D WRIGHT/MASON/FORREST	D	R	C-	26.3	B.3
4(K)D FORREST/NICHOLSON RDS	D	R	C-	40.8	B/P.4
4(L)D ARMADALE DAMPLAND	D	R	P-	18.6	B/P.4
13D ALLEN RD/BALANNUP SPRING	D	R	P-	4.8	B/P.4
4(E)D ANSTEY RD	D	R	P-	100.3	B/P.4
26(B)D ALLEN/RANFORD RDS	D	R	C-	141.7	B/P.4
26(A)D ALLEN/FORREST RDS	D	R	VC	42.3	B/P.4
26(D)D WESTFIELD RD/STHN R.	D	R	P-	133.2	B/P.4
Total: Resource Enhancement Damplands				1023.7	
Multiple Use Damplands					
4(F)D WRIGHT/FORREST RDS	D	M	C-	41.5	B.3
25D KARGOTICH/FORREST RDS	D	M	C-	20.2	B/P.4
16D WESTFIELD RD	D	M	C-	3.4	B/P.4
Total: Multiple Use Damplands				65.0	
Damplands Not Assessed					
26(S)D ARMADALE DAMPLAND	D	NA	-	4.5	B/P.4
279D WESTFIELD PK SCH DAMPLAND	D	NA	-	44.5	B/P.2
282D DARLING RANGE WETLAND	D	NA	-	1.4	D.2
283D DARLING RANGE WETLAND	D	NA	-	8.7	D.2
295D DARLING RANGE WETLAND	D	NA	-	1.2	D.2
284D DARLING RANGE WETLAND	D	NA	-	1.3	D.2
285D DARLING RANGE WETLAND	D	NA	-	3.0	D.2
286D DARLING RANGE WETLAND	D	NA	-	2.7	D.2
297D DARLING RANGE WETLAND	D	NA	-	1.2	D.2
287D DARLING RANGE WETLAND	D	NA	-	4.5	D.2
289D DARLING RANGE WETLAND	D	NA	-	0.9	D.2
288D DARLING RANGE WETLAND	D	NA	-	1.5	D.2
293D DARLING RANGE WETLAND	D	NA	-	3.9	D.2
298D DARLING RANGE WETLAND	D	NA	-	1.1	D.2
292D DARLING RANGE WETLAND	D	NA	-	1.6	D.2
294D DARLING RANGE WETLAND	D	NA	-	3.3	D.2
291D DARLING RANGE WETLAND	D	NA	-	5.2	D.2

Total: Damplands Not Assessed				90.5	
TOTAL DAMPLANDS				1617.1	
ARTIFICIAL LAKES					
Artificial Lakes Not Assessed					
280AL WESTFIELD PK SCH ART.LAKE	AL	NA	-	1.7	B/P.2
409AL TWELTH/FORREST RD	AL	NA	P-	4.5	B/P.4
Other Artificial Lakes				129.0	
Total: Artificial Lakes Not Assessed				6.3	
TOTAL: ARTIFICIAL LAKES				135.3	
FLOODPLAINS					
Floodplains Not Assessed					
401F SOUTHERN R.FP,TWELTH RD	F	NA	VC	6.9	B/P.4
402F SOUTHERN R FP,TWELTH RD	F	NA	VC	5.1	B/P.4
Total: Floodplains Not Assessed				11.9	
TOTAL: FLOODPLAINS				11.9	
PALUSPLAINS					
High Conservation Palusplains					
3P RES 27165 FORRESTDALE	P	H	VV	11.8	B/P.4
Total: High Conservation Palusplains				11.8	
Open Space Palusplains					
20P RANFORD/WESTFIELD RDS	P	O	VP	9.3	B/P.4
Total: Open Space Palusplains				9.3	
Multiple Use Palusplains					
18(A)P ARMADALE	P	M	C-	2189.9	P.1
Total: Multiple Use Palusplains				2189.9	
Palusplain Not Assessed					
18(B)P ARMADALE PALUSPLAIN	P	NA	146.2	B/P.4	
46(D)P CANNING R. PALUSPLAIN	P	NA	35.6	R.2	
281P DARLING RANGE WETLAND	P	NA	7.6	D.1	
296P DARLING RANGE WETLAND	P	NA	2.8	D.2	
299P DARLING RANGE WETLAND	P	NA	11.9	D.2	
290P DARLING RANGE WETLAND	P	NA	14.0	D.1	
Total palusplains Not Assessed				218.2	
TOTAL PALUSPLAINS				2429.2	
TOTAL AREA OF ARMADALE'S WETLANDS					
				5130.5	

APPENDIX D

SOUTHERN BROWN BANDICOOT/QUENDA SIGHTINGS IN THE CITY OF ARMADALE AND THE PERTH METRO AREA

The two tables below list sightings of the Southern Brown Bandicoots logged with CALM from April 1991 to December, 1992. Sightings within the City of Armadale are listed first, in alphabetical order, followed by those for the remainder of the Perth Metropolitan Area. Each sighting is provided with the number of individuals seen and the cause of death if the animal sighted was dead.

