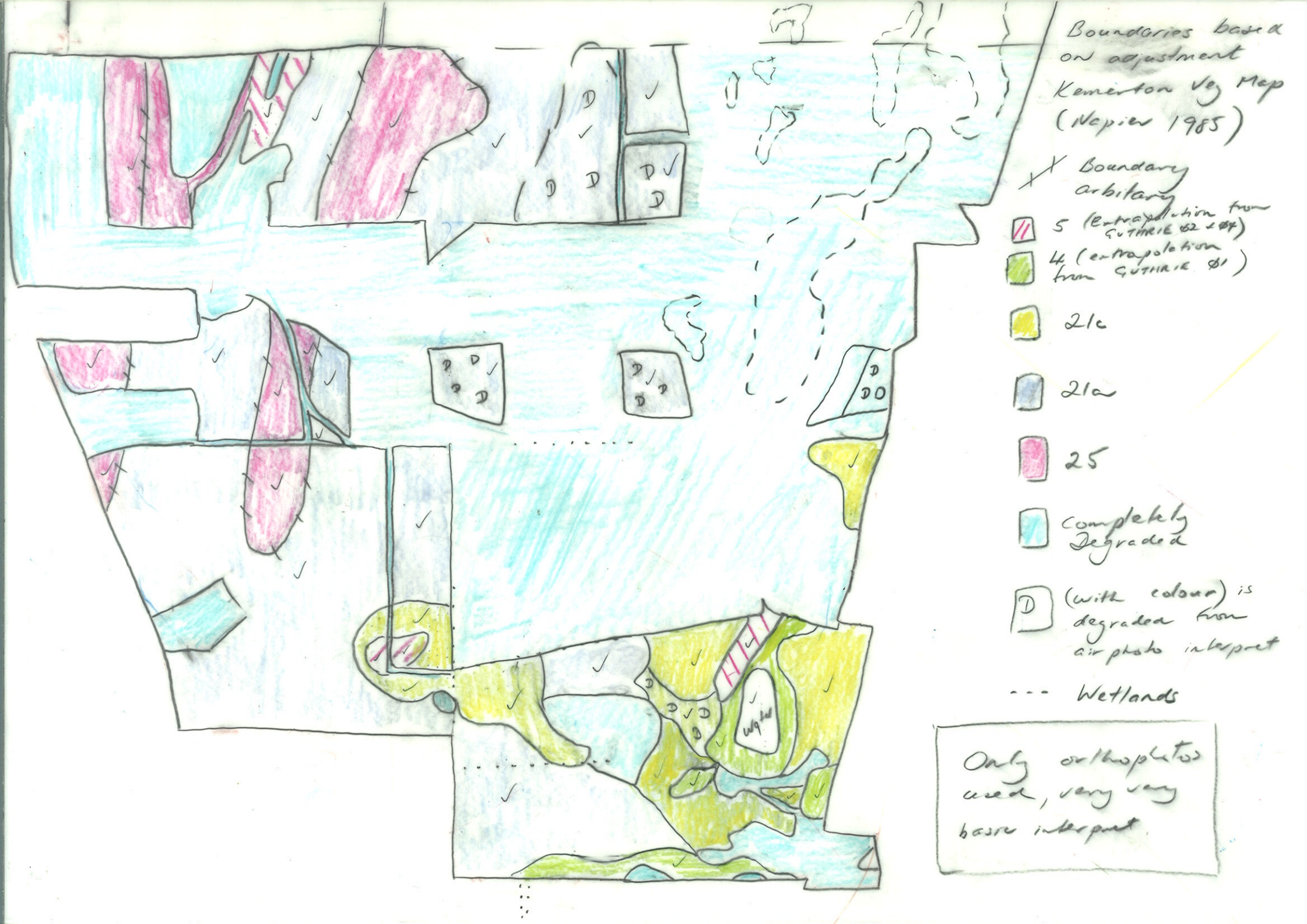

rolled,
?regenerating


Boundaries based on adjustment Kemerton Veg Map (Napier 1985)
Boundary arbitary
5 (extrapolation from GUTHRIE #2 + #4)
4 (extrapolation from GUTHRIE #1)
21c
21a
25
Completely Degraded
D (with colour) is degraded from airphoto interpret
--- Wetlands
Only orthophotos used, very very basic interpret.


5172 WA3786 (C)
BUNBURY (2031)
1: 100000 SHEET AREA
RUN 3 (5163-5177) 1:25000
6/10/96 960011
Copyright DOLA


(2031)
RUN 4 (5178-5192) 1:25000 6/10/96 960011
6/10/96 960011
Copyright DOLA

SHEET (2031)

25

5065 WA3788 (C) BUNBURY (2031)
1: 100000 SHEET AREA
RUN 6 (5060-5074) 1:25

1:25000 6/10/96 960011

BJK 19/5/95

System 6 Update - Floristic Community Type Mapping Information **DRAFT ONLY**

AREA INFORMATION KEMERTON

System 6 Area (C or M) or Update Area (Update)

Conservation Area
Nature Reserve
Reserve No
National Park
Reserve No
Local Government
Reserve No
Other
Proposed Conservation Areas CALM Section 5(g) Forest MP 1994
Local Government
Reserve No
Other

Conservation Area

Nature Reserve
Reserve No
National Park
Reserve No
Local Government
Reserve No
Other

TOTAL AREA Need to obtain CALM boundaries

~~Bushland~~ Area	hectares
Completely Degraded	

AREA MAPPED FLORISTIC UNITS

Units	Site (Condition) Code	Bound	Area (ha)

Boundaries determined by use of

aerial photograph
orthophoto
vegetation map
soil map

System 6 Update - Floristic Community Type Mapping Information **DRAFT ONLY**

KEMERTON

AREA INFORMATION

System 6 Area (C or M) or Update Area (Update)

Conservation Area	
	Nature Reserve
	Reserve No
	National Park
	Reserve No
	Local Government
	Reserve No
	Other
Proposed Conservation Areas	
	Local Government
	Reserve No
	Other

Conservation Area

	Nature Reserve
	Reserve No
	National Park
	Reserve No
	Local Government
	Reserve No
	Other

TOTAL AREA

Bushland Area	hectares
Completely Degraded	
Degraded from airphoto vegetation	
fire grazing, weeds	

AREA MAPPED FLORISTIC UNITS

Units	Site (Condition) Code C KEME	Bound	Area (ha)
4			
5			
21a	Ø2 (2.5)		
21c	Ø3 (2)		
25	Ø1 (3)		

Boundaries determined by use of

aerial photograph	NOT AVAILABLE
orthophoto	2031 1 SW, 1V SE August 1991
vegetation map	A.C. Napier - Vegetation survey of the proposed
~~soil map~~	Nov 1985 Aluminium Smelter Sue & Surrounds Kemerton

KEMERTON

total 2023.75

21a 37.5 + 29.062 + ~~29.688~~ 15 + 59.688 + 31.562 + 192.812 + 74.688 + 8.75 + 1.375 + 17.25 = 467.687

21aD 15.3125 + 12.812 + 39.688 + 13.5 = 81.3125

25 36.875 + 56.875 + 20 + 13.438 + 11.25 + 3.25 + 3.25 + 4 + = 148.938

5 7.25 + 1.875 + 2.875 + 11.5 = 23.5

21c 28.129 + 10.875 + 26.562 + 17.5 + 1.75 + 22.625 + 9.625 + 9.25 = 126.316

21cD 8.25

Water 8.75

CO 1116.6215

4 4 + 20.625 + 2.5 + 15.25 = 42.375

total 1323.75

21a 123.438 + 20.312 + 179.062 + 69.375 + 1.875 + 15.25 + 7.25 = 416.562

25 55 + 20 + (50.9375 - 2.5) = 123.438

4 (3.375 + 2.875) + 2.25 + (1.5 + 4.75) + 7.375 + 6.5 + 53.125 + 27.375 = 103.125

21c 27.5 + 11.188 + 15 + 56.375 + 6.75 + 36.25 = 153.063

5 6 + 11 + 18.25 = 35.25

rolled, regenerating" 209.375

CO

what is the D. in map 2

0.04 $5.3 \times .3 = 159\ cm^2$

22.125

10.5 26a 2.625

CD 1.5

5.5
2
1
2 5
11.0

11

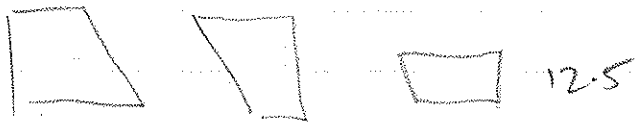
10b

?b = ~~24.75 ha~~ ?c = 3.75 ha

?a = ~~9.938 − 1.219~~ = 8.719

Total	3	21b	1b	7	79	CD	10b
~~46.875~~	~~2.125~~	~~25~~	0.625	05	~~8.5~~	25	6.562
~~49.375~~	~~2.25~~	~~24.75~~	1.219		9 2.812	0.875	3.281
	~~3.125~~		2.5				3.375
			1.125				10.312
			1.953				
			2.812				

34.688ha 28.125



52.0833

23.1875

Department of Conservation and Land Management

Bunbury Regional Office

telephone: (097) 25 4300 facsimile: (097) 25 4351

FAX MESSAGE

Attn: BRONWEN KEIGHERY

From: PETER HANLY

Date: 23 d 5 m 95 y

Location : c/- DEPT. ENVIRONMENTAL PROTECTION

Location : BUNBURY

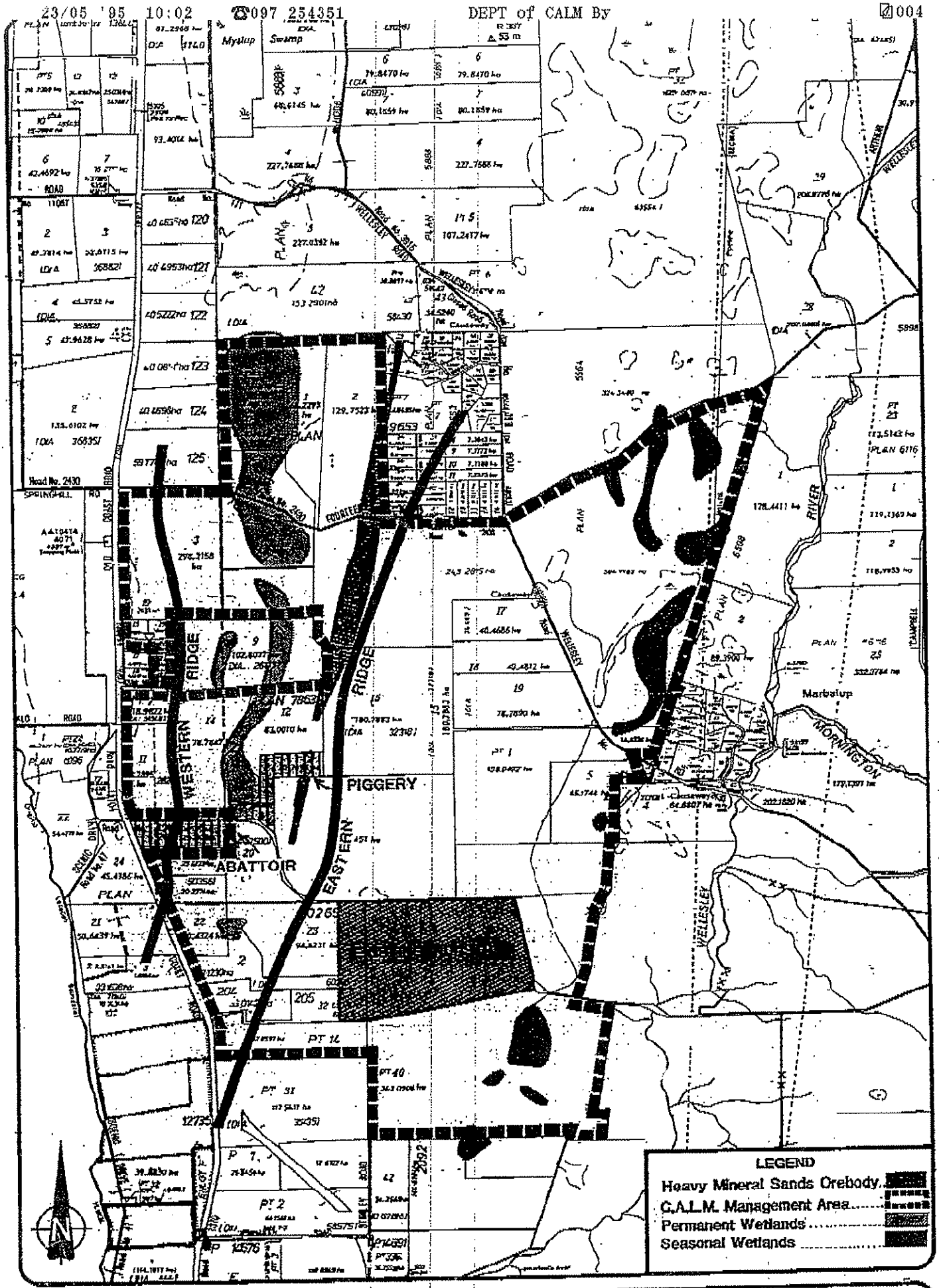
Number of pages (including this page): [4]

Operator : _____

message:

MAPS SHOWING KEMERTON AND BENGER SWAMP N.R. BOUNDARIES.

Please call Toni Jones or the operator on (097) 254300 if the message is illegible or incomplete. Thank you.



KEMERTON PARK

SITE PLAN

Date : APRIL 1989 Scale : 1:50,000

Feilman Planning Consultants

Kemerton

Fourteen Mile Rd = Treasure Rd

- Western • Woodland was OK Fenc design was missing understory (Quarry area to South probably has OK Fen/design)
- wetlands to E (triangle area grazed but Eastern most corner maybe) OK.
- wetland to W Suitable from road.

Marriot Rd (note New alignment in blue)

- 3 sites possible Bank on W ridge but to be burnt in next month.
- Swamp indicated (ARM map Suitable site Mike Shuttland

Kemerton generally degraded, good patches See Napier.

MAP 36

*For full legend see 'State Maps Legend' page preceeding **Map 1***

0 2 4 6 8 km

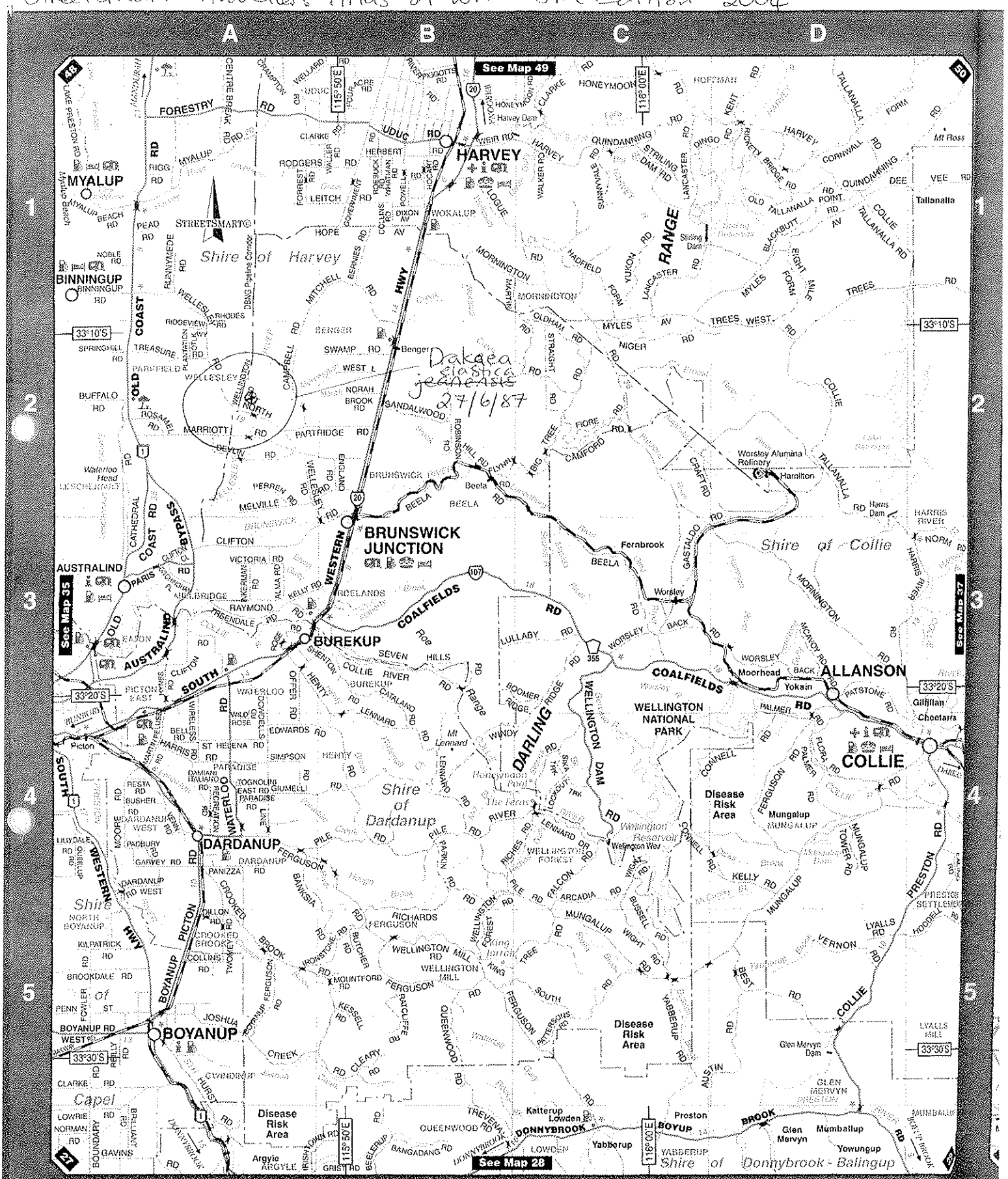
Scale 1:250 000

Primary/Secondary Road — sealed — unsealed
Minor Road
Track
Road Distances, Bridges
National Highway (95) State Route (102)
National Route (1) State Tourist Drive (251)

Population Centre >5000 ALBANY
Population Centre >500 MERREDIN
Population Centre <500 WALPOLE
Homestead • Marilla
Locality REDMOND
Place Name Pimelea

Accommodation
Airport/Aerodrome
Caravan Park/Facilities
Fuel
Information Centre/Bay
Medical Facility
Police Station
Rest Area

Street Smart Travellers Atlas of WA 8th Edition 2004



Species lists based on plot records from DEP (1996), Gibson et al. (1994), Griffin (1993), Keighery (1996) and Weston et al. (1992). Taxonomy and species attributes according to Keighery et al. (2006) as of 16th May 2005.