SIGHTINGS LISED FOR THE CITY OF ARMADALE				
SUBURB	LOCATION	No.	DEATHS	COMMENTS
ARMADALE	36 McNEIL RD	>1		
ARMADALE	56 CARRICK RD, NR QUARRY RD	>1		
BEDFORDALE	CHURCHMAN'S BROOK RD	1	CATKILL	
FORRESTDALE	109 LENTARA RD			DIGGINGS ONLY
FORRESTDALE	ARMADALE GOLF CRS, FORREST RD	6		
FORRESTDALE	ARMADALE GOLF CRES, FORREST RD	2		
FORRESTDALE	ARMADALE GOLF CRES, FORREST RD	>1		ON FAIRWAYS
FORRESTDALE	CNR NICHOLSON/ROWLEY RDS	2	RKILL	
FORRESTDALE	CNR NICHOLSON/FORREST RDS	1	RKILL	
FORRESTDALE	CNR WARTON/NICHOLSON RDS	>1		
FORRESTDALE	HANLIN RD	>1		
FORRESTDALE	LOT 109 MUSTANG RD	3		
FORRESTDALE	LOT 284 COMMERCIAL RD	5		
FORRESTDALE	LOTS 65/66 ANSTEY RD	>1		PSD INDUSTRIAL
FORRESTDALE	ROWLEY RD	1	RKILL	
FORRESTDALE	ROWLEY RD, NR FORRESTDALE LAKE	2	RKILL	
FORRESTDALE	WARTON RD, NR HARRIS SW	1	RKILL	
KARAGULLEN	17 ELIZABETH PLACE	1	CATKILL	
KELMSCOTT	CNR ALBANY HWY/OTTAWAY RD	1	RKILL	BUILT-UP AREA
KELMSCOTT	KELMSCOTT PRIMARY, RIVER RD	>1		
KELMSCOTT	LOT 190 BUCKINGHAM RD	1		
KELMSCOTT	PATERSON RD	1		
ROLEYSTONE	17 LESCHENAULTIA ST	>1		
ROLEYSTONE	268 URCH RD	>1	RKILL	MANY DIGGINGS
ROLEYSTONE	3.3KM WEST CHEVIN/BROOKTON RD	1	RKILL	
ROLEYSTONE	4 KNUCKEY CRT	>1	CATKILL	
ROLEYSTONE	5 MANN PL	>1	CATKILL	
ROLEYSTONE	6 RODGERS CRT	1		
ROLEYSTONE	9 POUND PL NEAR STONEY BROOK	1	CATKILL	
ROLEYSTONE	92 CROYDEN RD	1		
ROLEYSTONE	BIRTWISTLE RD	1		
ROLEYSTONE	CROYDEN RD TEAROOMS	>1		
ROLEYSTONE	HAWKSTONE RD	>1		
ROLEYSTONE	LOT 131 OLD COAST PL	1		
ROLEYSTONE	LT 32 BROOKTON HW, AGOSTINO RD	>1	CATKILL	
ROLEYSTONE	MACKEY RD	>1		
ROLEYSTONE	PEET RD, BTWN CHEVIN, RAEBURN	1	RKILL	
ROLEYSTONE	POUND PL, OPPOSITE STONY BROOK	1		
ROLEYSTONE	RESERVE NR PEET/KNUCKEY DR	10		
WESTFIELD	15 GLENHURST CRT	1		
WUNGONG	CORNER NINTH AVE/WUNGONG RD	1	RKILL	

SIGHTINGS LISTED FOR AREAS OUTSIDE OF THE CITY OF ARMADALE (Listed alphabetically by suburb)				
SUBURB	LOCATION	No.	DEATHS	COMMENTS
BALDIVIS	CNR DOGHILL & YOUNG RD	1	RKILL	
BALDIVIS	CNR ST. ALBANS/ZIGZAG RDS	1	RKILL	
BALDIVIS	MUNDIJONG RD	1	RKILL	
BANJUP	34 BORONIA RD	20		
BANJUP	CNR GIBBS/LIDDELOW RDS	>1		PPSD SUBDIVISION
BANJUP	DENNIS DE YOUNG RESERVE,	>1	RKILL	
BECKENHAM	1596 ALBANY HWY	>1		BUSH AT BACK
BECKENHAM	CNR WILLIAM/WELSHPOOL RDS	1		
BECKENHAM	CNR WILLIAM/WELSHPOOL RDS	1		
BELHUS	VINES AVE	1		
BIBRA LAKE	CNR HOPE/BIBRA DR	1		
BIBRA LAKE	HOPE RD, NR BIBRA DR	1	RKILL	
BIBRA LAKE	WEST SIDE OF LAKE, NR SCHOOL	1		
BYFORD	FLOUR MILL, MICHAEL ST	>1		
BYFORD	THOMAS ROAD RAIL CROSSING	>1		
CANNING VALE	30 TEMPLTONIA ST, LIVINGSTON	1		FEEDS AT HOUSE
CANNING VALE	VULCAN RD, BEHIND FIRE BRIGADE	1		
CANNING VALE	29 CATALANO RD, MYERS BAKERY	1		
CANNING VALE	AMHERST RD, NR GOLF COURSE	4		
CANNING VALE	CLIFTON & NICHOLSON RDS	>1	RKILL	
CANNING VALE	FRONT OF LIVINGSTON ESTATE	>1	RKILL	
CANNING VALE	CNR GOVAN/NICHOLSON RDS	1	RKILL	WHITTOME LAND
CANNING VALE	LOT 12A AMHERST RD	>1	RKILL	NUMEROUS SIGHTINGS
CANNING VALE	LOT 9 SPINIFEX PLACE	>1	RKILL	
CANNING VALE	RANFORD RD NR CLIFTON/HOPE RDS	>1		
CARABOODA	WANNEROO RD, 7.25KM N OF QUINNS	1	RKILL	
CASUARINA	ORTON RD, CNR FIREBREAK	>1		
EAST ROCKINGHAM	CNR DAY/OLD MANDURAH RDS	1	RKILL	REGULAR RKILLS
ELLENBROOK	MARALLA RD, ELLENBROOK ESTATE	>1	RKILL	
ELLENBROOK	MARALLA RD, ADJACENT VINES EST	>1		"HILLS GAZETTE"
ELLENBROOK	LOT 1452, MARALLA RD			
FORRESTFIELD	450M SOUTH OF ROE/TONKIN HWY	1	RKILL	
FORRESTFIELD	ROE HWY RUBBISH TIP	1		
FORRESTFIELD	VINTAGE CAR CLUB, CARETAKER'S	>1		FRMR CARETAKER
FORRESTFIELD	VINTAGE CAR CLUB, HALE/TONKIN	1		
FORRESTFIELD	VINTAGE CAR CLUB	1		
FORRESTFIELD	VINTAGE CAR CLUB, HALE RD	1		
FORRESTFIELD	WATERFALL RD, BASE OF FALLS	2		
GLEN FOREST	BETWEEN HAWTER/FERGUSON RDS	1		IN VALLEY
GOLDEN BAY	1 WOODLANDS RD	3		
GOOSEBERRY HILL	NR CNR ZAMIA/KALAMUNDA RDS	1	RKILL	
GOOSEBERRY HILL	4 CURRAWONG DRIVE	1		
GOSNELLS	500M FROM END OF VERNA ST	1		
GOSNELLS	35 MILLS RD	1		SEEN IN FIG TR.