BFS No	Plot Name	Growth Form	Wd?	Species Name	Family
201	KOON02	Tree		Banksia attenuata	Proteaceae
201	KOON02	Tree		Banksia menziesii	Proteaceae
201	KOON02	Tree		Eucalyptus marginata subsp. marginata	Myrtaceae
201	KOON02	Shrub		Acacia sessilis	Mimosaceae
201	KOON02	Shrub		Astroloma pallidum	Epacridaceae
201	KOON02	Shrub		Bossiaea eriocarpa	Papilionaceae
201	KOON02	Shrub		Conostephium pendulum	Epacridaceae
201	KOON02	Shrub		Conostephium preissii	Epacridaceae
201	KOON02	Shrub		Daviesia divaricata subsp. divaricata MS	Papilionaceae
201	KOON02	Shrub		Daviesia nudiflora subsp. nudiflora	Papilionaceae
201	KOON02	Shrub		Daviesia physodes	Papilionaceae
201	KOON02	Shrub		Daviesia triflora	Papilionaceae
201	KOON02	Shrub		Dryandra lindleyana	Proteaceae
201	KOON02	Shrub		Eremaea pauciflora var. pauciflora	Myrtaceae
201	KOON02	Shrub		Gompholobium confertum	Papilionaceae
201	KOON02	Shrub		Hakea prostrata	Proteaceae
201	KOON02	Shrub		Hemiandra pungens	Lamiaceae
201	KOON02	Shrub		Hibbertia huegelii	Dilleniaceae
201	KOON02	Shrub		Hibbertia hypericoides	Dilleniaceae
201	KOON02	Shrub		Hibbertia racemosa	Dilleniaceae
201	KOON02	Shrub		Hovea trisperma var. trisperma	Papilionaceae
201	KOON02	Shrub		Jacksonia sericea	Papilionaceae
201	KOON02	Shrub		Melaleuca systena	Myrtaceae
201	KOON02	Shrub		Nemcia reticulata	Papilionaceae
201	KOON02	Shrub		Petrophile linearis	Proteaceae
201	KOON02	Shrub		Petrophile macrostachya	Proteaceae
201	KOON02	Shrub		Stirlingia latifolia	Proteaceae
201	KOON02	Herb		Burchardia congesta	Colchicaceae
201	KOON02	Herb		Caesia occidentalis	Anthericaceae
201	KOON02	Herb		Chamaescilla corymbosa var. corymbosa	Anthericaceae
201	KOON02	Herb		Conostylis aurea	Haemodoraceae
201	KOON02	Herb		Conostylis setigera subsp. setigera	Haemodoraceae
201	KOON02	Herb		Dampiera linearis	Goodeniaceae
201	KOON02	Herb		Drosera erythrorhiza subsp. erythrorhiza	Droseraceae
201	KOON02	Herb		Drosera menziesii subsp. penicillaris	Droseraceae
201	KOON02	Herb	*	Gladiolus caryophyllaceus	Iridaceae
201	KOON02	Herb		Haemodorum laxum	Haemodoraceae
201	KOON02	Herb		Hybanthus calycinus	Violaceae
201	KOON02	Herb		Levenhookia pusilla	Stylidiaceae
201	KOON02	Herb		Lomandra caespitosa	Dasypogonaceae
201	KOON02	Herb		Lomandra hermaphrodita	Dasypogonaceae
201	KOON02	Herb		Macarthuria australis	Molluginaceae
201	KOON02	Herb		Monotaxis grandiflora	Euphorbiaceae
201	KOON02	Herb		Patersonia occidentalis	Iridaceae
201	KOON02	Herb		Ptilotus manglesii	Amaranthaceae
201	KOON02	Herb		Scaevola repens var. repens	Goodeniaceae
201	KOON02	Herb		Stylidium calcaratum	Stylidiaceae
201	KOON02	Herb		Stylidium piliferum subsp. piliferum	Stylidiaceae
201	KOON02	Herb		Thysanotus patersonii	Anthericaceae
201	KOON02	Herb		Thysanotus sparteus	Anthericaceae
201	KOON02	Herb		Thysanotus triandrus	Anthericaceae
201	KOON02	Herb		Tricoryne tenella	Anthericaceae
201	KOON02	Herb		Waitzia suaveolens var. suaveolens	Asteraceae
201	KOON02	Herb		Xanthosia huegelii subsp. huegelii MS	Apiaceae
201	KOON02	Grass		Amphipogon turbinatus	Poaceae
201	KOON02	Grass		Austrodanthonia occidentalis	Poaceae
201	KOON02	Grass		Austrostipa semibarbata group (Gibson et al. 1994)	Poaceae
201	KOON02	Sedge		Alexgeorgea nitens	Restionaceae
201	KOON02	Sedge		Desmocladus fasciculatus	Restionaceae
201	KOON02	Sedge		Desmocladus flexuosus	Restionaceae
201	KOON02	Sedge		Hypolaena exsulca	Restionaceae
201	KOON02	Sedge		Lepidosperma sp. (Coastal terete) (BJ Keighery and N Gibson 231)	Cyperaceae
201	KOON02	Sedge		Lyginia barbata	Restionaceae
201	KOON02	Sedge		Mesomelaena pseudostygia	Cyperaceae
201	KOON02	Sedge		Schoenus curvifolius	Cyperaceae
201	KOON02	Sedge		Tetraria octandra	Cyperaceae

Swan Coastal Plain Survey - SURVEY RECORDING SHEET Please use pencil

BUSHLAND AREA:

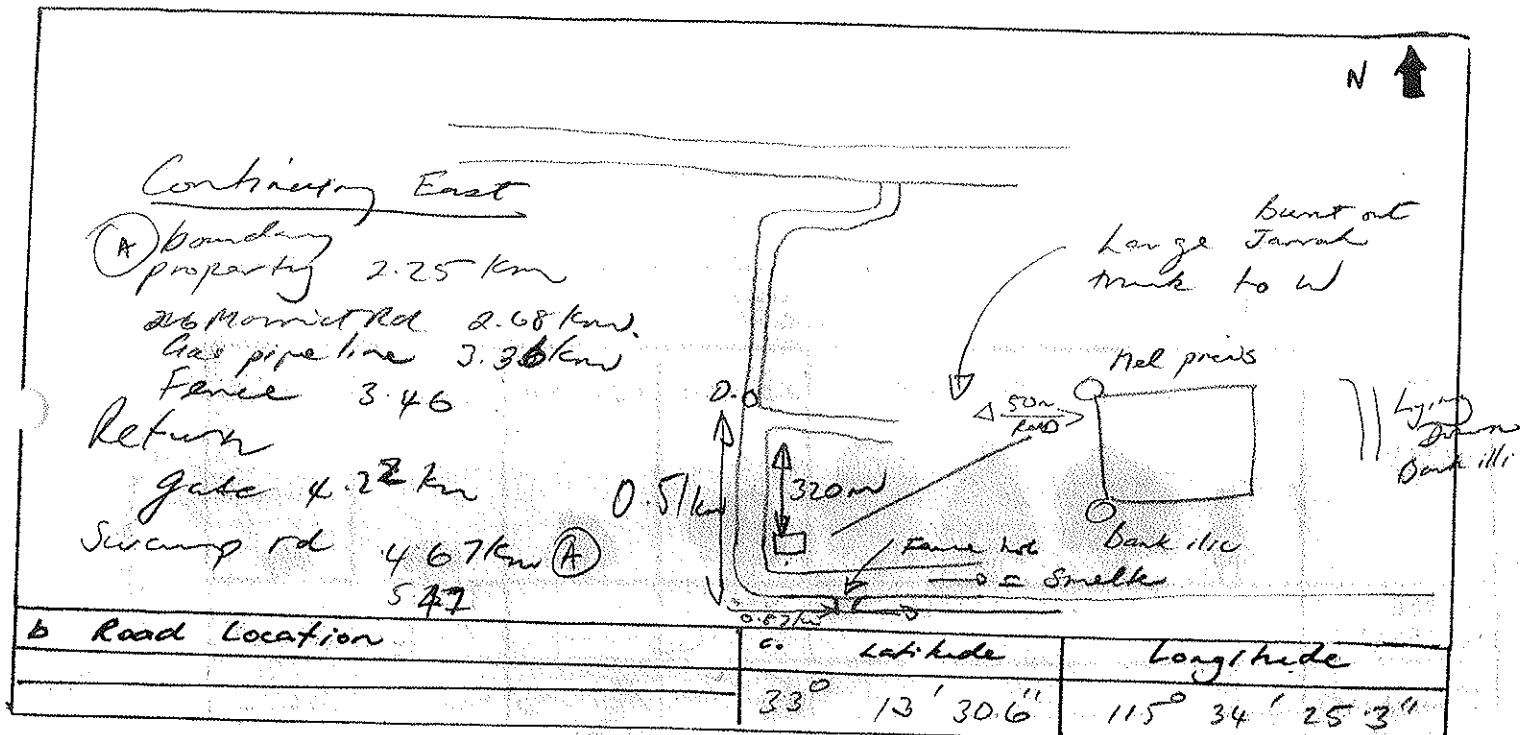
QUADRAT No. KEMP 03 VEGETATION TYPE Mel.preis / Bank.ilic / Mem.
DATE TRIP 25/9/93 BOTANIST NG / MC / DJK
VOLUNTEERS

DATE TRIP 16/11/93 BOTANIST NG / MC
VOLUNTEERS

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN
SURVEY. WILDFLOWER SOCIETY of WA

1. LOCATION of the QUADRAT

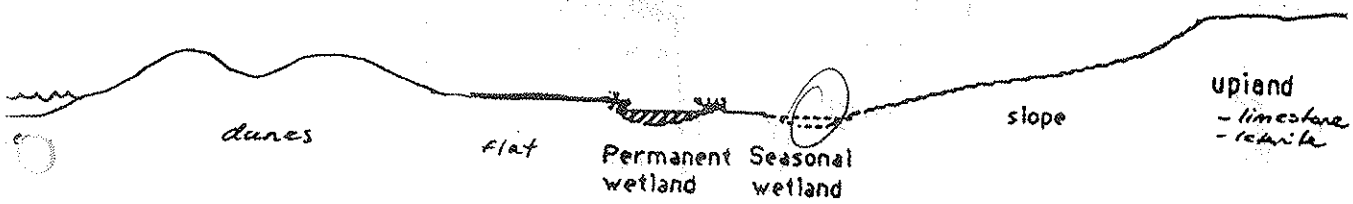
a. Mud Map Draw a sketch of the location of the quadrat



b Road Location	c. Latitude	Longitude
	33° 13' 30.6"	115° 34' 25.3"
		Altitude 65m ± 100m

d. Photograph Photographer's name NG Photo No

e. Topographic position - Circle position of quadrat



2. SITE DATA - Circle the correct response

Slope (flat) gentle steep

Aspect [N] [NE] [E] [SE] [S] [SW] [W] [NW]

Surface soil grey / black peaty sand

Sub-surface soil ? peat EG = Qpb / Qpa (S10)

Drainage well (mod) (poor)

Wet All year (winter/spring)

Litter (% cover) 98%

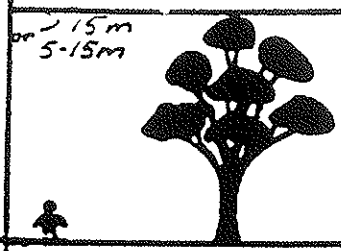
% Bare ground 6%

P.T.O.

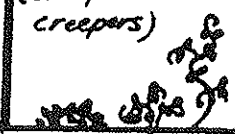
3. VEGETATION STRUCTURE AND COVER. Record appropriate cover class

Cover Class – percentage classes

0%	under 2%	2-10%	10-20%	20-30%	30-50%	50-70%	over 70%

	TREES		MALLEES	
LIFE FORM	over 15m / 5-15m 	under 5m 	MALLEE SHRUB less than 8m 	MALLEE TREE 8m or more 
COVER CLASS (%)	>15m 5-15m 20-30%			
Dominant Species	Mel pres Banksili Bank att			

	SHRUBS (use the height classes indicated)					
LIFE FORM	over 2m 	2.0-1.5m 	1.5-1.0m 	1.0m-.5m 	under 5m 	
COVER CLASS (%)		2-10%	50-70%	10-20%	2-10%	
Dominant Species		Tacktun.	Peri ellip Melthym	Xanth	Hibb sp	

	BUNCH GRASSES	HERBS	SEDGES	
LIFE FORM	under .5m 	under .5m (except creepers) 	over .5m 	under .5m 
COVER CLASS (%)		20-30%		
Dominant Species		Phleb cil		

Height (metres): 3m, 2m, 1m; 8.0m, 1.5m, 1.0m, .5m

4. VEGETATION CONDITION

PRISTINE	
EXCELLENT	✓
VERY GOOD	
GOOD	
DEGRADED	

Comments

Few weeds only scattered
* ~~Hyparrhenia hirta~~
Hyp Glab.

SPECIES PRESENCE 28/9/93

QUADRAT No. KEME Ø3

- work systematically through the vegetation, start with the tallest stratum, i.e. trees
- within each stratum try to record the **most common species first** and the most uncommon last.
- as each species is collected **label** it with a numbered tag and use this number on your recording sheet
- indicate if the species is in **flower**

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN SURVEY. WILDFLOWER SOCIETY of WA

Trees

Trees		No	ID
Mel preiss.	✓		
Bank att	✓		
Bank illic	✓		
Euc. calophy	✓		
Nuytsia flori (bucher)	✓		

Mallees

Mallees		No	ID

SHRUBS

SHRUBS		No	ID
Pericalyma ellip	✓	(USP)	
Adena meis	✓		
Xanth brunonis	✓		
Jacksonia furcellata	✓		
Mel. thymo.	✓		
Hibbert. vaginata	✓		
Hibb subvaginata	✓		
Acacia Semitrullata	✓	X	
Urola pungens	✓		
Bossiaea eric	✓		
Hemiandra pungens	✓		
Platysace compressa	✓	X	
Gompholobium capitatum	✓		
Leucopogon conosteph	✓		
Tetratheca hirsuta 'hairy'	✓		
Boronia ramosa	✓		

SHRUBS

16/11/93

SHRUBS		No	ID
Petrophile linearis	✓		
Porantheia microphylla	✓	x	(USP 28/9)

Bunch Grasses

Bunch Grasses		No	ID

Herbs

Herbs		No	ID
Phleb. ciliata	✓		
Lomandra micrantha	✓		
Drosera stolon	✓		
Chaem corymb	✓		
Hypolaena exsulca	✓		
Lomandra caesp	✓		
Trachymene pilosa	✓		
Thysanotus manglesianus	✓		
Stylid brun.	✓		
Stylid repens	✓		
Caladenia (flus) – flava	✓		
Thelymitra aff holmesii	✓		
Drosera erythro	✓		
Stylidium pilif.	✓		

Herbs

Herbs		No	ID
Conostylis / pilosa	✓		
~~Bitterdine~~			
Pterostylis vittata	✓		
Xanthosia hueg	✓		
Lyperanthus nig.	✓		
Stylidium junceum	✓		
Caladenia / flava	✓		

Sedges

Sedges		No	ID
Schoenus curvifolius	✓		
Lyginia barb	✓		
Lepidosperma sp. (Gearguest)			

Swan Coastal Plain Survey - SURVEY RECORDING SHEET Please use pencil

BUSHLAND AREA:

QUADRAT No. KEME 01 VEGETATION TYPE Euc. deciduous

DATE TRIP 28/9/92 BOTANIST BJK / NG / ML

VOLUNTEERS

DATE TRIP ▽ BOTANIST ML / NG

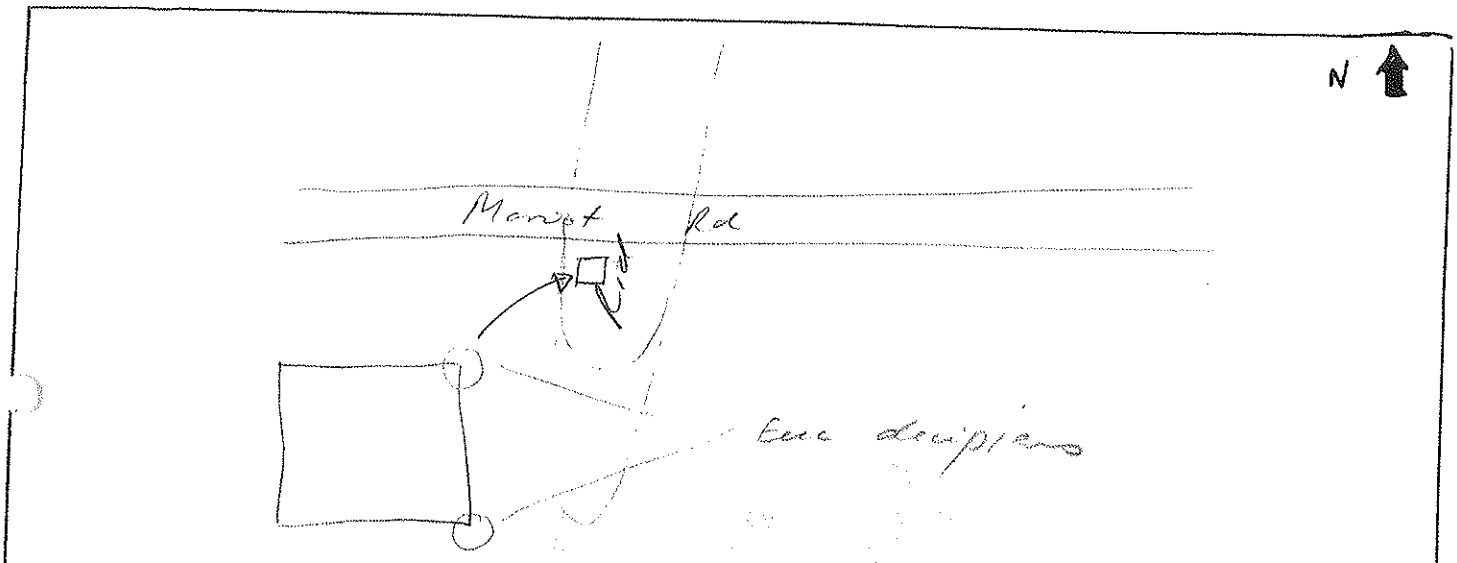
VOLUNTEERS 16/11/93

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN SURVEY. WILDFLOWER SOCIETY of W.A.

KEME

1. LOCATION of the QUADRAT

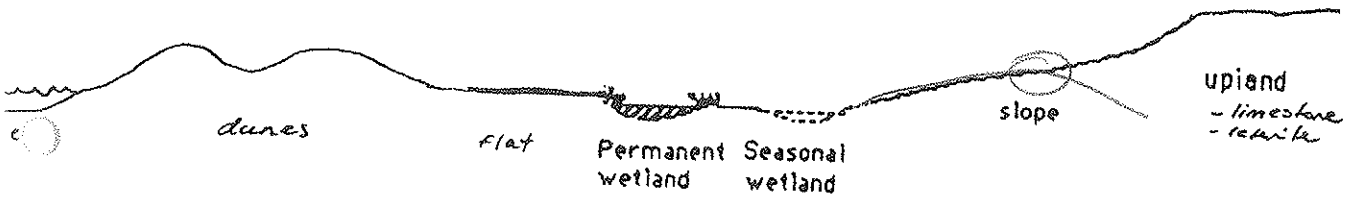
a. Mud Map Draw a sketch of the location of the quadrat



b Road Location	c. Latitude	Longitude
Marriot	33° 12' 56.5"	115° 44' 12.9"
		Altitude 30m ± 100m

d. Photograph Photographer's name NG Photo No 23

e. Topographic position - Circle position of quadrat



2. SITE DATA - Circle the correct response

Slope flat (gentle) steep

Aspect N NE E SE S SW (W) NW

Surface soil pale brown sand

Sub-surface soil yellow/orange sand EB = LS (Q+S)

Drainage (well) mod poor

Wet All year winter/spring

Litter (% cover) 70%

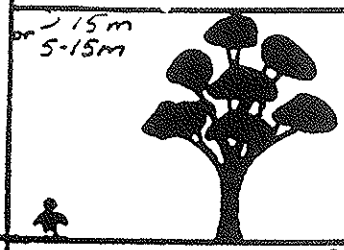
% Bare ground 4%

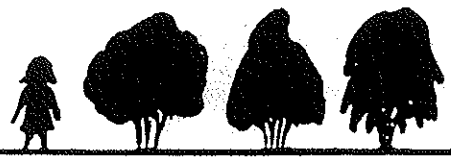
P.T.O.

3. VEGETATION STRUCTURE AND COVER. Record appropriate cover class

Cover Class – percentage classes

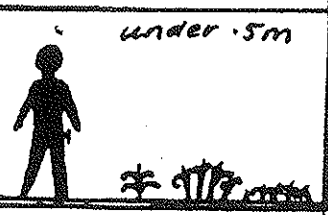
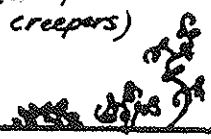
0%	under 2%	2-10%	10-20%	20-30%	30-50%	50-70%	over 70%

LIFE FORM	TREES		MALLEES		
	>15m or 5-15m 	under 5m 	MALLEE SHRUB less than 8m 	MALLEE TREE 8m or more 	15m 10m 5m
COVER CLASS (%)	>15m 5-15m 10-20%				
Dominant Species	Euc decipiens				

LIFE FORM	SHRUBS over 2m	2.0-1.5m	1.5-1.0m	1.0m - .5m	SHRUBS under .5m	
						3m 2m 1m
COVER CLASS (%)		2-10%		30-50%		
Dominant Species		Hak pros		Cryp Hibb hyp Phy Pedy		

Use the height classes indicated

Height (metres)

LIFE FORM	BUNCH GRASSES under .5m	HERBS under .5m (except creepers)	SEDGES over .5m	SEDGES under .5m	
					2.0m 1.5m 1.0m .5m
COVER CLASS (%)		50-70%			
Dominant Species		* Brisa * Hyp * Amyotaea			

4. VEGETATION CONDITION PLUS.

PRISTINE	
EXCELLENT	
VERY GOOD	✓
GOOD	
DEGRADED	

Comments

* Brisa max, * Hyp glab Amyotaea very common in Herb layer.

? fire ? grazing

Swan Coastal Plain Survey - SURVEY RECORDING SHEET Please use pencil

BUSHLAND AREA:

QUADRAT No. KEMC Q2 VEGETATION TYPE Jarrah/Marri/Banksia woodland

DATE TRIP 28/9/93 BOTANIST ML/NG/BJK

VOLUNTEERS

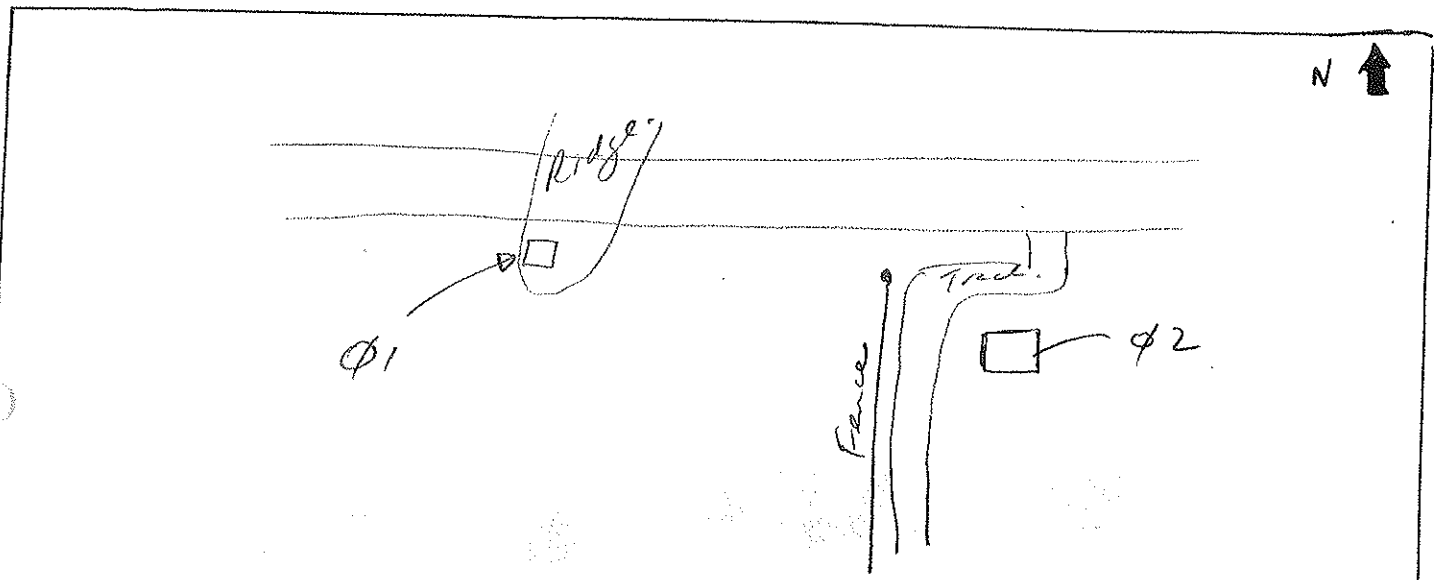
DATE TRIP 16/11/93 BOTANIST ML/NG

VOLUNTEERS

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN
SURVEY. WILDFLOWER SOCIETY of WA

1. LOCATION of the QUADRAT

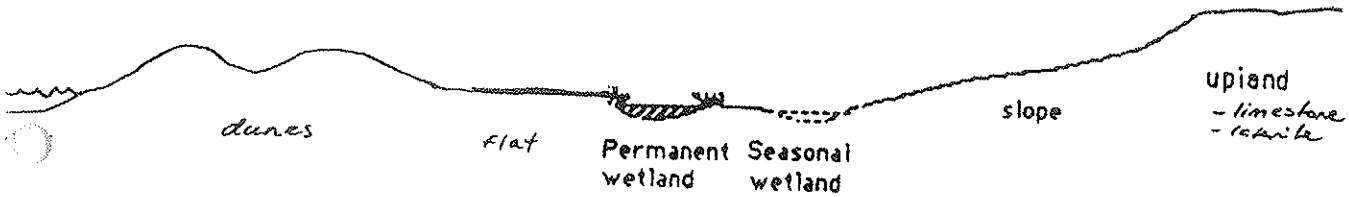
a. Mud Map Draw a sketch of the location of the quadrat



b Road Location	c. Latitude	Longitude
	33° 12' 57.4"	115° 44' 23.3"
		Altitude 25m ± 100m

d. Photograph Photographer's name NG Photo No

e. Topographic position – Circle position of quadrat



2. SITE DATA – Circle the correct response

Slope flat (gentle) steep

Aspect N NE E SE S SW (W) NW

Surface soil grey sand

Sub-surface soil grey sand EG = Qts

Drainage (well) mod poor

Wet All year winter/spring

Litter (% cover) 90%

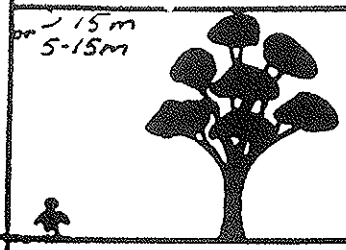
% Bare ground 1%

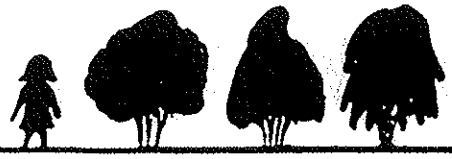
P.T.O.

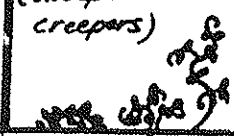
3. VEGETATION STRUCTURE AND COVER Record appropriate cover class

Cover Class – percentage classes

0%	under 2%	2-10%	10-20%	20-30%	30-50%	50-70%	over 70%

LIFE FORM	TREES		MALLEES	
	>15m or 5-15m 	under 5m 	MALLEE SHRUB less than 8m 	MALLEE TREE 8m or more 
COVER CLASS (%)	>15m 5-15m			
Dominant Species	Mami / Jarrah 2-10%	Banksia sp 2-10%		

LIFE FORM	SHRUBS over 2m	2.0-1.5m	1.5-1.0m	1.0m - .5m	under .5m	SHRUBS use the height classes indicated
						
COVER CLASS (%)			50-70%			
Dominant Species			Yant brun Hib typ Bos sp			

LIFE FORM	BUNCH GRASSES under .5m	HERBS under .5m (except creepers)	SEDGES over .5m	SEDGES under .5m
				
COVER CLASS (%)		20-30%		2-10%
Dominant Species		Phleb sil Daisy brown		Lax sp

Height (metres): 3m, 2m, 1m; 2.0m, 1.5m, 1.0m, .5m

4. VEGETATION CONDITION

PRISTINE	
EXCELLENT	)
VERY GOOD	)
GOOD	
DEGRADED	

Comments

Scattered * Hyp 5/06

HT fires

4. SPECIES PRESENCE
28/9/93

QUADRAT No.
KEME 01

- work systematically through the vegetation, start with the tallest stratum, i.e. trees
- within each stratum try to record the **most common species first** and the most uncommon last.
- as each species is collected **label** it with a numbered tag and use this number on your recording sheet
- indicate if the species is in **flower**

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN SURVEY. WILDFLOWER SOCIETY of WA

Trees

Trees	No	ID
~~Euc. decip~~		
Bank grandis (sapling) /		
Agonis flex (suckers) /		

Mallees

Mallees	No	ID
Euc decipiens /		

SHRUBS

SHRUBS	No	ID
Acacia pulchella /		
Hakea prostrata /		
Jacksonia furcellata /		
Cryptandra mutila /	✓	VSP
Phyllanthus calycinus /		
Leucopogon drooping /		
Hibbertia racemosa /		
Synaphea spinosa /		
Gompholobium toment /		
Acacia (broad winged) with /	✗	VSP
Astroloma palli /	VSP 28/9	16/11
Hovea trisperma /		
Tricoryne elatior /		
Macrozamia reidl (seedling) /		
16/11/93		
Lechenaultia? hypoacti... ✓		
Lepidobolus? chaetoides? ✓		✗
~~Stipe~~ Stipa flavescens ✓	VSP.	
Lobelia tenuior ✓		✗

SHRUBS ~~HERBS~~

SHRUBS	No	ID
Caladenia flava /		
Patersonia occident /		
Thysanotus arenarius /		
Lomandra suaveolens /		
Stylidium schoenoides /		
Drosera erythro /		
Pterostylis (rosette only) ✗		
? Anigoz manglesii /		
Caladenia (spider) /		
(Weed) Silene gallica /	/	VSP
Caladenia latifolia /		

Bunch Grasses

Bunch Grasses	No	ID
* Briza max /		.
Stipa - (hairy ... flavescens		
Microlaena stip		
* Aira cary /		✗
* Briza minor /		

Herbs

Herbs	No	ID
Kennedia prostrata /		
Hardenbergia comp /		
Sonchus oleraceus /		VSP
* Erodium botrys /		✗
Geranium retorsum (VSP) /		✓
Pelargonium litt /		✓
Isotropis cunei /		
Conostylis aculeata /		
* Anagallis arvensis /		
* Ursinia anthem /		
Oxalis perennans /		
Daucus glochid /		
Hibbertia? pulverulenta /		
Lomandra micrantha /		
* Trifolium ~~[illegible]~~ camp /		
Lagenifera huegelii /		
~~Chorizema?~~		
Tricoryne? Trichocline spath /		VSP

Herbs

Herbs	No	ID
Trachymene pilosa ✓		
* Helichrysum? pusilla ✓		
Lobelia (seedling) ✓		
Sowerbaea lax ✓		
* Hypochaeris glab. ✓		
Millotia tenuifolia ✓		✗
* Petrorhagia velut. ✓		
Lomandra caespitosa ✓ tha		✗
Patersonia occid. ✓		
Orobanche ✓		
Hybanthus calycinus ✓		
~~[illegible]~~ (no pic)		[illegible]
Thysanotus pat / many ✓		
* Stellaria media ✓		
Calandrinia ... ✓		✗
Crassula colorata ✓		
Homalosciadium homalocarpum? ✓		✗
Davenpa? debilis ✓		
Anigozanthos humilis ✓		
Drosera stolonifera ✓		

Sedges

Sedges	No	ID
~~Tetra~~ Schoenus grand		
Loxocarya flex		
Lepid august /		
Isolepis marg		
Tetraria octandra ✓		

ADJ
Kennedia coccinea /

4. SPECIES PRESENCE

28/9/93

QUADRAT No. KEME 02

- work systematically through the vegetation, start with the tallest stratum i.e. trees
- within each stratum try to record the **most common species first** and the most uncommon last.
- as each species is collected **label** it with a numbered tag and use this number on your recording sheet
- indicate if the species is in **flower**

Keighery and Keighery, 1990
Adapted from Griffin and Keighery, 1989
MOORE RIVER to JURIEN SANDPLAIN SURVEY. WILDFLOWER SOCIETY of WA

Trees

Species	No	ID
Marri ✓		
Jarrah ✓		
Bank att ✓		

Mallees

SHRUBS

Species	No	ID
Jacksonia furcellata ✓		
Hibbertia hyp ✓		
Bossiaea eri ✓		
Xanth ~~gracilis~~ brunonis ✓		VSP
Tetratheca hirsuta SP ✓		VSP
Astroloma pallidum ✓		
Leucopogon propinqua ✓		
Xanthosia hueg ✓		
Phyllanthus cal ✓		
Gomph tomentos ✓		
Astroloma ciliatum ✓		
Hovea trisperma ✓		
Leucopogon ~~aff polym stats~~		VSP
Hibbertia racemosa		
Leptomeria cunninghamii VSP		
Persoonia saccata		
Petrophile linearis		
Eriostemon spic.		
Gompholobium confertum ✓		
Acacia stenoptera ✓		
Daviesia divaricata ✓		
Acacia wild aff. ✓		
Logania serpyl. ✓		
Platysace compressa ✓		
Conostaph. pend. ✓		
Macrozamia reidii ✓		

SHRUBS

Species	No	ID
Gomph polymorphum ✓		
Conymostheca micrantha ✓		
Opercularia hispida ✓		
~~Conostylis juncea~~		
Billardiera ~~?~~ variifolia	✓	
Cassytha racemosa	✓	VSP
Conostephium preissii ✓		
16/11/93 Comesperma confertum ✓		
Helichrysum cordatum ✓		
Hibbertia tenuior ✓		
Levenhookia stipoides ✓		
Cassytha racemosa ✓		
Dasypogon brom ✓		

Bunch Grasses

Species	No	ID
* Briza max ✓		
? Microlaena stip ✓		
Dichelachne crinita ✓		
Danthonia sp ocid ✓		

Herbs

Species	No	ID
Sowerbaea lax ✓		
Hyperanthus nig ✓		
Caesia / blue / micrantha		VSP
Drosera erythro ✓		
Lagenifera hueg ✓		
Trachoclina spark ✓		
Conostylis aculeata ✓		
Phlebocarya ciliata ✓		
* Hypochaeris glabra ✓		
Trachymene pilosa ✓		
Thysanotus manglesianus ✓		
Dianella revoluta ✓		
Lomandra herm ✓		
Millotia tenuis ✓		
Caladenia flava ✓		
Plerostylis nana ✓		
Drosera (climb glab) pallida		
Stylidium schoen		

Herbs

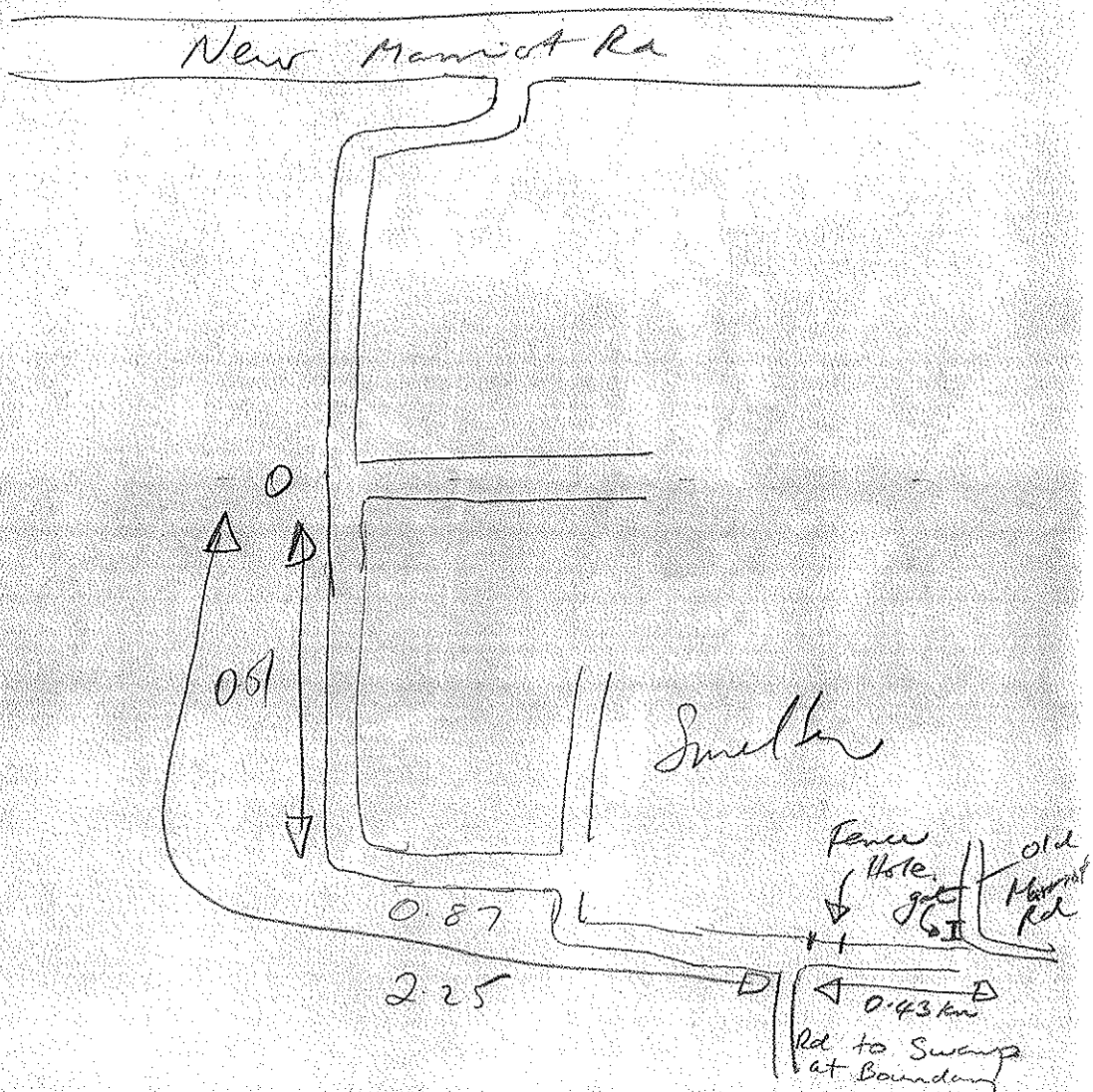
Species	No	ID
Chamaescilla corymb. ✓		
Dasypogon brom ✓		
Stylidium carnosum ✓		
Lomandra caespitosa ✓		
~~Dichelachne~~		
Lomandra micrantha ✓		
Drosera stolon ✓		
Eriochilus dilatatus ✓		
Conostylis juncea ✓		
Pterostylis ✓		
Patersonia occid. ✓		
16/11/93 Banksia grandis (seed) ✓		