GOSNELLS	RICHARD RUSTON CENTRE	1		
GREENMOUNT	VACANT BLOCK NR 20 CAMFIELD RD	>1		
HENLEY BROOK	LOT 66, PARK ST			DIGGINGS SIGHTED
HIGH WYCOMBE	35 BRAE RD	1		RAISING YOUNG
HIGH WYCOMBE	47 BRAE RD	1		
HIGH WYCOMBE	BRAND RD	>1		
HIGH WYCOMBE	VACANT BLOCK ADJ 35 BRAE RD	10		
HOPE VALLEY	ARMSTRONG ROAD	1		
HUNTINGDALE	GOSNELLS PONY CLUB, BALFOUR ST	1		
JANDAKOT	21 GLENDALE CRESS	2		FEEDING NR HSE
JANDAKOT	300M KWINANA FWY/FORREST RD	2		MANY DIGGINGS
JANDAKOT	AIRPORT ENTRANCE	>1		
JANDAKOT	AIRPORT ENTRANCE ON RIGHT	>1		
JANDAKOT	GLENDALE CRES	>1	RKILL	ALSO CATKILLS
JANDAKOT	LAWN ENTERING AIRPORT	9		
JANDAKOT	LEFT FORK LAWN AIRPORT	3		
JANDAKOT	LEFT OF AIRPORT ENTRANCE	2		FEEDING ON LAWN
JANDAKOT	PRINSEP RD/HOPE RD	1		
JANDAKOT	VERNA CRT, BEFORE FREEWAY	2		
JARRAHDALE	1KM NORTH OF JUBB RD RW	2		
JARRAHDALE	JUBB RD, NEAR CREEK	2		
KALAMUNDA	110 HUMMERSTON RD, NEAR CREEK	1		
KALAMUNDA	SPRING RD, NEAR QUARRY	1		
KENWICK	1 PARK RD	>1		
KENWICK	15 AVILA PLACE	1	DOG KILL	
KENWICK	15 OLIPHANT ST, NR BICKLEY BRK	>1	CAT KILL	
KENWICK	19C AVILA PLACE	1		FEEDS AT HOUSE
KENWICK	19B AVILA PLACE	2		
KENWICK	21 BOUNDARY RD	10		
KENWICK	234 BICKLEY RD	>1		
KENWICK	268 VICTORIA RD	>1		FEEDS WITH CATS
KENWICK	82 STAFFORD RD	1	CAT KILL	
KENWICK	99 WANAPPING RD, TO RAILWAY	>1	CAT KILL	
KENWICK	BRIXTON STREET RESERVE	>1		
KENWICK	BRIXTON STREET RESERVE	1		
KENWICK	CNR BICKLEY/BROOK RDS	>1	RKILL	+RKILL JAN 1992
KENWICK	CNR BRIXTON/ALTON RDS	1	RKILL	
KENWICK	GROVE RD	1	RKILL	
KENWICK	MYOLA RD, NR BICKLEY BRROK	1		
KENWICK	VICTORIA RD	>1		
KENWICK	YULE BROOK RESERVE	1		
KEWDALE	WESTRAIL FREIGHT TERMINAL	1		
LANGFORD	MIDDLETON NURSERY	>1		
LANGFORD	TOM BATEMAN SPORTS COMPLEX	1		
LESMURDIE	CNR WELSHPOOL/LESMURDIE RDS	1	RKILL	
LESMURDIE	FALLS PICNIC AREA	1		
LESMURDIE	FALLS PICNIC AREA	1		
LESMURDIE	FALLS PICNIC AREA	2		
LESMURDIE	FALLS PARK PICNIC AREA	1		
LESMURDIE	FALLS PARK PICNIC AREA	1		
MADDINGTON	105 CLIFFORD ST	>1		