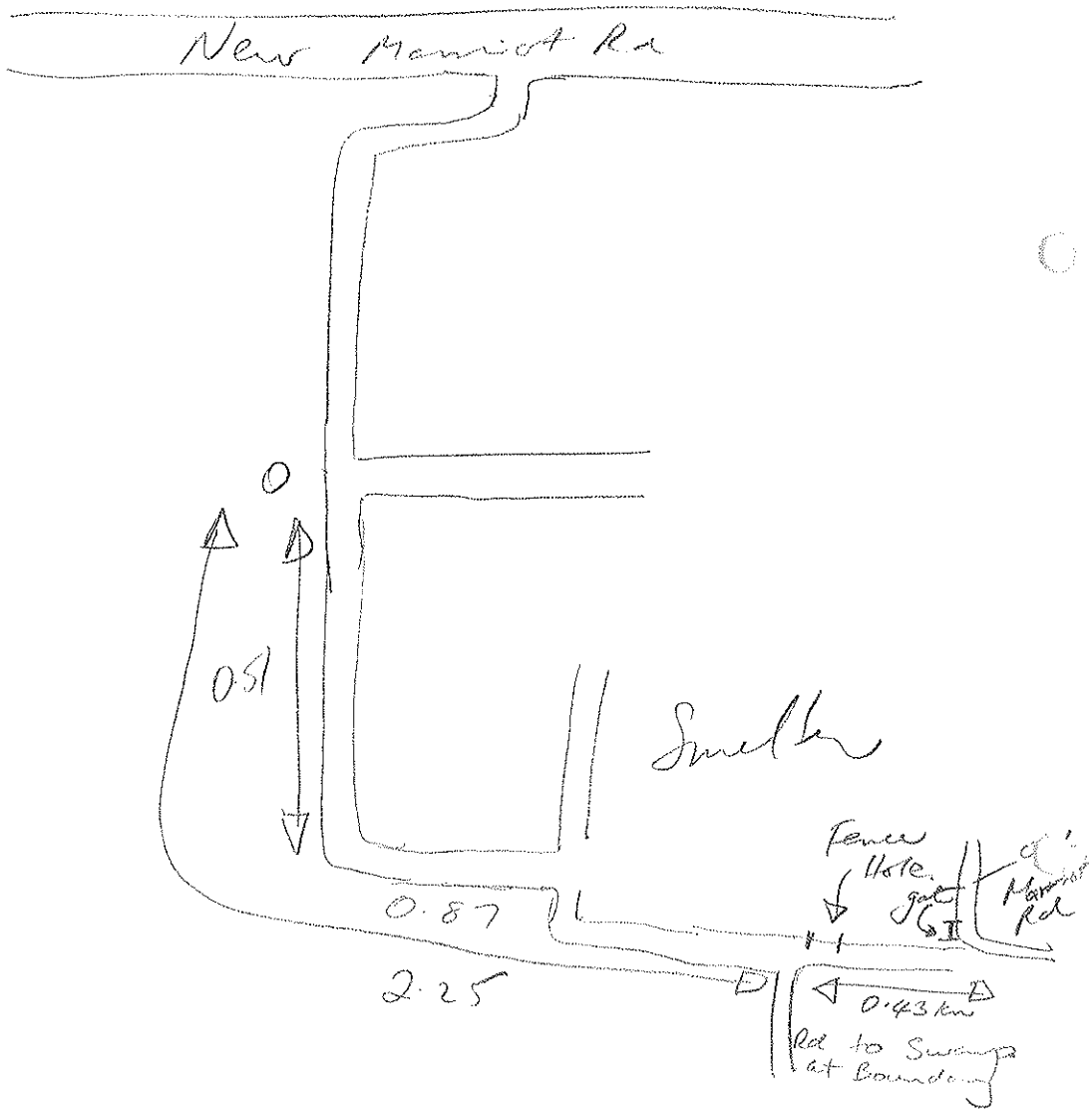
Sedges

Species	No	ID
Lyginia barb ✓		
Loxocarya cinerea ✓		
Lepid angust (broad) = squarrosa leaf	✓	
Loxocarya flex ✓		
Lepidosperma angustatum (narrow)	✗	VSP

ADJ
Xylomelum occ ✓
Persoonia long (scattered) ✓
Agrost scabrum ✓
Allen ?ocis ✓

Leucopogon ? squarrosus ✓ (VSP) 28/9

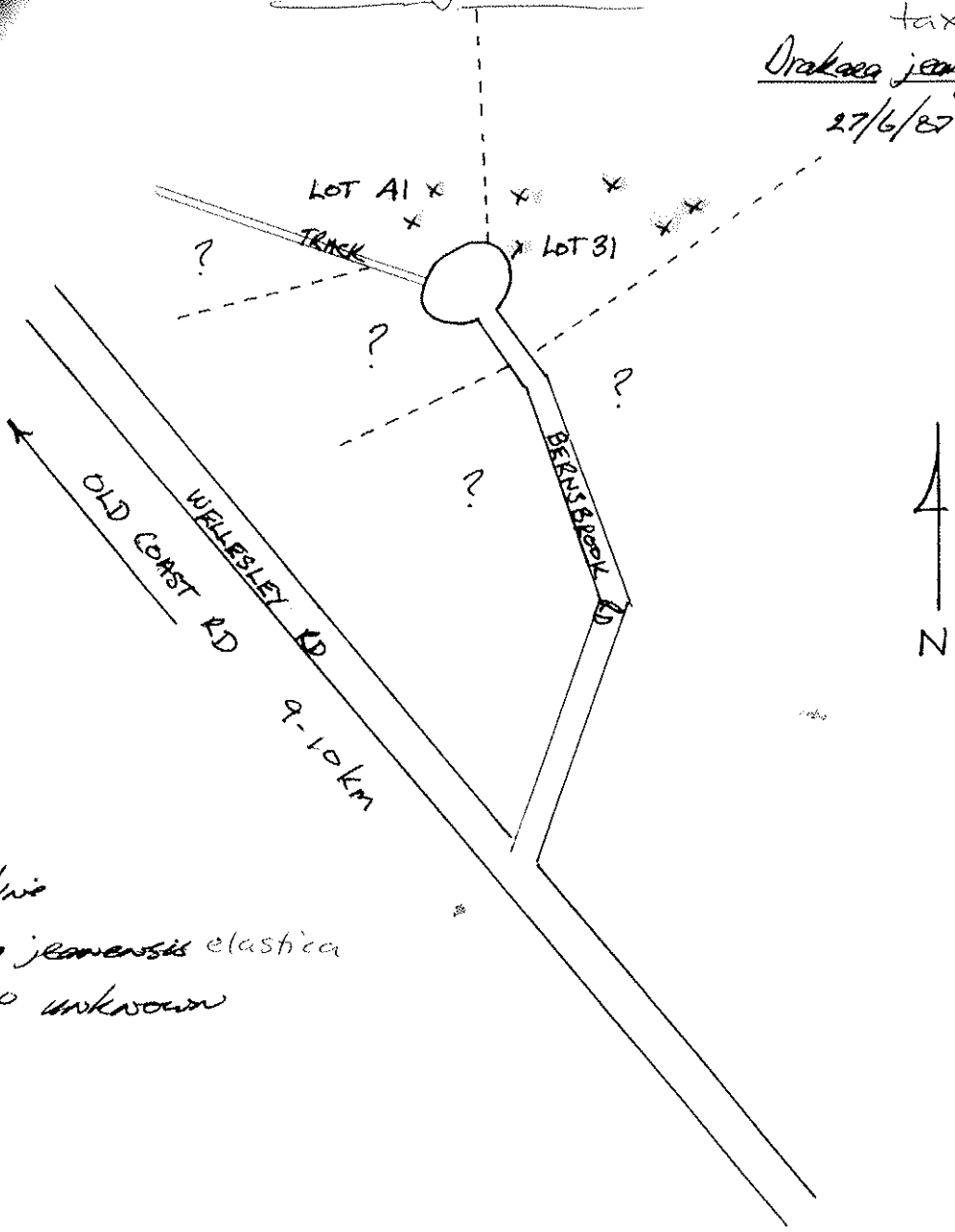

New Marriott Rd
0
061
Smelter
Fence Hole
Old Marriott Rd
087
225
0.43 km
Rd to Swamp at Boundary


New Mannicott Rd
0
0.51
Smelter
Fence Hole
0.87
2.25
0.43km
Rd to Swamp at Boundary


1
2
3
KODAK SAFETY FILM

Information from Gillian Stack, DEC for Swan Bioplan Project 17/4/07. 65

Note: Gillian Stack is currently preparing the interim recovery plan (IRP) for Drakaea jeanensis = D. elastica under current taxonomy



Key.

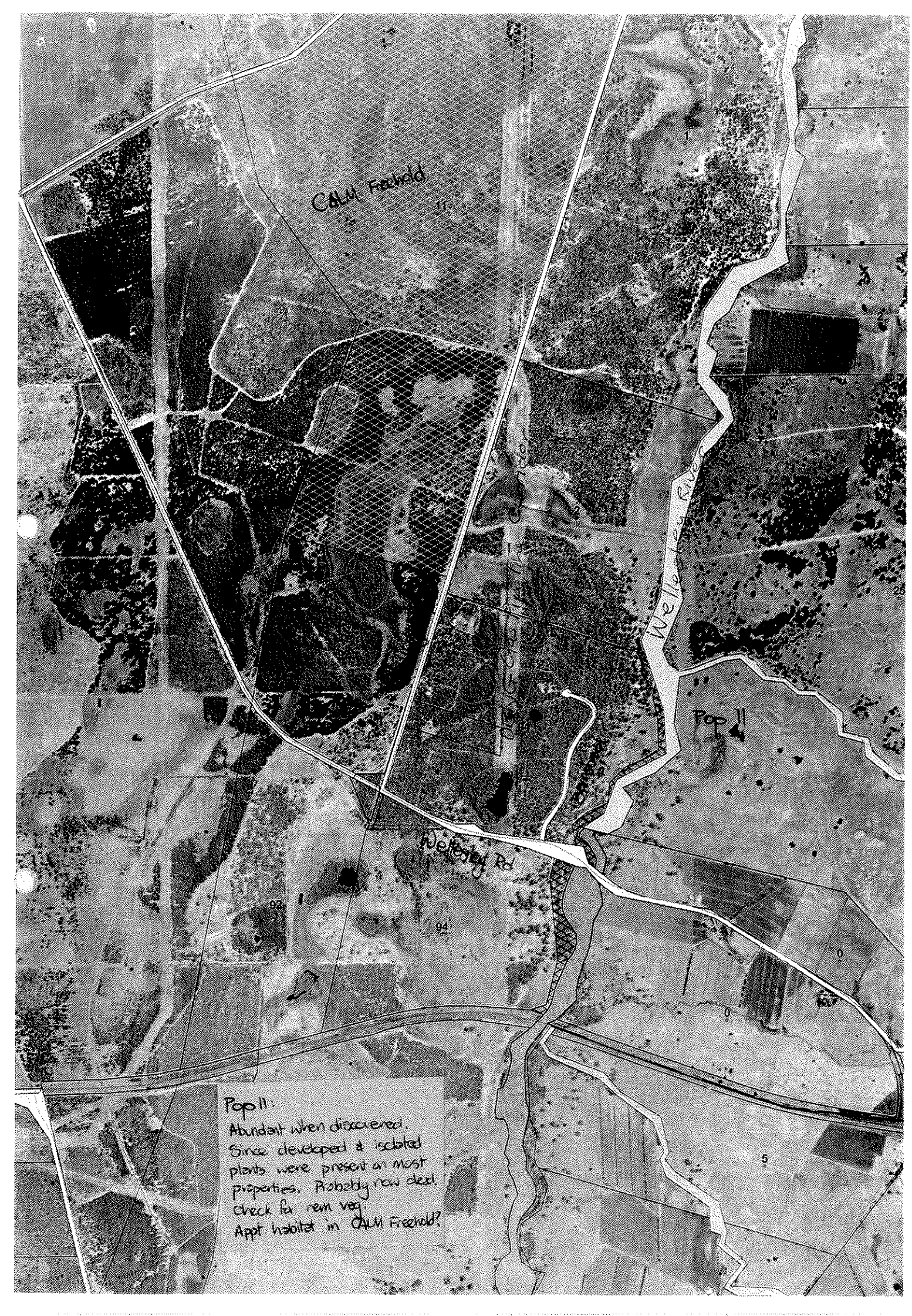
---- Fence line

× *Drakaea jeanensis* elastica

? Lot No unknown

Gillian Stack IRP

Vanessa / Gillian – field trip in 07?


CALM Freehold
Wellesley Rd
Wellington River
Pop 11
Pop 11:
Abundant when discovered.
Since developed & isolated
plants were present at most
properties. Probably now dead.
Check for rem veg.
Appt habitat in CALM Freehold?

WATERWAYS COMMISSION

PEEL INLET MANAGEMENT AUTHORITY

FACT FINDING STUDY

Prepared by Miss T. Schwinghammer
B.Sc. (Gen. Sc.)

May, 1978

ERRATA noted by E.P. Hodgkin

2.2 para 1. The bar did not close each summer before dredging in 1967, though it shallowed. Tydeman (1948) says it closed "at intervals of about 8 years". J. Barman believes it closed more frequently, but I have found no records to support this.

para 2. It is misleading to say that Harvey water "tends to be more saline .... than Peel water". It is generally fresher in winter and only sometimes more saline in summer.

para 4. The Serpentine is probably tidal for about 20 km, to the diversion drain.

3.2 The temperature range is more like 11°-25°C (I have not looked it up).
"In summer-autumn cold fresh water tends to flow over warmer saline water."

Table 2 I have not checked all the figures, but the following corrections should be made:.
The discharge salinities are all 10 x too high, e.g.

Serpentine	0.5 ppt
Murray	0.5-3.0 ppt
Harvey	0.5 ppt

Serpentine tidal for 20 km
Murray tidal for 24 km
Collie Tidal for km

3.3 Harvey Estuary is seldom so hypersaline (the 50 ppt was 1978.). Probably usually not much above sea water salinity.

The annual evaporation from the water surface is equal to about 1.5 times the volume of the estuary - not four times as stated.

3.4 "Tidal water is flushed ....." is a misleading statement. There are estimates of 'tidal exchange' in summer, but this requires explanation and an agreement between the relevant 'experts' which we do not yet have.

The report quotes other data from the Peel-Harvey Estuarine System Study which must be regarded as preliminary only and subject to revision, e.g. Table 5.

5.2.1 Heterozostera sp., Posidonia australis, and Amphibolus antarctica are certainly not important in Peel Inlet. It is most unlikely they grow there at all.
Zostera mucronata - not Z.muelleri.

5.2.2 Halophila sp., is not listed below - dont know where this record came from.

Gracilaria verrucosa - not G. vemicosa.
Oscillatoria.

5.2.3 When I have spoken with fishermen they have been adamant that it was sea grasses which accumulated and were carted away, not Cladophora.

5.2.3.1 "Laboratory experiments ... increase by 50% in one month. "

6.1 There are no lobsters in the estuary.

6.1.1, 2 & 3 The information on which these are based relates to the Swan estuary and may not apply in detail to Peel-Harvey where hydrological and biological conditions are different in many respects.

9.0 Fisheries and Wildlife Department has some information on crabbing and fishing pressure.

10.0 It should be noted that Fisheries and Wildlife Acts do control access and usage of the estuary and adjacent land.

One, of many, deficiencies of knowledge of the area is with respect to magnitude of the amateur fishery (particularly crabs). Amateurs probably take more fish and crabs than do professionals.

11.2.5 The typing is misleading.

Bayley-Jones wrote Tourism and Recreation etc.

Urban Systems wrote Multi-density Feasibility Study.

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1. INTRODUCTION

Estuaries, inlets, rivers, lakes and other waterways provide recreational facilities such as boating, yachting, fishing and swimming and are essential for the maintenance of our modern way of life. However, the number of such waterways in the South-western portion of Western Australia which are reasonably accessible to the major centres of population is limited both in number and extent.

Environmental Protection Authority (1977) has pointed out that wetlands (lakes, swamps, rivers and estuaries) are amongst the scarcest resources in Western Australia. These areas are of importance as :

(i) habitat for flora and fauna

(ii) areas of scientific research and education

(iii) areas of water balance and drainage and for maintenance of water quality

(iv) areas for recreation such as boating, swimming, fishing, water skiing, crabbing and prawning, all of which need open water of good quality. Picnicking, rambling, photography, birdwatching, hang gliding and other sports and hobbies are greatly enhanced by the presence of nearby water

(v) scenic landscape features which have economic value for locally based tourist facilities

It has been estimated that 70% of the original 200,000 hectares of wetland on the Swan Coastal Plain has been filled or drained. The remaining 65,000 hectares is potentially threatened by pollution, development and salination due to clearing of forests and agri-cultural activities.

Table 1 shows water areas below high water mark of the three areas currently under the control of the Waterways Commission and, in addition, that of the Hardy Inlet at Augusta and Westernport Bay in Victoria.

TABLE 1: Water Areas of Four South-western Estuaries

Waterway	Area below high water mark (H.W.M.)
Swan & Canning Estuaries*	5,300 hectares
Peel Inlet & Harvey Estuary*	13,620 hectares
Leschenault Inlet*	2,540 hectares
Hardy Inlet	890 hectares
Westernport Bay (Victoria)	68,000 hectares

* Excludes water areas in associated rivers.

Hardy Inlet was selected for its accessibility from the Metropolitan region and because of the probability that it may be brought under the control of the Waterways Commission when extension of its activities in this direction is considered advisable.

In the State of Victoria there are three major waterways. They are Port Phillip Bay, Westernport Bay and the Gippsland Lakes System. Westernport Bay was included in Table 1, firstly, as its area is intermediate between these other two waterways and secondly, due to the existence of French Island in the middle of the bay and Phillip Island at its seaward or southern end, shore-to-shore distances approximate those in the Peel Inlet. While a section of the western side is used for port and industrial purposes and further extension of these activities can be anticipated in the future, the greater part of this waterway and associated foreshores are available for recreational usage.

While the Peel Inlet, Harvey Estuary, and lower sections of the Murray and Serpentine Rivers represent a substantial area of waterway, careful planning of all recreational activities must be carried out to obtain optimum recreational usage consistent with minimum disturbance of the environment. It must be borne in mind that while the local population is relatively small, increasing pressures will come from the metropolitan region in the future.

The purpose of this study is to assemble all available factual knowledge of the waterways and adjoining lands to assist in the preparation of a Management Programme. Some studies are still in progress and undoubtedly further studies will be required but neither of these factors should delay preparation of the Management Programme.

2. REVIEW OF FOUR SOUTH-WESTERN ESTUARINE SYSTEMS

South-west Australian estuaries are described by Rochford (1951), as generally having scoured riverine channels which discharge into shallow lagoons separated from the sea by sills or sand bars. The systems are dominated by the seasonal pattern of river flow, and are mainly fresh during winter runoff and brackish to hypersaline (i.e. more salty than ocean water) in summer.

Because of the salinity variation, relatively few species of bottom-dwelling flora and fauna are found. Marine fish enter the estuary during the summer, but few species remain throughout the year. Species which use the estuaries as a permanent breeding and nursery habitat have special adaptations for extreme ranges of salinity.

2.1 The Swan-Canning Estuary

The Swan River Estuary is one in which a shallow marine bar and deep estuarine basin are well developed. The lagoonal section is deep (up to 20 metres) so that during winter runoff, sea water becomes trapped behind the sill at the entrance, with the fresh water flowing over the top. Thus an extreme density and chemical stratification is set up. During this time only the true estuarine flora and fauna survive.

As the freshwater flow decreases, penetration of marine tidal water occurs beneath the fresh layer. The marine water cascades over the sill and moves as a density current along the bottom of the estuarine basin. Horizontal mixing gradually occurs between the two layers, so that the system returns to a marine phase. The tidal range is quite small, however, favourable wind sets assist the movement and mixing of the tidal water.

The main rivers discharging into the estuary are the Avon and Canning Rivers. The Swan River is tidal as far as Upper Swan, and the Canning River is tidal as far as Kent Street Weir.

2.2 The Peel Inlet - Harvey Estuary

The Inlet channel is narrow and 5 km long. It extends from the training walls at the sea outlet to the Peel Inlet and has deltas at both ends. Before dredging in 1967, the sea bar was closed each summer. Minimal tidal exchange occurredduring these periods.

The Peel Inlet is a shallow and nearly circular basin on the Coastal Plain. It has wide peripheral platforms (less than 0.5 metres in depth) which occupy more than half the total area. It is generally fresh to brackish in winter and saline to hypersaline in summer.

The Harvey Inlet is a long shallow coastal lagoon in an interdunal depression of the Spearwood Dune System (McArthur and Bettenay, 1974), with limestone out-crops on the eastern and western foreshores. The Inlet is generally fresh in winter and hypersaline in summer. Harvey water tends to be more saline, richer in phytoplankton*, and containing more clay and organic matter than Peel water. There is a narrow channel 2 metres in depth which connects the two bodies of water.

The Murray River is the most substantial inflow in this region. The water from the Darling Range is fresh, and runoff from the agricultural hinterland is saline, so that the inflow to the estuary is marginal to brackish in salinity. The Murray River is not dammed, and is tidal from Yunderup delta to the Pinjarra Weir.

The Serpentine River collects several short escarpment tributaries before flowing into the delta at Coodanup. Flows in the Serpentine-Dandalup stream are fresh, and large water supply storages exist on the Serpentine and South Dandalup Rivers. The Serpentine is tidal for about 10 km.