MADDINGTON	BETWEEN DELLAR RD & TONKIN HWY	1		
MAIDA VALE	HAWTIN RD	1	RKILL	
MAIDA VALE	HAWTIN RD	2		
MANDURAH	MANDURAH BYPASS/RAFFERTY RD	1	RKILL	
MUNDIJONG	ALONG WATKINS/WRIGHT RDS RW	>1	RKILL	
MUNDIJONG	LOWLANDS RD, OFF WRIGHT RD	3		
MUNDIJONG	ON WRIGHT/PUNRAK RDS	>1	RKILL	
MUNDIJONG	WATKINS RD	>1		
MUNSTER	200M NW MAYOR/FAWCETT MAYOR RD	1	RKILL	
MUNSTER	JERVOIS BAY CHALETS, NR REC. CMP	1		
MUNSTER	LOT 8 HENDERSON RD	10		
NEWBURN	100M E TONKIN HW/HORRIE MILLER	1	RKILL	
NORTH LAKE	JUST SOUTH OF NORTH LAKE	1		
OAKFORD	698 NICHOLSON RD	>1	DOGKILL	
OAKFORD	BLAIR RD	2	CATKILL	
OAKFORD	CNR ANKETELL/TUART RD	>1		
OAKFORD	CNR THOMAS/NICHOLSON RDS	1		
OAKFORD	LOT 24 TUART RD	10	FO XKILL	
OCEAN REEF	11 KATOORA PL OPP BEAUMARIS	1		CLEARING HEATH
ORANGE GROVE	KELVIN RD RUBBISH TIP	1	RKILL	
PERTH AIRPORT	100M NW TONKIN/LEACH HWY	1	RKILL	
PICKERING BROOK	CUNNOLD CLOSE	>1	DOGKILL	
ROCKINGHAM	ENNIS AVE	1	CATKILL	
ROCKINGHAM	GOLF COURSE, ELANORA DRIVE	>1		
ROCKINGHAM	LEISURE INN BEER GARDEN	1		
ROCKINGHAM	LEISURE INN BEER GARDEN	>1		
ROCKINGHAM	TAFE COLLEGE, SIMPSON AVE	>1		
ROCKINGHAM	TAFE COLLEGE, SIMPSON AVE	>1		
SERPENTINE	AROUND LOT 821 UTLEY RD & RW	>1		
SERPENTINE	LOT 820 UTLEY RD	>1		
SERPENTINE	CNR HALL/SUMMERFIELD RD	>1		
SERPENTINE	UTLEY/HALL RDS	>1	RKILL	ALSO CATKILLS
SOUTHERN RIVER	CNR RANFORD/WARTON RDS	>1	RKILL	
SOUTHERN RIVER	LOT 1601, BALFOUR ST	>1		
SOUTHERN RIVER	MATISON RD	2		NESTS NEAR HOME
SOUTHERN RIVER	RANFORD/SOUTHERN RIVER RDS	>1		SEEN REGULARLY
SOUTHERN RIVER	RANFORD/BALANNUP/WARTON RDS	1	RKILL	
SOUTHERN RIVER	BTWN BALANNUP LAKE & WARTON RD	1	RKILL	
SOUTHERN RIVER	RANFORD RD, NR BALANNUP LAKE	1	RKILL	
SOUTH GUILDFORD	WATERHALL RD, NR ROSEHILL GOLF	>1	RKILL	
STONEVILLE	ANKETELL RD	1	CATKILL	
SUCCESS	LORIMER RD, NEAR THOMSON	>1		MANY DIGGINGS
THORNLIE	27 MURDOCH RD	2		
THORNLIE	4 MAGENTA CLOSE	>1	CATKILL	
THORNLIE	CNR BARDWELL/BURSLEM RDS	1	RKILL	FRESH DIGGINGS
THORNLIE	CNR HAIGH/FORREST CR.	>1		
THORNLIE	HICKERY/REDHEART RDS (SCHOOL)	2		BUSH NR SCHOOL
THORNLIE	HUME RD WILDLIFE RES			FRESH DIGGINGS
THORNLIE	MULGA CRT	3	CATKILL	
THORNLIE	OFF MURDOCH RD	>1		

THORNLIE	VACANT BLOCK , MURDOCH RD	3		BEING CLEARED
THORNLIE	WILFRED RD	1		
WANDI	? BROUGHT TO VET, MAULED BY FOX	1		
WANDI	LIDDELOW RD, NR NAVEL BASE	>1		
WANDI	LIDDELOW RD	>1		
WANDI	LOT 6 BODEMAN RD	2		
WARNBRO	SAFETY BAY RD	1	CATKILL	
WATTLE GROVE	50M SE TONKIN/ROE HW ON TONKIN	1	RKILL	
WATTLE GROVE	CNR TONKIN/WELSHPOOL RD	1		
WATTLE GROVE	CNR TONKIN/WELSHPOOL RD	2	RKILL	
WATTLE GROVE	CRYSTAL BROOK RD	1		
WATTLE GROVE	HALE RD BTWN TONKIN/ARTHUR RD	>1		
WATTLEUP	PEARSE RD, NR THOMSON LAKE RES	1		
WEST MARTIN	86 MILLS RD, MANOLAH RET. VILL	1		
WHITBY	136 GALVIN RD	>1		
WHITBY	SW HWY, NR LUPINO PK STREAM	1	RKILL	
WHITEMAN	100M S KEITH MAINE YC, BCHBR RD	1	RKILL	
WILSON	100M NW KENT ST WEIR			DIGGINGS
WINTHROP	EASTEND PINEY LAKES RES, MUR. DR	2		
YANGEBUP	35 PIONEER DR	1		
YANGEBUP	CNR OSPREY/MUDLARK, NR L. YANGBP	1	CATKILL	
YUNDERUP	ONE OF THE ISLANDS	1		

APPENDIX E

ARMADALE'S WETLANDS IN A REGIONAL PERSPECTIVE

Natural Groups of Wetlands in the Perth to Bunbury Region

A regional perspective of Armadale's wetlands may be gained from the concept of natural wetland groups, defined as consanguineous wetland suites by C.A. Semeniuk. (The term "consanguineous" denotes "relatedness".)

Mapping of consanguineous suites (as seen in Map 1) shows which wetlands share a common origin and developmental history. Wetlands within the same natural group may also be expected to be of similar size and shape, with a similar stratigraphy, hydrological dynamics and water salinity (Semeniuk, 1987b).