The Harvey River is the outlet for all waters from the catchment area between Harvey and Waroona. The history of this area is one of gradual clearing, grading and intensified development of farms, with a consequent increase in runoff and flooding of agricultural land. The lower reaches of the Harvey River were cleared and desnagged by 1905. Construction of the Harvey Main Drain, Samson Brook, Logue Brook, Clark Brook and Weekes Brook Drains occurred in conjunction with the South-West Railway. Waroona Main Drain was completed by 1920, and by 1932 the Harvey River was diverted directly to the sea in order to alleviate flooding. Following further flooding and clearing for agricultural land, a survey by Public Works Department showed that 26 km of the river from the mouth needed to be widened by 50% to contain a one-year flood. The drains also needed clearing and enlarging.

Bulldozing, destruction of the vegetation and building up of the banks has continued until 1977, when work ceased due to a request by the Fisheries and Wildlife Deaprtment to save the last few kilometres of vegetated river banks as area of importance to wildlife and recreation.

2.3 The Leschenault Inlet

The Leschenault Inlet is a shallow interdunal coastal lagoon which is about 11 km long and 2 km wide. The western shore is formed by the Quindalup Dune System while the eastern side is formed by dunes of the older Spearwood and Bassendean Systems. The northern and southern ends are alluvial soil.

*Phytoplankton are free floating plants, often microscopic.

The extensive sand flats on the eastern shore are exposed at low tide, and the central channel is about 2 metres deep. Because most of the Inlet is so shallow, sudden fluctuations of temperature and salinity can occur.

The southern end of the estuary near Bunbury has been greatly alerted by engineering works over the last twenty years. In 1951 the original outlet to the sea at Bunbury was filled at Point McLeod. This area is now known as the "Plug". A new outlet was constructed in the western dune peninsula, almost opposite the mouth of the Collie River, and this new opening is called the "Cut". The new harbour was completed in 1967. This work resulted in the reclamation of the Inlet on both sides of the harbour basin with a new entrance channel to the sea. The Preston River was diverted northwards and a channel constructed immediately north of the "Plug", connecting the southern section of the Inlet (where the mangroves, Avicennia marina grow) to the sea.

Construction of Wellington Dam in 1960 reduced the duration and flow of the Collie River, and lessened the freshwater input to Leschenault Inlet.

The Laporte effluent pipe from Australind to the western dunes was completed in 1960. A kilometre of the eastern end of the pipe is supported by a solid fill bank.

The hydrology of the Inlet shows seasonal variation. The area adjacent to the "Cut" reflects the salinity of the ocean. The salinity of the water flowing down the Collie River varies seasonally, depending on whether the runoff is from the cleared land on the southern or eastern tributaries, or from the forested coastal plain. During winter, the fresh river water flows out over the salt water in the Inlet. In summer the marine water penetrates into the Collie River. In winter freshwater also flows from the Parkfield Drain into the northern part of the Inlet. This area tends to become hypersaline in the summer due to tidal influence and evaporation.

2.4 The Blackwood River Estuary - Hardey Inlet

The Blackwood Estuary shows some features which are characteristic of other estuaries in the South-west with some significant differences.

Ocean waves break over the shallow sand bar across the mouth. The bar is breached by a narrow and fairly deep tidal channel. Historically the bar has completely closed up with dramatic environmental effects.

Deadwater and Swan Lakes open by a narrow channel east of the mouth of the estuary. Deadwater Lake is an old river channel up to 5 metres deep but shallow at its eastern end and at the margin behind the sand dunes. Swan Lakes are saline and connected to Deadwater by a winding tidal channel through sand dunes. The lakes contain a rich growth of aquatic plants, and are of importance to fish and birds.

The inlet channel is about 2.5 km long and 0.5 km wide with mobile sand banks in the southern part. The east bank coincides with the Dunsborough Geological Fault, and is sandy with reeds and limestone outcrops. The west bank is bounded by steep rocks of Precambrian time (greater than 600 million years B.C.).

The lagoon is small in comparison with other South-western estuaries, and is shallow throughout (less than 2 metres).

The upper estuarine section is upstream of Island Point, and from here to Molloy Island has some of the characteristics of a lagoon, with wide, shallow areas around the island and banks. There is a clearly defined channel between Island Point and Alexandra Bridge, which is deeper on the northern side of Molloy Island. The channel narrows down between Alexandra Bridge and Warner Glen Bridge.

The Blackwood River is tidal to a rock bar 42 km from its mouth. The Scott River is also estuarine for about 4 km from Molloy Island to a rocky bar. Sea water penetrates this far in summer, forming a pronounced halocline (water layers of different salinity) with fresh water lying on top. The whole estuary is fresh in winter.

3. PHYSICAL FEATURES

The following account is based largely on the work of the Estuarine and Marine Advisory Committee (E.M.A.C.) of the Environmental Protection Authority (E.P.A.) and is described by Dr. E.P. Hodgkin.

3.1 Comparison of Four South-western Estuaries

Table 2 on the following page gives a broad outline of the physical features of the catchments and waterbodies of the Swan, Peel-Harvey, Leschenault, and Blackwood Estuaries.

3.2 Hydrology

The total volume of the estuary is about 125 x $10^6 m^3$. During winter, when rivers are flowing, much water is lost to the sea.

Data collected by Spencer (1952) shows that water temperature in the Peel varies from about 16°C in winter to about 21°C in summer with little difference at depth. The Harvey Estuary is similar. The Murray River however, has a temperature stratification associated with the seasonal halocline. In winter, cold fresh water tends to flow over warmer saline water and in summer this can become reversed due to movement of density layers.

Peel Inlet and Harvey Estuary differ greatly with respect to water clarity. In the Peel the water is almost always clear so that the bottom can be seen. The Harvey Estuary contains much suspended matter and phytoplankton (microscopic floating plants) so that the bottom can seldom be seen.

3.3. Salinity

The normal salinity of oceanic water is 35 ppt*. Peel Inlet water varies each year from about 9 ppt (sometimes less) in winter, to over 45 ppt in summer. This range is even greater in Harvey Estuary, which is normally fresh (less than 5 ppt and sometimes as low as 1 ppt) in winter and hypersaline (over 50 ppt) in summer.

The factors which determine the salinity are :

(a) The volume and duration of river runoff to the estuary;
(b) Loss of estuary water to the sea;
(c) Entry of sea water with tidal and density currents and mixing of this within the estuary;
(d) Evaporation

*ppt - parts per thousand (see Section 4)

CATCHMENT		
Total Area		23,000 km^2
River runoff (Mean Annual)		
x 10^{-6} m^3	Blackwood	1057
	Scott	1030
Salinity at point of discharg (ppt = parts per thousand)	Blackwood	10 - 30 ppt
	Scott	5 ppt
Less than 5 ppt is fresh		
From 5 to 30 ppt is brackish		
Area of Dams (km^2)		Not dammed

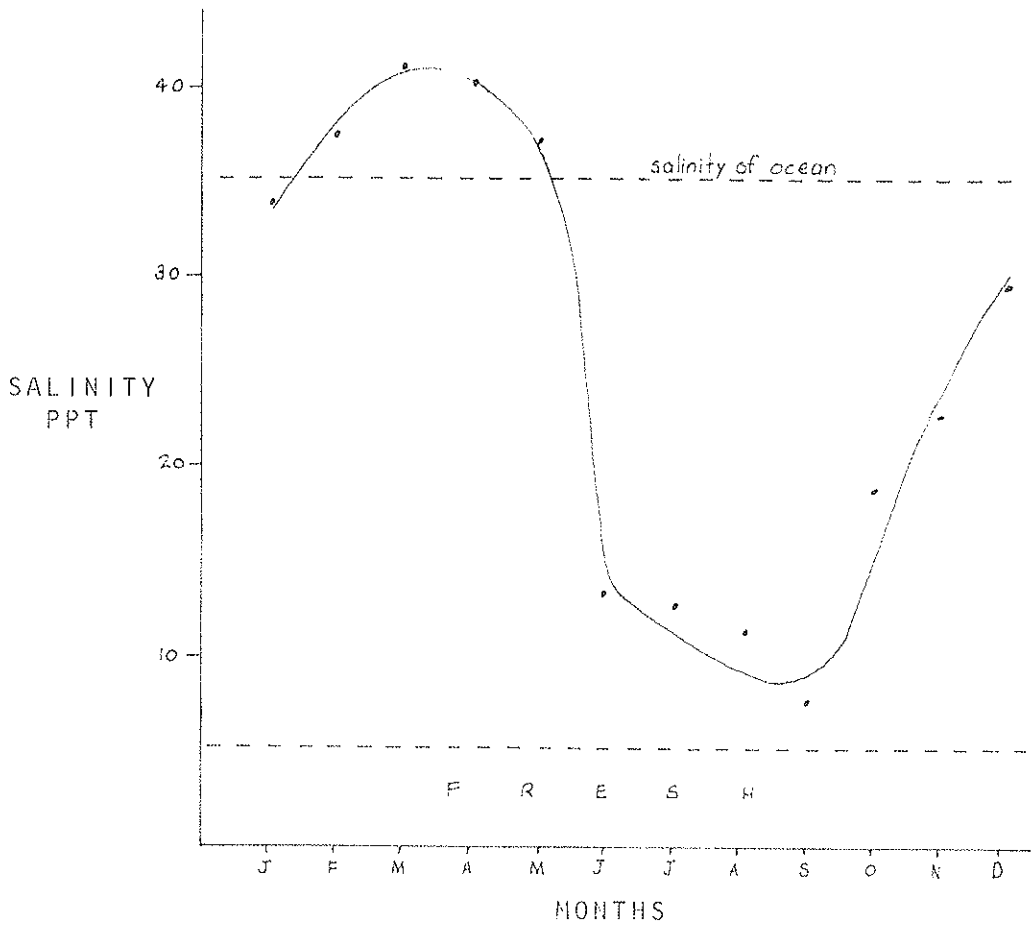
ESTUARY		
Tidal Rivers-Length from mou	Blackwood	42 km
	Scott	4 km
Basin Geomorphology	A small shallow basin in Pleistocene sediments against the Leewin Ridge.	
Total area		-
Navigable area over 0.6m deep		-
Perimeter		-
Greatest Depth	2 metres (small area only)	
Tidal range % of oceanic	70%	
Barometric tide	undamped	
Inlet channel - length	2.5 km	
Depth of sand bar at mouth	2 metres	

POPULATION - 1976 Census	Augusta	464
	Margaret River	701

The annual evaporation from the water surface is equal to about four times the volume of the estuary. It is obvious that in the absence of adequate exchange with the sea the water of the estuary would become a concentrated brine in the summer.

Figure 1 below, illustrates the pattern of salinity changes throughout the year in Peel Inlet. The data is for 1952 and although the entrance channel was not dredged at this time and tidal exchange in summer would have been very restricted, the present picture is very much the same, despite the increase in oceanic exchange brought about by the widening of the entrance channel.

Figure 1 Salinity Changes in the Peel Inlet during 1952 (C.S.I.R.O.)



3.4 Water Movement

Waters of different densities tend to retain their integrity and move as independent bodies of water, mixing only when force is applied to them. Tidal water entering the estuary in winter is of greater salinity and density than estuarine water, whilst in summer the incoming sea water is of lower salinity and density than estuarine water. The higher density water (i.e. more saline) flows under the less dense (fresh), producing a stratified situation. This is called a halocline. Mixing takes place at the interface between the two water bodies as they move independently as a result of tidal and other currents.

The principal forces affecting mixing of the density layers are tidal pumping, riverflow, density currents and stress. Tidal exchange is a very important force in mixing. Tidal water is flushed from the western Peel Inlet in about 4-5 weeks, from the Coodanup region in 6-7 weeks, from the southern part of the Peel Inlet in 14-15 weeks and from the Harvey in about 23 weeks.

A dye-release experiment carried out by E.P.A. in February, 1978, showed that wind stress has little effect on circulation in the Peel Inlet. However, in the stratified situation, turbulence caused by wind stress certainly aids mixing. Strong winds also result in a water-level set of about 10 cm. This happens at Coodanup during south-westerly winds of 40 - 50 knots, and the consequent slop from one side to the other may also assist mixing. Northerly winds during cyclone Alby in April, 1978, lowered the water-level at Coodanup and raised the water-level at the Ford by about 1 metre.

Public Works Department data shows that storm surge and wave run-up on the eastern shores resulting from cyclonic or very strong winds can be as much as 1.3 metres above normal tide levels.

3.5 I Inflow

The mean annual volume of river flow into the estuary from the various sources have been listed below. These are only flow estimates and are from the Public Works Department.

TABLE 3 : Estimated Mean Annual Flow from Rivers and Drains into the Peel-Harvey Estuary

Murray River	420	x	$10^6 m^3$
Serpentine River	62	x	$10^6 m^3$
Harvey Drainage	90	x	$10^6 m^3$
Minor drains	5	x	$10^6 m^3$
Mean Total	580	x	$10^6 m^3$

Two-thirds of the annual flow occurs during the winter.

The annual volume of flow varies greatly from year to year and is also strongly seasonal.

In a wet winter the river flow will exceed the mean annual flow and much of the water is lost to the sea. In a dry winter the river flow approximates 125 x 10^6 m^3 and there may be no net loss of water to the sea.

A hypothetical assumption is that over a 12-month period, the net tidal exchange will be zero. Table 4 shows a list of relative inputs and outputs calculated from composite 1976 mean monthly yields and transposed 1977 data. It is important to note that these figures do not represent actual volumes, but estimated relative contributions of the various components.

TABLE 4 : Estimated Water Balance of the Peel-Harvey Estuary in 1976

Input	Relative Contributions	Output	Relative Contributions
River Flow (Murray	3.2	Evaporation (net lake)	6.3
(Serpentine*	0.2	(Based on annual pan	
(Harvey**	1.0	Factor of 0.8- needs	
Drain Flow (Mayfields	0.03	Several years data for	
(Mealup	0.03	verification)	
(South Coolup	0.01		
(All other	0.01		
Precipitation on inlet	2.0		
Groundwater (Eastern Shoreline, Unconfined)	0.02		
TOTAL =	6.5	TOTAL =	6.3

*Subsequent Public Works Data suggest this figure is too low.

**Estimated from weekly gaugings and thus likely to overestimate short term peak flows.

Possible omissions from this table could be input from groundwater from northern and western areas, and seepage loss.

3.6 Tides

Tidal exchange with the sea is restricted by the dimensions of the inlet channel relative to the volume of the estuarine system. Daily astronomic tidal range in the Peel Inlet is only 10% of the ocean tide and lags behind in time. On a rising tide, Public Works Department tide-gauges show about a 10cm rise at Mandurah Jetty, a 4cm rise at the Chimneys 1 hour later and a 1cm rise at Coodanup, Falcon and Robert Bay about 5 hours later. No astronomic tide can be detected at the Ford.

Changes in barometric pressure which have a period of 5-15 days cause a variation in sea-level particularly in summer. This barometric tide is delayed by 50 hours but not damped by the inlet channel and often causes changes of water level in the Inlet of about 0.3m. Such a change in water-level is equivalent to over a quarter of the volume of the estuarine system. This water undergoes mixing by currents in the Inlet and the same volume of estuarine water will leave the inlet on a falling barometric tide. Much of the water that flows out comes back on the next rising tide.

Harvey Estuary is a semi-independent body of tidal water which has the effect of pumping water from Peel Inlet through the Sticks Channel.

The effects of the astronomic tide, seasonal change in sea-level, barometric storm surge and wind set altogether could produce changes of water level from 0.45m below mean sea-level (M.S.L.) to 0.55m above M.S.L.

3.7 Floods

Public Works Department maintains gauging stations on all the rivers. These record streamflow and monitor water salinity throughout the year. This data is associated with a much larger project to trace the history of land-use and of flooding. The research programme on flooding is directed to plotting flood recurrence levels for 25 years and for 100 years on a map. Metropolitan Regional Planning Authority will not recommend any development within the 25-year flood boundary and only recreational use within the 100-year flood boundary.

A flood flow plan on the Serpentine River showing 25-year and 100-year flood-levels has been prepared by Public Works Department and is shown on Map 1 (2 sheets).

Twenty-nine years of flow data for the Murray River at Hughes Bridge are available for study. These results have been analysed to determine the frequency distribution of peak flows, and show that the volume of a 20-year flood would be 660 m^3/s and a 100 year flood, 1,250 m^3/s. Within the period investigated there has not been a flood of 100 year magnitude. Floods of 20-year magnitude occurred in 1945 and 1964.

In 1945 the shop on the Murray River at Yunderup was flooded to 1.7m and Yunderup delta was flooded to 1.3m above mean sea level. In 1964 the flood level was 1.4m above M.S.L. at the eastern side of the delta islands. Both these flood-level readings coincided with a high tide. Historic records show that the Murray River was 6m higher than its banks at Pinjarra in 1904 and 1920.

The Murray and Serptentine River have a common floodplain which is defined in the Serpentine flood study.

Despite damming of some of the rivers and tributaries within the Peel-Harvey Estuary catchment in recent years, flood potential is still a major consideration. The clearing of land in the catchment downstream from the dams has contributed significantly to increased run-off from these areas.

4. WATER QUALITY

When speaking of concentrations of certain substances in water various different units are used for convenience, depending on the magnitudes of the concentrations under examination. The following table is designed to overcome any confusion which may arise in the interpretation of these units.

1 gram = 1,000 milligrams

1 milligram per litre (mg/l) = 1,000 micrograms per litre (ug/l)

1 part per thousand (ppt) = 1,000 parts per million (ppm)

1 mg/l ≃ 1 ppm

4.1 Nutrients

Enrichment of waterways by nutrients is of concern because of the problem of eutrophication. This is the process by which excess quantities of plant nutrients enter waterways as the result of human activities and cause increased production of algae and other aquatic plants. Rapid growth and subsequent decay of the plants may lead to deoxygenation of the water with resultant depletion of fish, loss of water quality and objectionable odour.

It is generally considered that the nutrients, or limiting factors, most likely to be important, are phosphorus and nitrogen. Although plant growth requires carbon, hydrogen and oxygen as well as nineteen other elements, it is the high concentrations of nitrogen and phosphorus that create the 'blooms' of algae and aquatic plants which form the base of the food chain. In some cases algae produce toxic substances, making nutrient enrichment of waterways a real hazard.

The eutrophic levels of nitrogen and phosphorus will certainly vary with the locality of the waterway, climate etc. Surveys of several Wisconsin lakes concluded that nuisance algal growths can be expected when concentrations of inorganic phosphorus and nitrogen exceed 1 mg/litre and 30 mg/litre respectively (Sawyer, 1952). Local studies on growth of the species of alga called Cladophora (see Section 5.2) suggest nitrogen levels of 10-30 mg/litre and phosphate levels of 1-2 mg/litre cause rapid growth although published data based on growth in tanks give higher values. (Pitcairn and Hawkes, 1973).

The chemical quality of the water depends on the nature of the surrounding catchment and the activities that occur within that area. The sources of nutrients are discussed by Wood (1975).

4.1.1 Natural Sources

Mechanical and chemical breakdown of rocks, together with the products of animal and plant decay produce the soils of the region. Rainwater percolating through the soil dissolves these nutrients, passing them through to the groundwater, or nearby stream, and thence to the estuary. The type of plant cover of the region is important as this will affect the amount of nutrients remaining in the soil. In Australia many native plants can fix atmospheric nitrogen or obtain nitrogen from the soil and store phosphorus in the seed pod.

4.1.2 Rainfall

The loadings of nitrogen and phosphorus in rain have been studied in other countries. The results are extremely variable. The relevant factors seem to be duration of rainfall, proximity of industry and proximity to the sea, all of which result in presence of nutrients in the rain.

4.1.3 Aquatic Birds

In comparison with other sources of phosphorus and nitrogen, guano (droppings) contribution is not large, but may be of significance in certain parts of the estuary.

4.1.4 Forest Management

Clear felling of forests and erosion of forest land increases the amounts of runoff and sediment entering waterways. Plants which would normally be using the soil nutrients have been removed so that the amounts of nitrogen and phosphorus flowing off cleared and deforested country will greatly increase.

4.1.5 Agriculture

To achieve greater food production, increasing amounts of fertilizer are used in agriculture, irrigation techniques are common in dry areas, and high intensive livestock techniques are used. These factors lead to flow of nutrients into waterways. Nutrient loss from agricultural land is not considered to be important, but from the point of view of causing eutrophication these additions may be significant.