Thirty-two wetland suites have been mapped by C.A. Semeniuk in the Wedge Island to Mandurah part of the Perth to Bunbury Region. These are listed overleaf with the common stratigraphy and origin of the wetlands within each suite. Six of these natural groups or suites occur within the City of Armadale as shown in Table 3. (The natural group into which each wetland falls is shown in Table 7).

The concept of natural wetland groups may be used in conjunction with Semeniuk's classification of wetlands to guide wetland research and reserve selection. For example, it may explain why two lakes within different suites are quite dissimilar, or why a floodplain and a sumpland within the same suite share a number of common features. For the natural resource manager, the concept of natural groupings may provide guidance when selecting wetlands as representative examples of the resource for the conservation estate.

Statistics of the of Region's Wetlands by Natural Group

The wetlands of the Gingin to Mandurah, including those of the City of Armadale have been grouped by consanguineous suite. Wetlands which may occur within the City of Armadale's have been highlighted to provide a regional perspective of the City's wetlands.

APPENDIX E: NATURAL GROUPINGS (Consanguineous Suites) OF WETLANDS IN THE PERTH TO BUNBURY REGION

GEOMORPHIC SETTING	CONSANGUINEOUS WETLAND SUITE		DESCRIPTION OF WETLAND SUITES		
	NAME	KEY	STRATIGRAPHY (Semeniuk, 1987b)	ORIGIN OF WETLANDS (Semeniuk, 1987b)	PRIMARY WETLANDS (after Semeniuk, 1987b)
	Cooloongup	Qu.1	Carbonate mud over Becher sand; L.Richmond:unfilled with sedi	Originated as barred oceanic basins as part of the prograding shoreline; now freshwater rec	Lakes
Quindalup Dunes	Becher	Qu.2	Humic sand or peat & thin carbonate mud over Safety Bay sand	Wetlands are a series of inter-ridge depressions which intersect the water-table	Sumplands & damplands
	Peelhurst	Qu.3	Safety Bay sand overlain by (carbonate) muddy sand	Wetlands are basins deflated to the water table by prevailing onshore winds	Sumplands and damplands
	Yanchep	S.1	Thin layer of peat overlying grey to yellow sand	Wetlands occur in depressions between limestone ridges fed by discharge from limestone &	Lakes and sumplands
Spearwood Dunes	Balcatta	S.2	Variable: Peat over yellow sand, to peat & clay over thick yellow	Wetlands occur in depressions between hills	Sumplands (& lakes subsequent to clearing)
	Coogee	S.3	Carbonate mud overlying limestone	Carbonate mud filled depressions now acting to pond meteoric water	Lakes and sumplands
	Stakehill	S.4	Carbonate mud and peat overlying yellow sand	Carbonate and mud filled depressions	Sumplands and damplands
Spearwood/Bassendean Dunes Interface	Bibra	S/B.1	Mud, peat or peaty sand overlying Bassendean Sand	Contact depressions with g/water impounded against Spearwood Dune ridge	Lakes and sumplands in a north-south chain
Bassendean Dunes	Pinjar	B.1	Quartz sand sheet overlying clay sheet on Bassendean Sand	Coalesced Bassendean Dune wetlands; meteoric water & discharge from Gnarara Mound	Sumpland
	Gnarara	B.2	Diatom mud, peaty sand and clay overlying quartz sand	G/water wetlands. Drainage is impeded by thin clay or diatom mud	Lakes, sumplands & occasional damplands
	Jandakot	B.3	Peat or peaty sand or humic sand overlying quartz sand	G/water surfacing or near surface in depressions to develop water table basins	Damplands & sumplands