Leaching (removal from the soil through groundwater) is most important for nitrogen, especially if it is in the nitrate form. Phosphorus tends to become chemically bound to soil particles and organic matter and although it may be leached to lower levels does not so readily flow out into watercourses via the groundwater.

After heavy rainfall, water tends to move over the surface rather than percolate downwards, so surface runoff enters streams carrying debris, animal waste and excess fertilizer. Losses depend on duration and intensity of rainfall, length and slope of the land, area, soil type, vegetation and agricultural use. The nitrogenous compounds tend to become washed into the soil, where they are used in plant growth or leach into the groundwater. The phosphorus in surface matter reacts differently. The phosphorus present in the soil is in equilibrium with that in the organic matter on the surface so that any excess phosphorus can be washed away. Irrigated areas tend to have higher amounts of nitrogen and phosphorus in the runoff than other agricultural areas.

4.1.6 Septic Tanks

A great deal of domestic water makes its way to a septic tank. This water is rich in nutrients from human waste, household waste and detergents.

Research is being undertaken by several people at C.S.I.R.O.'s Division of Land Resources and Management on the effect of septic tank leachate on groundwater of the Swan Coastal Plain and the effect of the flow of this groundwater into coastal estuaries. The investigations have come up with some interesting facts.

Septic systems located on the Swan Coastal Plain work very effectively due to the sandy soil. The yellow sands in particular are rich in iron and aluminium and so tend to hold the phosphate as the effluent filters through the soil. The presence of detergents makes the flow easier and faster. Once the sand is saturated with phosphate, however, the excess is free to flow in the groundwater,

It seems that the eventual build-up of chemicals, particularly of nitrogen compounds in the groundwater, will, in time, eventually make the water unsuitable for domestic use. Work also done at C.S.I.R.O. by Sewell (unpublished) shows that there may be a relationship between flow of nitrogen in groundwater from residential areas into the Peel Inlet and the phenomenal growth of algae (Cladophora species) there.

4.1.7 Stormwater

Untreated urban stormwater may be a contributing factor to eutrophication. It contains significant quantities of nitrogen and phosphorus from gardens, industrial debris and street-cleaning practices.

4.1.8 The Intra-System Cycle

This may be one of the most significant sources of nutrients in South-western estuaries. The nutrients come from growth and decay of animals and plants within the biological system. Input of nutrients increases the living matter in the estuary, so that the amount of decaying matter and nutrients rises incrementally year by year. Much of the nutrients are cycled through the sediment.

4.1.9 Sampling Data

Generally speaking, nutrient loading is highest in winter when increased runoff and seepage bring nutrients into the rivers and drains. Because of the extreme variability of rainfall and runoff, not only between seasons but from one year to the next, the levels and loadings of nutrients in the rivers and drains will also vary enormously.

This extreme variability is well illustrated by the Quarterly Samplings of the Murray River carried out by the Peel Inlet Management Authority from 1972 to 1976 and analysed by Government Chemical Laboratories. This data is shown as Table 5 on the following page.

As can be seen during this 5-year period alone, the approximate amount of nitrogen flowing into the Peel Inlet from the Murray River varied between about 300,000 kgs in 1974 and 30,000 kgs in 1976, while an ever greater variation occurred in the amount of total phosphorus (50,000 kgs in 1974 and 3,000 kgs in 1976). This variation is partly due to the differing concentrations of these nutrients between seasons and from year to year and largely because of the enormous variations in seasonal and annual flow of the river (707 million cubic metres in 1974 and 88 million cubic metres in 1976).

Since 1976, R. Black of the Physics Department at the West Australian Institute of Technology (W.A.I.T.) has led a data collection programme which has involved sampling and gauging of the rivers and drains feeding the Peel-Harvey Estuary. This is a part of the Peel-Harvey Estuarine System Study being made by E.M.A.C. of E.P.A. As a part of this programme, levels of nutrient, including total nitrogen and phosphorus, have been measured and recorded.

The data so far collected through this programme is available. However, since these years had record dry winters, interpretation of the data is difficult and awaits collection of further data. This programme will continue and an interim report will be made available shortly.

TABLE 5 : Approximate N and P Loadings to Peel Inlet from the Murray River

Year	flow ($\times 10^{-6} m^3$)	Nitrogen (Albuminoid - N plus NH_4			Total Phosphorus		
		Conc. (ug/litre)	Loading		Conc. (ug/litre)	Loading	
			Kg/yr	$g/m^2 yr$		Kg/yr	g/m^2 yr
1972	140	300	40,000	0.6	40	5,000	0.08
1973	360	500	200,000	3	50	20,000	0.3
1974	707	400	300,000	5	70	50,000	0.8
1975	216	200	48,000	0.7	30	6,000	0.09
1976	88	400	30,000	0.5	40	3,000	0.04
Mean 1939-75	302	400	100,000	2	50	20,000	0.3
Mean	525						

Data Sources : PWD monthly Streamflow records (Hughes Bridge)
Peel Management Authority Quarterly Survey analyzed by Govt. Chem. Labs.

Note : Water samples taken at Ravenswood Bridge

Both the Peel Inlet and the Harvey Estuary are at times eutrophic, the Peel being dominated by algae and the Harvey by phytoplankton. Nutrient levels in the Murray River during 1974 were very high (Table 5) and may have contributed to the growth of algae (Cladophora spp) during that year.

4.2 Agricultural Chemicals

Much work has to be done in Australia in the area of setting standards for use of agricultural chemicals such as pesticides and herbicides. The United States Environmental Protection Agency (E.P.A., 1973) has set standards, or working levels (TABLE 7), but it must be remembered that these are safe levels for situations in the United States. Until much more local data is available, standards for water quality in the southwest of Australia cannot effectively be set.

Below is a discussion of the various pesticides and herbicides which are potentially dangerous in waterways together with some sampling data taken in the Peel-Harvey Estuarine system.

4.2.1 Chlorinated Hydrocarbon Pesticides

D.D.T., H.C.H., Dieldrin, Endrin, Aldrin and Endosulphan are all problem chemicals because they are chemically mobile and persistent in the environment, where they settle in living things causing adverse effects and death in non-target species.

Food has been the major source of D.D.T. intake by man, however because of its persistence, the United States Environmental Protection Agency has published working levels and safety factors for all chlorinated hydrocarbons in drinking water. Chlorinated hydrocarbons are accumulated by aquatic organisms directly from the water or sediments and these in turn are accumulated by animals (mainly fish and birds) that feed on the smaller forms. In this way insecticides enter the human food chain. To provide a minimum of protection they recommend that the derived working levels of the concentration of these chemicals should be the amount that would kill 50% of the most sensitive species from that locality in 96 hours. This concentration is often referred to as the 96 hour LC_{50} value.

4.2.2 Organophosphate and Carbamate Insecticides

Malathion, Parathion etc., are relatively soluble in water and are carried to rivers, estuaries and the sea by runoff. Evaporation and spray loss may also return these chemicals to aquatic systems in rainfall droplets. These compounds fall into the same toxic class as the chlorinated hydrocarbons, though there is little evidence that organisms accumulate organophosphate pesticides, or that these compounds accumulate through the food chain.

They act on the nervous system and most hydrolyse quite rapidly to less harmful products. They do however, have an unfortunate blanket effect when used in an aquatic environment, and may for example, kill mosquito lavae as well as important food sources for fish and birds.

The increased use of organophosphate and carbamate insecticides has necessitated the establishment of criteria to protect public health. United States Environmental Protection Agency recommends working levels of 0.1 ug/l for domestic water supplies and a maximum of 0.01 of the 96 hour LC_{50} value using local water and the most sensitive important species.

4.2.3 Herbicides

Xylene, copper sulphate 2 4-D, 2,4,5-T, Diquat etc., enter water resources from runoff, direct application, wind drift, treatment of drainage channels and accidental or careless spillage. 2,4-D lasts quite a long time (6 months in water) though most compounds break down fairly rapidly. In the United States 2,4,5-T was banned because of its harmful genetic effects on humans, though its content of the harmful agent, Dioxin, has been greatly reduced in Australia.

The recommended working levels for 2,4-D and 2,4,5-T inadvertently entering domestic water supplies are 0.02 ug/l. Maximum concentrations of all herbicides in aquatic systems should be less than 0.01 of the 96 hour LC_{50} value using local water and the most sensitive important species.

4.2.4 Sampling Data

Some sampling results from the Government Chemical Laboratories are given below. The levels of D.D.T. and Dieldrin taken from drains are listed for times when the drain was actually flowing into the Peel-Harvey Estuary, and from rivers when they were at their peak annual flow. All readings except for the Mayfields drain (July, 1977) were taken in August, 1977.

TABLE 6 : Levels of Pesticides in water flowing into the Peel-Harvey Estuary (July & Aug., 1977)

* <:"less than"

	ug/l.		
	D.D.T.	Dieldrin	Aldrin
Coolup Drain (into Austin Bay)	0.002	0.001	
South Coolup Drain (into Harvey Estuary	0.001	<0.001 *	
Mayfields Drain (into Harvey delta)	<0.001	0.002	<0.001
Harvey River	<0.001	<0.005	
Serpentine River	<0.001	0.003	

No other common chlorinated pesticides were detected.

It should be borne in mind that 1977 was a dry year and sampling should be matched in this way each year so as to make sure the levels of chlorinated hydrocarbons do not exceed the recommended working levels. The Murray River was not sampled.

TABLE 7 : Recommended Working Levels for Pesticides in Unfiltered Water
(from the U.S. Environmental Protection Agency, 1973)

Compound	Recommended Derived Working Level (ug/l.)	Compound	Recommended Derived Working Level (ug/l.)
Chlorinated Hydrocarbons:			
Aldrin	0.01	Mevinphos	0.002
DDT	0.002	Naled	0.004
DDE	0.006	Oxydemeton Methyl	0.4
Dieldrin	0.005	Parathion	0.001
Chlordane	0.04	Phosphamidon	0.03
Endosulphan	0.003	TEPP	0.3
Endrin	0.002	Trichlorophon	0.002
Heptachlor	0.01	Carbamates:	
Lindane	0.02	Carbaryl	0.02
Methoxychlor	0.005	Zectran	0.1
Toxaphene	0.01	Hericides:	
Organophosphates:		Aminotriazole (Amitrole)	300.0
Azinphosmethyl	0.001	Dalapon	110.0
Ciodrin	0.1	Dicamba	0.2
Coumaphos	0.001	Dicholbenil	37.0
Diazinon	0.009	Dichlone	0.7
Dichlorvos	0.001	Diquat	0.5
Dioxathion	0.09	Diuron	1.6
Disulfonton	0.05	2, 4-D (BEE)	4.0
Dursban	0.001	Fenac (Sodium salt)	45.0
Ethion	0.02	Silvex (BEE)	2.5
EPN	0.06	Silvex (PGBE)	2.0
Fenthion	0.006	Simazine	10.0
Malathion	0.008	Botanicals:	
		Allethrin	0.002
		Pyrethrum	0.01
		Rotenone	10.0

5. FLORA

5.1 Vegetation on the Foreshores

A large part of the margin of the Peel Inlet and western margin of the Harvey Estuary are situated on the Spearwood Soil System (McArthur and Bettenay, 1974). Associated with this soil is Tuart woodland (Eucalyptus gomphocephala). Healthy stands of high Tuart woodland also occur near Mealup Point and Point Grey on the eastern side of the Harvey Estuary. Tuart woodlands have a well defined understorey of peppermint (Agonis flexuosa) on the low-lying areas, and of Jarrah (Eucalyptus marginata) on the higher land further back from the water. The Tuart woodland changes abruptly at its margin to stands of wattle (Acacia saligna) with the freshwater or saltwater-tolerant communities fringing on either side.

The low-lying swampy areas support Banksia littoralis with a dense undergrowth of moisture-loving species. Deeper depressions which have built up a moisture-retaining peaty soil support freshwater swamp paperbarks (Melaleuca rhaphiophylla and Melaleuca preissiana) along with ti-tree (Leptospermum ellipticum) and various sedges.

In areas where the groundwater is persistently fresh, the flooded gum (Eucalyptus rudis) and the swamp paperbark (M.rhaphiophylla) are common. Banksia verticillata and the bullrush (Typha orientalis) occur in association with these. Freshwater flushes such as at Robert Bay are indicated by the sedges, Viminaria juncea and Gahnia trifida.

The saltwater affected areas of foreshore are dominated by two species of trees. The swamp sheoak (Casuarina obesa) is common right to the water's edge (Figure 8), as at the Chimneys and other places around the Peel Inlet. The saltwater swamp paperbark (Melaleuca cuticularis) commonly occurs on the water's edge, although the swamp sheoak seems to prefer higher ground.

The open areas of shoreline are vegetated by dense interlocking tufts of the rush (Juncus kraussii) which appear to withstand long periods of submergence in saline water. These reed beds provide an effective barrier to erosion, particularly on the Harvey Estuary, and also protect the rich assemblage of salt-tolerant plants which grow behind. (Figures 4 and 6).

The protected salt flats of Cyperus nitens, Wilsonia backhousii, Sueda australis, Triglochin striata and the samphires such as Salicornia quinquiflora support a rich assemblage of grazing water birds. This habitat is very rich in nutrients, indicated by the amount of plant material and fauna supported there.

However, very little is known about the complex inter-relationships between the bacteria, fungi and nitrogen-fixing algae in the re-cycling of nutrients, and the purification of the whole estuarine system.

Further identification of the above species and the associated ground plants can be sought in Erickson, George, Marchant and Morcombe (1973).

5.2 Aquatic Flora

5.2.1 General Discussion

Many fish and crustaceans* use South-Western estuaries as a permanent habitat. These are black bream, cobbler, garfish, yellow tail, grunter and the school prawn. Species such as mullet, whiting, silver bream, tailor, mulloway, flathead, flounder, perch roach, whitebait, blue manna crabs and king prawns use these estuaries as nursery and feeding habitat for juveniles, since the environment is rich in food and less boisterous than the sea. (See section 6.1). Thus the dependency of so many important commercial and sport fisheries on the estuaries is a major economic reason to preserve these habitats. (Odum, 1971). Characteristically, estuaries tend to be more productive than either the sea or the stream which drains into them. (Figure 2).

Estuaries form a sink of nutrients washed in to the slower shallower waters where micro-organisms, aquatic plants, fish and birds set up a cycle which is self enriching and unique in each case. There is a problem, however, in that all pollutants from human development also get trapped in the system.

In all cases, the macrophytes (sea-weed, sea-grass and fringing marsh plants) form the greatest mass of living material in estuaries and support the bottom-dwelling organisms and the planktonic organisms** which are all food for fish and birds. Breakdown of these plants produces grass detritus which is the beginning of the food chain for all estuarine fauna. During summer, microscopic algae "blooms" on the sea-grass, providing food for animals such as crabs which feed in the estuary at that time of year. Without the cover of benthic (bottom-attached) sea-grass and the fringing marsh, the nutrients swept into the estuary could not be used in this food chain, and the estuary becomes eutrophied (without oxygen).

*Crustaceans: Shrimps, prawns, barnacles, crabs, crayfish, etc.

**Planktonic organisms are animals and plants which float in waters as opposed to those which are attached to, or crawl upon the bottom. (Usually microscopic).

The tidal action of the sea provides a "subsidised" fluctuating environment. The back-and-forth movement of the water does all the work of removing wastes and transporting material within the estuary. Yet the whole system remains sessile or stationary. This is because the sea-grass meadows are physically holding the system down in one place. Removal of the benthic flora would result in massive erosion and loss of fauna.

Sea-grasses of importance in the Peel-Harvey system are Halophila ovalis, (paddle weed), Ruppia maritima, (sea-grass) Zostera muelleri, (Dwarf grass-wrak or eel-grass), Heterozostem sp. (eel-grass) Posidonea australis, (fire-ball plant) Amphibolus antarctica (sea nymph).

The distribution, ecology and specific requirements of these plants in the south-western Australian estuaries is not sufficiently understood. Where sea-grass has been lost due to pollution or dredging it may be feasible to transplant these areas with the same or another grass to restore stability and utilisation.

The mangrove, Avicennia marina (figures 10 and 11) which grows on Anglesea Island at Bunbury, is also very important in the detritus food chain. (Figure 3). Lear and Turner (1977) note that nutrients such as nitrogen and phosphorus are quickly utilised by mangroves and converted to food for fish and crustacea. Odum (1971) points out that sea-grasses, sea-weeds and salt marsh plants fulfil a similar function where they grow.

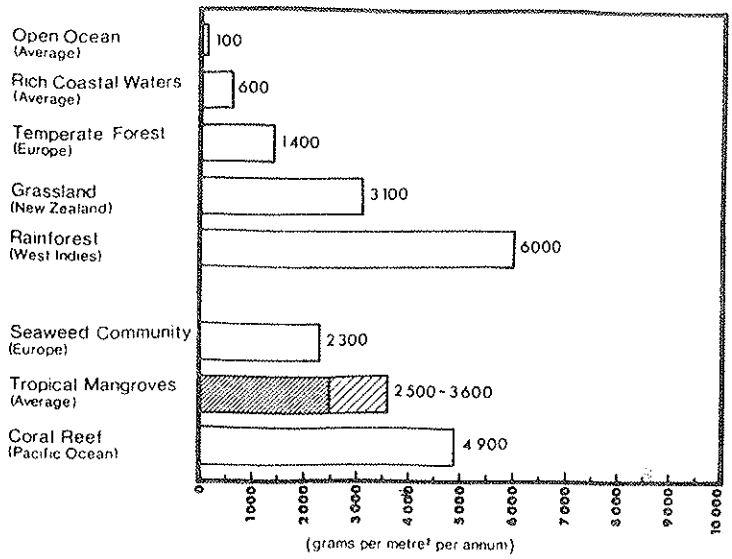
5.2.2 Peel-Harvey Estuary

The Peel Inlet and Harvey Estuary display different floral characteristics, the Peel being dominated by benthic (attached) plants, whilst the Harvey is rich in phytoplankton (floating plants). The following plants occur in the Peel-Harvey system.

(i) Cladophora spp.: This alga is most common in the Peel Inlet where it occasionally accumulates in large amounts on the beaches. (Figure 5).

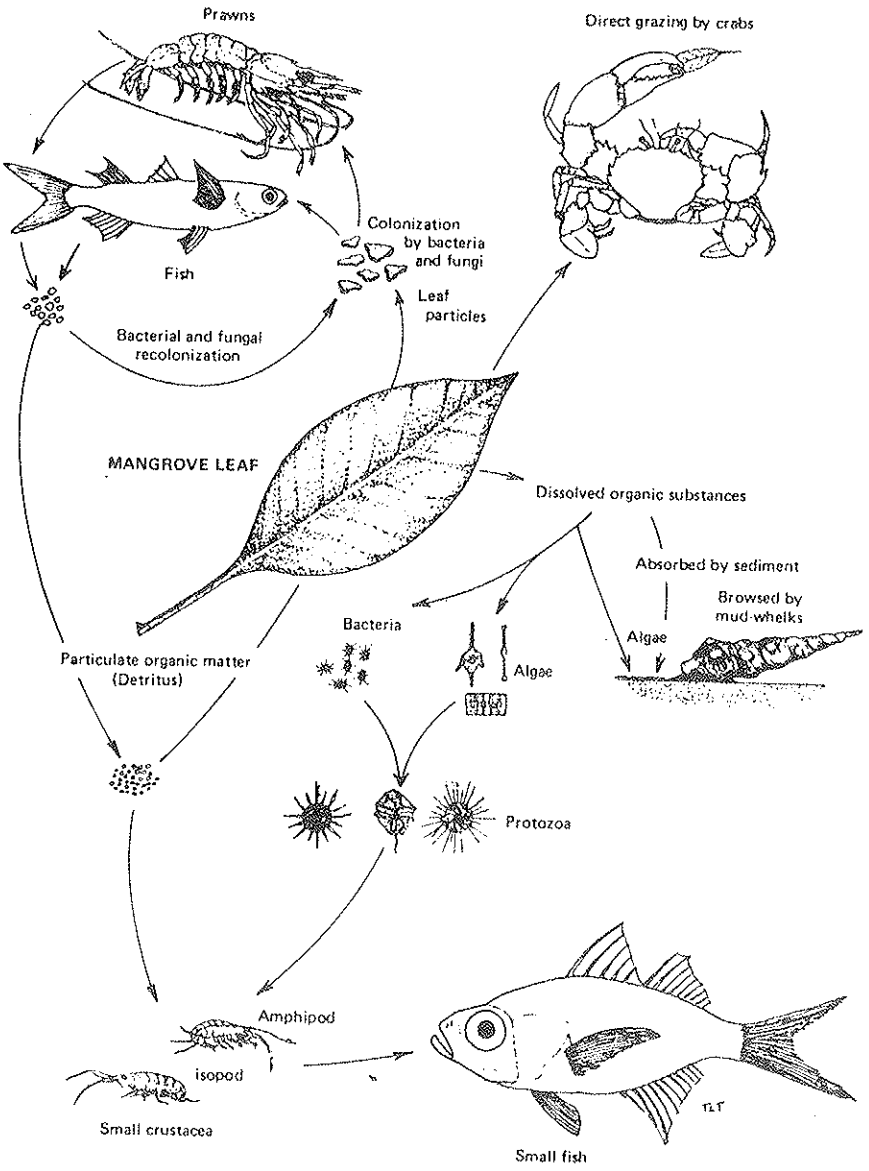
(ii) Chaetomorpha linum: or "Rope Weed" is becoming increasingly prominent in the Eastern Peel Inlet and Northern Harvey Estuary.

Figure 2



Net productivity of selected natural ecosystems.

Figure 3



Supply of mangrove material to basic estuarine food chains.

(iii) Ruppia maritima: or "Sea-Grass" grows in shallow water to a maximum depth of 50 cm and therefore is mainly distributed on the northern and eastern shallows of the Peel. It is a major food source for black swans (Cygnus atratus).

(iv) Halophila ovalis: or "Paddle Weed" grows in deeper water to a maximum of 1 metre. Lenanton (in press) has shown that these areas are of great importance as feeding and breeding grounds for a great many species of fish and crustacea.

(v) Halophila sp.: grows widely in the Peel and in the northern sections of the Harvey Inlet.

Red sea-weed can be found in patchy distribution, and in small amounts growing on the eastern side of the Peel Inlet and the northern part of the Harvey Estuary.

Regions of bare sediment occur in the Sticks Channel and central Harvey Estuary where lack of light and the presence of currents inhibit plant growth. The depth of the central basin of the Peel Inlet, and the turbidity of the southern end of the Harvey Inlet exclude light and inhibit growth in these regions.

The following micro-algae have been collected in Peel Inlet and are represented by specimens in the Botany Department Herbarium of the University of Western Australia (U.W.A.).

CHLOROPHYTA

Acetabularia calyculus Quey and Gaim

Acetabularia peniculus (R.Br.) Solms.

Chaetomorpha aerea (Dillw.) Kuetz.

Chaetomorpha linum (Muell.) Kuetz.

Cladophora spp. - probably several species

Enteromorpha spp. - probably several species

Lamprothamnium papulosum (Wallr.) J.Gr.em.R.D.W.

PHAEOPHYTA

Caulocystis uvifera (Ag.) Aresch.

Cystoseira trinodis (Forsk.) Ag.

Dictyota sp.

Hormophysa triquetra (l.) Kuetz

RHODOPHYTA

Chondria sp.

Corynospora australis Harv.

Gracilaria vemicosa (Huds.) Pafenfuss

Polysiphonia sp.

Laurencia sp.

CYANOPHYTA

Oscillatroia sp. mats

AQUATIC ANGIOSPERMS

Halophila ovalis (R.Br.)Hook.f.

Ruppia maritima L.

Zostera mucronata den Hartog

5.2.3 The "Weed Problem" on the Peel Inlet

The accumulation of Cladophora spp. or "goat weed", particularly in the years 1972-1974, with its subsequent breakdown to release a foul-smelling odour (hydrogen sulphide gas) was a great source of complaint from the residents adjacent to the Peel Inlet. Investigation results are confusing, since the Harvey Estuary has a high level of nutrient phosphorus but no Cladophora problem. High concentrations of these nutrients are thought to stimulate algal growths. Recent observation on the Peel Inlet in 1977 suggests that the macroalga Chaetomorpha spp.is now a problem of similar amplitude.

Verbal accounts from fishermen indicate that Cladophora used to be collected and carted away by bullock cart in the past. The"weed" problem on the Swan River dates back to the 1880's, where Chaetomorpha and Melosira spp. were the principal algae. This was reviewed by Hodgkin and Vicker (1975).

In 1976 the Estuarine and Marine Advisory Committee of Environment Protection Authority undertook a study of the Peel-Harvey estuarine system. The purpose of this study as stated in March, 1977, was:

(i) General - to gain an understanding of the working of this estuarine ecosystem as the basis for decisions about its management.

(ii) Specific - to determine the causes of the excessive growth and accumulation of green algae, principally Cladophora spp. in Peel Inlet and if possible to propose a method for its control.

The course of the study has resulted in the following points:

5.2.3.1 The weeds causing the nuisance are Cladophora aff. nitidula and Cladophora aff. battersii. The life cycle starts with spores which come to lie on the substrate and grow rhiziods or projections which hold it down. When the structure enlarges, it begins to photosynthesise and then floats to the surface where it moves under the influence of the wind. In the Peel Inlet, it grows as a perennial species and does not depend upon its classical life cycle.

Cladophora spp.grow in two areas, namely off-shore at Falcon and in a large area between Coodanup and the Yunderup Delta, where it builds up into thick beds of "ooze". Only the top 2cm are photosynthesising since the buried weed is excluded from the light. Laboratory experiments show that the weed can increase by 50% in twelve months.

It is thought that growth of Cladophora spp. is related to the presence of phosphorous and nitrogen and to warmer temperatures, rather than to a preferred salinity. The Cladophora is grazed upon by amphipods and crabs.

5.2.3.2 The computer model developed by the Centre for Resources and Environmental Studies at A.N.U. has resulted in the use of several formulae which can be used to simulate the effects of variations in the following :

Cladophora growth

Phytoplankton growth

Phosphorus concentration in the inlet

Phosphorus concentration in sediments

Sediment volume

Conservation of water in the inlet

5.2.3.3 Phosphate and nitrogen may be arriving in appreciable quantities into the estuary from the Murray River. The highest values occurred in 1974 when Cladophora growth was extremely high. In 1974 the addition of nitrogen into the inlet from the Murray River was 300,000 kg and of phosphorus was 50,000 kg. The phosphorus is mainly in an organic form.

5.2.3.4 The silty sediment in the central basin of the Peel Inlet is high in both phosphorus and nitrogen when compared to the sandy peripheral platforms. Another important source of nutrient is the decaying mass of Cladophora.

The interalgal water contains five times as much phosphorus and is richer in nitrogen than the water above. (It seems that phosphorus arriving in the estuary in river water is being trapped in sediment and Cladophora growth). It has also been shown that Cladophora produce a substance called phosphotase which assists in the breakdown of organic phosphates in the sediment so that they can be recycled into the system.

5.2.3.5 Sewell (unpublished) notes that Cladophora did not become a localised problem until 1965. Up until this time and up to 1969, the groundwater which was the sink for septic sewerage systems was being enriched in nutrients.

In 1970 the Mandurah-Coodanup area became reticulated. This would have increased the volume and flushing effect of the nutrient-laden groundwater into the estuary.

It is hypothesised that the explosive growth of Cladophora in 1973-1974 could have been encouraged by nutrient nitrogen leaching from residential areas surrounding the estuary. The sediment of the Peel Inlet is fairly rich in phosphorus anyway. Growth was occurring in August-September when flushing out of nutrients could be expected.

In 1973 Soldier's Cove went under sewerage. Reticulation of the rapidly growing Mandurah-Coodanup area since 1970 has gradually diluted the nutrients in the groundwater.

Since 1974 the Cladophora growth has tended to fall off, though the process of raking and carting away the weed is still being carried out. This removal has caused total destruction of foreshore vegetation in some areas, particularly at Coodanup (see Figure 5).

Observation in January, 1978, showed the major areas of accumulation of Cladophora were on the foreshore at Coodanup, Estuary Gardens, Placid Waters and from Iluka Road around to Dawesville.

5.3 Vegetation for Protection of the Foreshore

Erosion by people, boat launching and boat wash occur in two different situations.

(i) Gently sloping banks such as along the foreshores of Peel-Harvey Inlet where banks of reeds have been torn up and trees have been burned by campers' fires (figures 8 and 9).

Figure 4:

A typical natural sequence of foreshore vegetation grading from reed marsh to paperbarks (Maleleucas) and sheoaks (Casuarinas) to Eucalypt woodland. This natural sequence can be duplicated on eroded foreshore areas and recreation reserves.

Figure 5:

This denuded shoreline at Coodanup was once thickly vegetated, however the growth of "weed" (Cladophora algae) in this part of the Peel Inlet and the subsequent removal of it by bulldozers has resulted in the total destruction of all foreshore vegetation in this area. The rotting piles of "weed" seen in this photograph give off a strong, unpleasant odour.

(ii) Steep banks such as along the Serpentine and Murray Rivers, where boat launching and worm digging have gouged away the banks (figure 7). These unsightly gaps will worsen over the years if not rehabilitated. A further problem is that the banks are layered. The top layer is often of a stickier texture on which plants such as the sheoak (Casuarina obesa) and reeds (Juncus krausii) are growing. Below this layer is a grey to light yellow sand. The waves from boats tend to wash out the sand from beneath the clay, so that the trees and reeds gradually lean and eventually topple into the river.

The first situation may best be treated by planting the reed Juncus krausii. The seed heads can be collected in late summer, dried at room temperature so that the seed falls out. These can be placed in trays to germinate. They should bekept thoroughly wet with tap water.

The best way to protect the newly planted reeds is probably to cover the whole transplanted tray with a bed of chicken wire. One square metre of chicken wire could be pegged to the ground at intervals of ten metres along an eroded shoreline with the reeds planted beneath the wire. As the reeds become established, each node will begin to accumulate soil and eventually stabilize the foreshore.

Other plants normally associated with reed beds will germinate and grow in time. Sheoak (Casuarina obesa) and/or paperbark (Melaleuca spp.) can then be planted behind the reed bed (Figure 4).

It may be considered useful to transplant the mangrove, Avicennia marina, along shorelines which are susceptible to erosion. Savage (1972) shows that mangroves are very efficient shoreline stabilizers, even in very turbulent conditions. Because of their rapid utilization of nitrogen and phosphorus and subsequent conversion into food for fish and crustacea, mangroves, reeds and sea-grasses may be considered useful not only for erosion prevention but also in areas where there is an excess inflow of nutrients and eutrophication is a problem. (See section 5.2.1).

The second situation is much more difficult to treat. Any tree that is leaning excessively may have to be cut off close to the ground. If the root system is not disturbed, the tree should sprout again. Where the bank has been totally denuded of vegetation it could be battered back to about 30° and planted with reed (Juncus krausii and Scirpus validus).

It is always difficult to protect newly planted areas from vandalism or careless use, and if an area of shoreline is to be successfully regenerated and stabilized, methods must be adopted to limit public access for periods of time deemed sufficient for this to occur.

Figure 6:

Healthy reed beds (Juncus krausii) offer excellent protection from foreshore erosion as well as being important recyclers of nutrients to produce food for fish and crustaceans. These reed beds are also crucial nesting and feeding sites for many species of birds.

Figure 7:

Erosion of foreshore is initiated by the removal of the reed beds (Juncus krausii) which protect the shorelines. Here the practice of "worm digging" has caused serious erosion.

Figure 8:

Indiscriminate removal of reeds (Juncus krausii) along foreshores for the purpose of easier boat launching and access to the water has a cumulative effect of causing erosion along the whole length of shoreline. These areas can be revegetated with reeds, behind which sheoaks (Casuarinas) paperbarks (Melaleucas) and Eucalypts may be planted. Here, Casuarina obesa grows behind the reeds, with a Tuart (Eucalyptus gomphocephala) woodland behind.

Figure 9:

Removal and trampling of reeds beside each jetty leads to erosion of the whole length of foreshore. Here the saltwater-tolerant sheoaks (Casuarina obesa) have had their roots exposed and many have toppled or are ready to topple into the water.

Figure 10:

Mangroves (Avicennia marina) play an important role in nutrient recycling and food supply for fish and crabs. They grow on Anglesea Island at Bunbury but not on the Peel - Harvey Estuary, however, they could be considered valuable in foreshore stabilisation programmes in this Estuary.

Figure 11:

The 4-metre high stand of Mangroves (Avicennia marina) on Anglesea Island near Bunbury.

5.4 Vegetation Suited to Planting in Recreation Areas

With consideration of the soil, drainage and position of the area to be planted, it would be possible if not desirable to use the plants which are native to the area in recreational areas. These plants have been described in section 5.1 and are well adapted to local conditions of seasonal drought and salinity. In particular the paperbarks (Melaleuca spp.) and sheoaks (Casuarina spp.) are valuable for this purpose.

In some areas it may be decided to use plants other than those naturally found growing in the district. These introduced plants would probably require irrigation, and their survival depends upon the quality of the water used. Five fundamental principles should be observed when watering with salty water.

(i) Water in large doses.
(ii) Provide good drainage.
(iii) Control evaporation by watering at night.
(iv) Keep water off the plants and leaves.
(v) Use salt-tolerant plants.

The plants below are divided into two groups according to the concentration of salt tolerable, and listed within these groups in order of their tolerance within these salinity ranges.

5.4.1 Plants which can tolerate 1.5 - 3.5 ppt of salt

(a) Ground Cover

Oats, Wheat, Rye, Lucerne and Sudangrass Strawberry Clover, Sweet Clover, Millet, Wimmera Ryegrass, Rhodes Grass, Couch Grass, Barley, Birdsfoot trefoil, Buffalo Grass and Kikuyu Grass, Paspalum (Paspalum dilatatum).

(b) Ornamentals

Stock (Matthiola incana), Chrysanthemum (Chrysanthemum spp), Carnation (Dianthus spp.) Hibiscus (Hibiscus spp.), Oleander (Nerium oleander), Bougainvillea (Bougainvillea glabra), Vinca (Catharanthus roseus), Australian Hop Bush (Dudenea attenuata), Coprosma, Japanese Pepper (Schinus terbinthifolius), Indian Rubber Plant and Figs (Ficus spp.) False acacia (Robinia Psuedoacacia), Queensland Pyramid Tree (Laguaria patersonii), New Zealand Christmas Bush Metrosiderous tomentosa), False mahogany (Eucalyptus botryoides), Rottnest ti-tree (Melaleuca pubescens), Rottnest cyprus (Callitris robusta), Sydney wattle (Acacia longifolia), Pigface (Portulaca grandiflora), Livingstone daisy or Mesembryanthemum (Dorotheanthus bellidiformis), Boobyalla (Myoporum acuminatum), Morrel or Redwood (Eucalyptus oleosa var. plenissima), Swamp yate (Eucalyptus occidentalis), York gum (Eucalyptus loxopheba), Bamboo, Kondinin blackbutt (Eucalyptus kondininensis), Native pine (Actinostrobus pyramisalis).

5.4.2 Plants which can tolerate 3.5 - 13 ppt of salt

(a) Ground Cover

Paspalum vaginatum, Puccinella ciliata, Saltwater couch, (Sporobolus virginicus)

(b) Ornamentals

Canary palm (Phoenix canariesis), Salt Sheoaks (Casuarina cristata), Salt River Gum (Eucalyptus sargentii), Tamarisks (Tamarix parviflora), and Saltbushes (Atriplex spp.).

6. FISHERIES AND BIRDLIFE

6.1 Fisheries

Species of fish using the estuary are of the classes elasmobranchs (sharks and rays), teleosts (bony fishes) and crustaceans (e.g. prawns crabs and lobsters). Many of these species are of commercial interest. Lenanton (1977) describes the environmental factors which affect the utilisation and distribution of fish or crustaceans of the estuary as salinity, temperature, dissolved oxygen, turbidity, available food and shelter.

All the fish and crustaceans which utilise the estuary can be included in one of the following three categories, grouped on the basis of how they mostly use the environment. These categories are described by Lenanton (publication in press).

6.1.1 Permanent Breeding and Nursery Habitat

Species typical of this group include black bream, cobbler, Perth herring, some flathead and flounder species, river garfish, yellowtail grunter, some of the non-commercial species such as the hardyhead gobbleguts, and some of the gobies. The only commercial crustacean in this group is the greasyback, school or common river prawn. It should be noted that a number of these fish, e.g. cobbler, flounder, and flathead are also capable of reproducing and living entirely outside the estuary in marine embayments such as Cockburn Sound. Other species such as black bream and Perth herring are capable of making excursions into similar areas, mainly in response to winter flood conditions. However, irrespective of the above cases, all species in this group are capable of reproducing and living entirely within the estuarine system. Some, such as the hardyhead, gobies, and cobbler, have rather specialised breeding habits which help to make them well adapted to living in such extreme habitats. They produce relatively few eggs, but take rather better care of them than most fish. Hardyheads attach their eggs to sea-grass leaves, and gobies actually build nests under stones and other objects, attaching their eggs to the inner surfaces of their nests (Lenanton, 1977). The cobbler is also thought to be a nest builder, although the precise details of the nest structure are unknown (Kowarsky, 1975).

6.1.2 A Nursery Habitat for Juveniles

Fish in this group include the bulk of the most important commercial and amateur species. Species typical of this group include the mullets (sea and yelloweye), the whitings (King George, Western Sand, and Trumpeter), Silver Bream, Tailor, Mulloway, some of the Flatheads and Flounders, Sea Garfish, Striped Perch (or Trumpeter), Roach, Whitebait and Anchovy, and the commercial crustaceans such as Blue Manna Crabs and King Prawns. They all utilise the estuarine habitat as a nursery area. Abundant food and shelter both from predators and from the more boisterous marine environment are important factors

which encourage the utilisation of the estuaries by the young life stages of many of these species. From research in other estuaries (Lenanton, 1977) and preliminary work in the Swan River (joint programme on fishes of the Swan by Department of Fisheries and Wildlife of Murdoch University), it is clear that the shallow banks, in particular the sea-grass (Halophila ovalis) area, are the most important nursery habitats for these fish. This is mainly because of the abundant supply of small invertebrate animals which are a principal source of food for these small fish (Thomson, 1957 and Wallace,1975). These banks are certainly more productive (see Figure 2) in terms of abundance of potential food for fish than the deeper areas (Wallace, 1977). This is reflected in differences in the abundance and distribution of fishes inhabiting the two areas (Chubb, unpublished).

It should be emphasised that this natural history pattern is the one which could be expected during a year when a reasonable freshwater flush is experienced during the winter months. In years of reduced winter freshwater flushing, species such as trumpeter whiting, tailor,mulloway, and crabs may remain in the system all year, particularly in waters which do not become fresh. Conversely, in years of prolonged heavy winter freshwater flushing, these four species may be forced out of the system for long periods of the year.

6.1.3 An Occasional Feeding Area for Maturing and Mature Adults

Species typical of this group include Australian herring and salmon, skipjack, blowfish, school whiting, scaly mackerel, pilchard (mulie), blue sprat, blue (common) mackerel, and most of the sharks and rays. Species in this group form only a minor part of the commercial and amateur catch from the estuarine system.

Most of these species are more commonly caught in the marine environment, particularly in marine embayments such as Cockburn Sound, along coastal beaches and in waters around Rottnest Island. These species only venture into the estuary when the salinities are approaching those of sea water (usually in the summer months). However in abnormally dry years, they may remain in the system for a number of months, venturing far upstream into the tidal rivers. The blowfish is a good example of an animal from this group that is able to remain in the system for long periods.