	Riverdale	B.4	Clay, peat or peaty sand overlying quartz sand	Wetlands in interdunal swales, recharge by precipitation & g/water, often ponded due to cla	Sumplands and damplands
Bassendean-Pinjarra transition or	Beermullah	B/P.1	Clay	Discharge area for g/water. Precipitation is ponded	Palusplain. A few shallow sumplands & cha
	Mungala	B/P.2	Variable: clays to clay over quartz sand to quartz sand over lateri	Alluvial fan distributaries of creeks terminate in Bassendean sandplain, bringing water and s	Lakes & sumplands; paluspln., floodpln. & cr
Bassendean with fluvial features	Muchea	B/P.3	Complex & variable pattern of quartz sand, clay, laterite and calc	Discharge of g/water. Some ponding due to impermeable sediments	Sumplands; palusplains, floodplains
	Bennett Brook	B/P.4	Quartz sands, or clay overlying quartz sand	Depressions which intersect the water table. Precipitation is ponded by clay	Sumplands; creeks; palusplains; floodplains
Pinjarra Plain	Keysbrook	P.1	Clay overlying lateritic clay and sand	Sediment discharge to develop alluvial fans; g/water seepage, surface runoff from plateau &	Palusplains; creeks
	Moore Estuary	E.1	Quartz sand and shelly sand	Aeolian barrier across river mouth	Estuary
	Swan Estuary	E.2	Mud and sand overlying quartz sand and limestone	Marine-inundated river valley which was receiving basin for Canning, Helena & Swan River	Estuary
Coastal Plain rivers	Peel-Harvey E	E.3	Calcareous mud, muddy sand, quartz sand; limestone in some arc	Marine inundated valley system between two geomorphic units and barrier lagoon	Estuary
	Moore River	R.1	Quartz sand	Fluvial incision; sedimentation; surface runoff	Creeks, river, palusplain, floodplain
	Swan River	R.2	Alluvium of quartz sand and clay	Fluvial incision; sedimentation; surface runoff	River, palusplain, floodplain
	Ellen Brook	R.3	Clays and sandy clays overlying laterite and sandstones	Fluvial incision; sedimentation; surface runoff	Creek, palusplain, floodplain; river
Dandaragan Plateau	Goegrup	R.4	Quartz sand with iron indurated hardpans	Fluvial incision; sedimentation; river has been impounded and water flow reduced	River, floodplains, palusplains, creeks
	Red Gully	Dp.1	Quartz sand	Fluvial incision; surface runoff & depressions receiving g/water discharge from slopes	Creeks & floodplains grading into sumpland
	Coorang	Dp.2	Quartz sand sequence	Fluvial incision; broad valleys are the receiving basins for g/water & precipitation	Sumplands, floodplains, creeks
	Clewley	Dp.3	Clay on sand	Impounded channels segmented to form basins	Sumplands and damplands
Dandaragan Plateau-	Mogumber	Dp.4	Clay on sand	Large basin	Sumplands and damplands
Darling Plateau interface	Wannamal	Dp/D	Quartz sand	Discharge depression for g/water & creeks from Darling Plateau	Sumplands and lakes
Darling Plateau	Walyunga	D.1	Laterite or alluvium overlying Precambrian rocks	Fluvial incision; sedimentation; surface runoff channels	Creeks & rivers
	Little Dardanu	D.2	Laterite detritus or quartz sand and gravel over Precambrian rock	Fluvial incisions; surface runoff in steeply sloped areas; ponding in gently sloped areas	Creeks, rivers, floodplains, palusplains, surr
	Brockman	D.6	Alluvial fills	Established valley. Steep sides eroded to more gentle slopes. River incised.	Rivers
	Suite not defined			(NOTE: g/water = groundwater)	

APPENDIX E: NATURAL GROUPINGS (Consanguineous Suites) OF WETLANDS IN THE PERTH TO BUNBURY REGION

WETLANDS OF EACH NATURAL GROUPING (Consanguineous Suite): Wedge Island to Mandurah																							
CONSANGUINEOUS WETLAND SUITE		TOTAL AREA OF * WETLANDS BY CONSANGUINEOUS SUITE		TOTAL NUMBER OF * BASIN WETLANDS BY CONSANGUINEOUS SUITE		AREA AND NUMBER OF WETLANDS WITHIN CONSANGUINEOUS SUITE																	
						BASIN WETLANDS								FLAT WETLANDS				CHANNEL WETLANDS					
						LAKES				SUMPLANDS				DAMPLANDS				FLOODPLAIN		PALUSPLAIN		RIVER	
NAME	KEY	Area		Number		Area		Number		Area		Number		Area		Number		Area		Area		Area	
		(ha)	%	No.	%	(ha)	%	No.	%	(ha)	%	No.	%	(ha)	%	No.	%	(ha)	%	(ha)	%	(ha)	%
Cooloongup	Qu.1	1465	0.9	8	0.2	1459	99.6	3	37.5	2	0.1	2	25.0	4	0.3	3	37.5						
Becher	Qu.2	159	0.1	233	6.2					113	71.1	58	24.9	46	28.9	175	75.1						
Peelhurst	Qu.3	8	0.0	35	0.9					3	37.5	4	11.4	5	62.5	31	88.6						
Yanchep	S.1	1413	0.8	25	0.7	985	69.7	7	28.0	419	29.7	17	68.0	9	0.6	1	4.0						
Balcatta	S.2	807	0.5	27	0.7	476	59.0	5	18.5	327	40.5	21	77.8	4	0.5	1	3.7						
Coogee	S.3	248	0.1	15	0.4	78	31.5	2	13.3	170	68.5	13	86.7										
Stakehill	S.4	948	0.6	46	1.2					906	95.6	35	76.1	42	4.4	11	23.9						
Bibra	S/B.1	1448	0.9	43	1.1	747	51.6	16	37.2	630	43.5	21	48.8	46	3.2	6	14.0			25	1.7		
Pinjar	B.1	2229	1.3	3	0.1					2228	100.0	2	66.7	1	0.0	1	33.3						
Gnangara	B.2	2281	1.4	193	5.1	773	33.9	19	9.8	1001	43.9	124	64.2	475	20.8	50	25.9			32	1.4		
Jandakot	B.3	11840	7.1	1047	27.7	166	1.4	28	2.7	2941	24.8	298	28.5	7397	62.5	721	68.9			1336	11.3		
Riverdale	B.4	313	0.2	95	2.5	27	8.6	3	3.2	138	44.1	43	45.3	148	47.3	49	51.6						
Beermullah	B/P.1	4699	2.8	47	1.2	9	0.2	5	10.6	53	1.1	33	70.2	9	0.2	9	19.1	10	0.2	4618	98.3		
Mungala	B/P.2	20660	12.4	308	8.1	687	3.3	34	11.0	2691	13.0	210	68.2	1276	6.2	64	20.8	1975	9.6	14031	67.9		
Muchea	B/P.3	6540	3.9	292	7.7	1	0.0	1	0.3	1160	17.7	155	53.1	1206	18.4	136	46.6	423	6.5	3750	57.3		
Bennett Brook	B/P.4	19676	11.8	229	6.1	241	1.2	3	1.3	1431	7.3	140	61.1	6711	34.1	86	37.6	186	0.9	11081	56.3	26	0.1
Keysbrook	P.1	39391	23.6	222	5.9					462	1.2	174	78.4	666	1.7	48	21.6	3	0.0	38260	97.1		
Moore Estuary	E.1	105	0.1								0.0							35	33.3			70	66.7
Swan Estuary	E.2	4032	2.4	18	0.5	3	0.1	4	22.2	17	0.4	8	44.4	9	0.2	6	33.3	23	0.6			170	4.2
Peel-Harvey E	E.3	9545	5.7	9	0.2	29	0.3	2	22.2	109	1.1	6	66.7	5	0.1	1	11.1	436	4.6				
Moore River	R.1	4347	2.6	26	0.7					55	1.3	21	80.8	30	0.7	5	19.2	642	14.8	3620	83.3		
Swan River	R.2	4480	2.7	36	1.0	9	0.2	3	8.3	75	1.7	29	80.6	39	0.9	4	11.1	635	14.2	3211	71.7	177	4.0
Ellen Brook	R.3	11028	6.6	36	1.0					143	1.3	32	88.9	27	0.2	4	11.1	601	5.4	10257	93.0		
Goegrup	R.4	6058	3.6	34	0.9	270	4.5	1	2.9	172	2.8	31	91.2	7	0.1	2	5.9	1141	18.8	3930	64.9	538	8.9
Red Gully	Dp.1	1049	0.6	25	0.7					83	7.9	12	48.0	91	8.7	13	52.0	809	77.1	66	6.3		
Coorang	Dp.2	586	0.4	12	0.3	4	0.7	1	8.3	59	10.1	11	91.7					64	10.9	459	78.3		
Clewley	Dp.3	1524	0.9	174	4.6	53	3.5	2	1.1	291	19.1	91	52.3	420	27.6	81	46.6			760	49.9		
Mogumber	Dp.4	232	0.1	59	1.6					136	58.6	30	50.8	96	41.4	29	49.2						
Wannamal	Dp/D	715	0.4	27	0.7	144	20.1	5	18.5	229	32.0	21	77.8	23	3.2	1	3.7			319	44.6		
Walyunga	D.1	183	0.1	34	0.9					11	6.0	6	17.6	65	35.5	28	82.4			107	58.5		
Little Dardanu	D.2	1713	1.0	53	1.4					55	3.2	14	26.4	160	9.3	39	73.6	819	47.8	679	39.6		
Brockman	D.6	1296	0.8	6	0.2					250	19.3	4	66.7	58	4.5	2	33.3	219	16.9	769	59.3		
Suite not defined		5942	3.6	364	9.6	1499	25.2	16	4.4	855	14.4	129	35.4	2514	42.3	219	60.2	54	0.9	1020	17.2		
		166960	100.0	3781	100.0	7660	4.6	160	4.2	17215	10.3	1795	47.5	21589	12.9	1826	48.3	8075	4.8	98330	58.9	981	0.6