The attached production data in Table 8 has been extracted directly from the Australian Bureau of Statistics figures. Unfortunately, from time to time there are records of catches of a number of species which are normally not found in the estuarine environment. This is usually the result of fishermen assigning the incorrect area code (block) to their catches of the species in question. The one species which definitely falls into this category is Western Australian jewfish.

Australian salmon, groper, buffalo bream, yellowtail kingfish, leather jacket, scaly mackerel, pilchard samson fish, shark and snapper can also fall into this category, particularly if the catches of these species are relatively large by comparison to catches of the estuarine species.

However, if the catches of the above named species are irregular and relatively small by comparison to other species, then the data may have been correctly coded and truly reflect a chance occurrence of these species within the estuarine system in question.

It is very difficult to make anything but very general conclusions from a superficial look at the data available on fishes of the estuary. However, from the commercial catch statistics, and the results of the brief surveys by Scott and Chalmer (1974) and Lenanton (1977), the following general statements can be made:-

6.1.4 The fish species composition of the estuary appears to be typical of other west coast estuaries of temperate Western Australia. However, there are marked differences between the fish fauna of west and south coast estuaries based mostly on a comparison of the fishes from the Swan and Blackwood River estuaries.

6.1.5 There appears during summer at least, to be a decrease in species diversity between the mouth of the estuarine system and the top end of Harvey estuary, due probably to the increasing salinity gradient between the two areas(35 ppt at the estuary channel to 50 ppt at the upper end of Harvey estuary during early April, 1978).

6.1.6 The composition of the commercial catches does not appear to have changed markedly between 1952 and 1975. However, there are one or two changes that may be of interest.

(i) Large catches of crabs were not common until the early 1960's.

(ii) There appeared to be a greater proportion of mulloway and black bream in the catches during the 50's and 60's.

(iii) Scaley mackerel and pilchards first appeared in the catches during the early 1960's.

6.1.7 Over the period 1970-1974 (inclusive) comparisons of the catches of species from both the Swan-Canning and Peel-Harvey system whose mean annual production was over 1,000 kg revealed some interesting points.

(i) Sea mullet, yelloweye mullet, cobbler and Perth herring were amongst the top producers for each system.

(ii) The catches of King George whiting and western sand whiting were much greater in the Peel-Harvey system.

(iii) Catches of mulloway and flathead were much greater in the Swan-Canning system.

(iv) Catches of pilchards and scaly mackerel were slightly greater in the Peel-Harvey system.

(v) Catches of prawns were much greater in the Peel-Harvey system.

The differences illustrated in points (ii) and (iii) above probably reflect the preference by whiting for extensive shallow flats, and by mulloway and flathead for the deeper estuarine areas.

The greater prawn catches from Peel-Harvey are mostly due to the fact that the traditional professional fishery for them is better developed in this estuarine system.

Fisheries and Wildlife are presently working on the preparation of the preliminary checklist of fishes of the lower West Coast estuaries. This document, together with all the other information available on the fishes of the Peel-Harvey system would provide sufficient basis for the preparation of a reasonably comprehensive account of the fish fauna of the system.

6.2 BIRDLIFE

The following data was supplied by J. Lane of Fisheries and Wildlife Department.

Peel-Harvey Estuary supports large populations of a wide diversity of waterbird species. As a conservation area for waterbirds it is probably the most important estuary in south-western Australia.

At least 70 species of waterbirds are known to occur on the estuary. 10 of which are summer migrants with their breeding grounds in the northern hemisphere. Table 9 gives a list of waterbird species on the Peel-Harvey system during 1976 and 1977. Some of the most outstanding features of the Peel-Harvey's birdlife are outlined in the first three subsections below.

6.2.1 Pelicans

Peel-Harvey has the largest pelican population of any estuary in the south-western part of Australia. In January, 1976, more than 1,000 birds inhabited the estuary (60% of the total number of pelicans known to occur on all South-western estuaries at that time). In December, 1976, the population reached a peak of 2,100 birds.

	1973	1974	1975
MEN	677	716	673
BOATS	454	448	427
SEA MULLET	211,772	245,884	240,151
SAND MULLET	43	78	
YELLOWEYE MULLET	131,130	162,354	313,520
WESTERN SAND WHITING	15,146	18,956	9,744
KING GEORGE WHITING	16,662	9,792	2,891
ROACH		51	54
BLACK BREAM	10		
TARWHINE			
COBBLER	204,791	218,436	51,574
PERTH HERRING	1,136	11,428	1,908
SOUTHERN TREVALY			
TAILOR	1,751	8,500	21,574
WEST AUST JEWFISH		25	
AUST SALMON	81	55	
GROPER		125	
RUFF	595	432	693
BUFFALO BREAM			
MULLOWAY	185	810	1,305
ANCHOVY	916	4,160	1,561
FLOUNDER		25	7
YELLOWTAIL KINGFISH		45	
DUSKY FLATHEAD			
LEATHER JACKET	14	4	24
YELLOWTAIL PERCH	370		
SCALY MACKEREL	2,423		
SEA GARFISH	1,017	1,572	4,233
PILCHARD		12,857	34,827
SAMSON FISH	24	140	
OTHER WETFISH	161		764
SHARK	505	1,414	
SNAPPER		16,794	
CRABS	38,372	16,360	5,635
PRAWNS	8,953	3,051	27,117
FISH	588,732	713,937	684,830
CRUSTACEANS	47,325	19,411	32,752

6.2.2 Waterfowl

The Estuary also supports very large waterfowl populations. Grey Teal (Anas gibberifrons), Black Duck (Anas superciliosa) and Mountain Duck (Tadorna tadornoides) are the most abundant duck species and, during the summer of 1975/76 their numbers reached a peak estimated at 8-10,000 birds. Black Swans (Cygnus atratus) are also abundant. A three-day survey in all South-western estuaries in November, 1975, showed the Peel-Harvey Estuary supporting more than 2,500 swans (40% of the total South-western estuarine population at that time). In October, 1976, 8,000 Black Swans were present in the Peel-Harvey system.

The most important waterfowl habitats are the shallows off the eastern and southern shores of Peel Inlet and the Harvey Estuary south of Herron Point. The Harvey River delta is of particular importance in late summer when thousands of ducks congregate on its banks.

6.2.3 Wading Birds

Many thousands of resident and migratory waders occur in the Peel-Harvey Estuary. Resident species are present from mid-summer to late autumn and migrants from spring to late summer. Major populations are of Banded Stilt (Cladorhynchus leucocephalus) which were estimated to number 15-20,000 birds in February, 1976, and 40-50,000 birds in February, 1977.

Most of the stilts were in Austin Bay, underlining the importance of shallows and marshes to waterbirds. Over 10,000 migratory waders were present during the summer of 1976/77.

Three areas of samphire flats and marshes bordering the main channel from Peel Inlet to the ocean are also important to the bird population. These are worthy of preservation to maintain the habitat of the Eastern Curlew (Numerius madagascarensis) and Whimbrel (Numenius phaeopus).

6.2.4 Areas of Importance

The areas of importance as breeding, feeding or loafing grounds for waterbirds within the Waterways Commission boundaries are shown on Map 4.

(i) Goegrup Lake (Willie's Lake) is a shallow, brackish-to-saline lake, some 6 km from the mouth of the Serpentine River. The lake has long been recognised as an important breeding and feeding ground for mullet, prawns and crabs.

In the Serpentine River to the north are three brackish-to-fresh pools (Yalbanberup, Guanarnup and Kerulup Pools), while to the south-east are an interconnected series of brackish-to-salt lakes (Cogrup, Salt, Walyanup, Bulbiba and Road Lakes). This chain of pools and lakes is a major watering and loafing area for waterfowl, many seeking fresh water daily from the seepages and waters of the Serpentine River. On separate days in November, 1977, 432 birds of 18 species were observed on the river, north of Lake Goegrup and over 7,000 birds of 23 species on the lakes south-east of Goegrup.

Lake Goegrup also supports large numbers of waterfowl. In November, 1972, the most abundant species were Mountain Duck (500 birds), Black Duck (700) and Black Swan (1,000). Approximately 2,000 Grey Teal were found on the lake in November, 1977.

(ii) Harvey River and Harvey Estuary south of Island Point and Herron Point.

(iii) Austin Bay, Robert Bay and the shallows of the Serpentine and Murray deltas.

(iv) Channel Island, Creery Island and the salt marsh flats south of Mandurah.

(v) The areas of samphire flats in the inlet channel near Mandurah.

TABLE 9: WATERBIRD SPECIES RECORDED ON PEEL-HARVEY ESTUARY DURING PERIOD AUGUST 1976-JUNE 1977

SPECIES	ESTIMATED MAXIMUM POPULATIONS	
	1,000 to 10,000 BIRDS	MORE THAN 10,000 BIRDS
Hoary-headed Grebe		x
Crested Grebe		
Australian Pelican	x	
Black Cormorant		
Little Black Cormorant	x	
Pied Cormorant	x	
Little Pied Cormorant	x	
Darter		
Reef Heron		
Little Egret		
White Egret		
White-faced Heron	x	
White Ibis		
Straw-necked Ibis		
Glossy Ibis		
Royal Spoonbill		
Yellow-billed Spoonbill		
Black Swan	x	
Mountain Duck	x	
Black Duck	x	
Grey Teal		x
Chestnut Teal		
Mallard (Domestic variety)		
Shoveller	x	
Pink-eared Duck	x	
White-eyed Duck		
Wood Duck		
Musk Duck	x	
Whistling Kite		
Swamp Harrier		
Osprey		
Spotted Crake		
Swamphen		
Coot		x
Red-kneed Dotterel		
Black-fronted Dotterel		
Red-capped Dotterel	x	
* Large Dotterel		
Australian Dotterel		
* Grey Plover		
* Eastern Golden Plover		
* Turnstone		
* Whimbrel		
* Eastern Curlew		
* Greenshank		
* Marsh Sandpiper		
* Common Sandpiper		

SPECIES	ESTIMATED MAXIMUM POPULATIONS	
	1,000 to 10,000 BIRDS	MORE THAN 10,000 BIRDS
* Tattler		
* Terek Sandpiper		
* Knot	x	
* Great Knot		
* Sharp-tailed Sandpiper	x	
* Pectoral Sandpiper		
* Red-necked Stint		x
* Curlew Sandpiper	x	
* Black-tailed Godwit		
* Bar-tailed Godwit		
Pied Stilt	x	
Banded Stilt		x
Avocet	x	
Silver Gull	x	
Gull-billed Tern		
Caspian Tern		
Crested Tern		
Roseate Tern		
Whiskered Tern		
Fairy Tern		
Sacred Kingfisher		
Little Grassbird		
White-faced Chat		
TOTALS: 70 Species	18 Species	5 Species

* Summer migrants with breeding grounds in the northern hemisphere (19 species).

7. FORESHORE OWNERSHIP

The foreshores of the south-western Australian estuaries, as well as the waterways themselves, are recreational resources which must be managed for the future. The following table gives some idea of the proportion of foreshore, currently developed, which is available for future planning, and that which is already recreational or wildlife reserves.

TABLE 10 Existing Development of the perimeter of the Peel-Harvey Estuary.

Perimeter	Length	Percentage
Developed (residential)	7km	8%
Undeveloped	53km	56%
Reserve	34km	36%

This figure only includes the foreshore frontage of reserves which have a substantial distance from foreshore to the land boundary at the rear of the reserve. It excludes any sections of the foreshore where a Road Reserve has a boundary at high water mark, or where rezoning has resulted in a narrow strip of land along the foreshore being designated Public Open Space. The locations of Freehold, Public and Crown Land are shown on Map 2.

7.1 Recreational Reserves

In comparison with other types of foreshore utilization, recreational areas are limited in number. The areas north of the bridge at Mandurah are already fully developed.

The Recreational Reserves on the western side of Harvey Estuary between Novara and Island Point are only partly developed for recreation, even though they are busily used during the summer. The result is that these areas are becoming denuded and badly eroded. A similar situation exists on the narrow Recreational Reserves along the Serpentine and Murray Rivers.

There are several gazetted Recreational Reserves which are not popular and not developed. These include:-

(i) Lake Goegrup
(ii) Stoney Point
(iii) Island Point
(iv) Herron Point
(v) Two substantial Foreshore Reserves on the Harvey River
(vi) The Yunderup Canals
(vii) A small island on the Harvey River
(viii) Boodalan Island on the Peel Inlet.

7.2 Fauna and Flora Reserves

A substantial amount of the perimeter of the Peel Inlet and Harvey Estuary is taken up by conservation reserves. These areas are :

(i) Delta Islands apart from parts of Cooleenup and Yunderup Islands.
(ii) Western side of Peel Inlet and Austin Bay.
(iii) South-eastern side of Harvey Estuary.
(iv) Two small reserves on eastern side of Harvey Estuary.
(v) Robert Bay.
(vi) Creery and Channel Islands.
(vii) Boodalan Island.

7.3 Privately Owned Land

Much privately owned land abuts the estuary. Both sides of the inlet channel south of Mandurah Bridge are privately owned as is much of the western side of the Harvey Estuary.

Two small sections of freehold land interrupt the Foreshore Reserve in Robert Bay.

The foreshores on most of the lower portion of the Serptentine River and all of the salt lakes in the vicinity of Lake Goegrup are privately owned.

The banks of the Murray River from the delta to Pinjarra and sections of Cooleenup and Yunderup Islands are largely privately owned. Land abutting the Murray River south of Pinjarra is all freehold land.

Apart from a camping reserve, the whole of the western bank of the Harvey River is Freehold rural land. Both sides of the Harvey River in the Shire of Waroona are privately owned.

7.4 Narrow Foreshore Reserves

The remaining perimeter not taken up by conservation, Recreational Reserves or Freehold land is reserved land only 7 to 13 metres wide. The land behind is invariably Freehold. The problems of space, erosion and access make these areas difficult to develop as recreational facilities to meet the requirements of an expanding population. Some of these reserves act as a buffer zone between water and rural land, such as the Crown reserve on the eastern bank of the Harvey River.

7.5 Vacant Crown Land

This land is accessible and could be considered as potential recreational area. These areas include :

(i) Dolphin Cove at Mandurah.
(ii) Small portion of river bank at Pinjarra.
(iii) Encounter Island south of Pinjarra.
(iv) Small section next to the southern camping ground on the Harvey River.
(v) Several small islands between Channel Island and the Chimneys.
(vi) Some areas of foreshore in Soldiers' Cove and Dalrymple Park.

7.6 Industrial Land

No part of the foreshore or estuary is being used for industrial or mining purposes.

8. SOCIOLOGICAL FACTORS

8.1 Projected Population Growths

The Martin Report (1974) to the Town Planning Department outlines two strategies for the urban/industrial development of the South-West Corridor (coastal area from Fremantle to Murray Shire inclusive) to the year 2000 A.D. Both of these strategies envisage the expansion centred on Rockingham/Kwinana, while they differ in their proposed relative expansion of the Cockburn and Mandurah areas. Their population breakdown under each strategy is shown in table 11.

TABLE 11 Population Growth Strategies for the South-West Corridor (Martin, 1974)

Locality	Population - Year 2000	
	Strategy One	Strategy Two
Cockburn	148,775	108,300
Rockingham/Kwinana	148,950	148,950
Mandurah/Murray	72,275	112,750
Total	370,000	370,000

The Martin Report forecasts that because of the proximity of jobs and facilities offering in the Cockburn Industrial Area, the proposed Cockburn locality will grow faster than Rockingham/Mandurah localities. Growth of Rockingham is not expected until the Cockburn area is well advanced, and similarly, the Report suggests that Mandurah/Murray is not expected to extend appreciably until Rockingham is advanced.

The Martin Report envisages that most of the expansion of the Mandurah/Murray localities will occur after the mid -1980's. The existing population of the Mandurah area is around 8,700 whilst the Mandurah-Murray-Waroona district supports about 15,000 people.

The Town Planning Department note that the growth of population in the South-West Corridor has been slower than the predictions of the Martin Report, and that unless provision is made for employment opportunities in the Mandurah area, the increase will not be as rapid as the Martin Report envisages for the district. Coupled with this is the realization of various environmental constraints, such as high water tables and existence of underground water fields in several parts of the South-West Corridor. These constraints on urban and industrial expansion may lower the capacity for the Mandurah district to accommodate these numbers under the densities envisaged in the Martin Report.

A report to be released later in 1978 by Town Planning Department will discuss these aspects and presumably offer alternative strategies.

8.2 Zoning of Foreshores

The zoning of the foreshores of the Peel Inlet is, so far, incomplete. The Mandurah Shire Scheme covers Mandurah and Halls Head and the western bank of the Serpentine River. The western foreshore of the Peel Inlet and Harvey Estuary between Halls Head and the Southern boundary of Mandurah Shire is unzoned. Town Planning Department are awaiting a preliminary scheme from Mandurah Shire which is based on the findings of the Peel Preston Planning Study.

Murray Shire has had schemes for several areas approved by the Town Planning Department. West Murray Scheme covers the western bank of the Serpentine River and the salt lakes. This scheme also includes the Murray River from Yunderup to Pinjarra. A separate Pinjarra Scheme zones the Murray River from north to south of the townsite along the South Western Highway. The eastern foreshore of the Peel inlet, the eastern foreshore of the Harvey Estuary, the Harvey River and the remainder of the Murray River within Waterways Commission boundaries are not as yet covered by any scheme from Murray shire. The southern section of the Harvey River within Waterways Commission boundaries is within the Shire of Waroona and not yet covered by any scheme.

Map 3 gives a colour key for the various approved schemes described above.

9. RECREATIONAL USAGE

9.1 Boat Population During Summer

This section is based on a census carried out by the Waterways Commission over the five-day period from the 26th-30th January (Australia day weekend), 1978, between 5.30 a.m. and 7.00 p.m.

Six public boat ramps were studied in the census, with the aim of obtaining rough estimates of boat populations and recreation behaviour.

Table 12 is a summary of the findings totalled over the five-day study period.

TABLE 12: Summary of Findings and Recreation Census, January 26-30th, 1978.

a) Boat Launchings on Peel-Harvey Inlet and Rivers Totalled over the Study Period.

	Dawesville Ramp	878
	Mary Street Ramp	757
	Fremantle Road Ramp	345
	North Yunderup	118
	South Yunderup	101
	Murray Bend	33
	Total	2,232
	Other sources (estimate)	2,670
	Estimated Total	4,900 launchings

b) Boat-oriented Activities on Peel-Harvey Inlet during the Study Period.

	Crabbing	1,314
	Fishing	427
	Sightseeing	344
	Skiing	76
	Miscellaneous	71

c) Origin of Users of Ramps during Study Period.

	Holiday makers	1,134
	Day Visitors	636
	Locals	462

9.1.1 Dawesville Launching Ramp

This ramp has two concrete pads, each capable of launching two boats at a time. There is a limestone parking area which, with careful parking, can accommodate about 50 vehicles with trailers. Space is available along a Reserve to extend southwards. There is a picnic area on the northern side of the ramp with barbeques, toilets and shade trees. Petrol and groceries are available from a store opposite the picnic area. The shallow water out from the ramp makes it suitable for smaller craft only.

Boat registration numbers were checked at Harbour and Lights Department confirming that 15% of boats were locally owned.

Boat Launchings during the Census Period

26 January	A.M.	105		3m to 5.5m
			136	
	P.M.	31		3m to 5.5m
27 January	A.M.	70		3.4m to 5m
			100	
	P.M.	30		3.6m to 5.5m
28 January	A.M.	138		3.4m to 6m
			229	
	P.M.	91		3.6m to 5.5m
29 January	A.M.	190		3.6m to 6m
			233	
	P.M.	43		3m to 5.5m
30 January	A.M.	149		3m to 6m
			180	
	P.M.	31		3.4m to 5.5m
Total	A.M.	652		
	P.M.	226		
Grand Total		878		

Origin of Users

Holiday Makers	429	49%
Day Visitors	322	36%
Local	127	15%

Frequency of Use Per Year

2-10 times	357	40%
11-50 times	348	39%
First time	120	11%

Purpose			Destination
Crabbing	822	93%	Harvey Estuary
Cruising for pleasure	25	3%	Harvey Estuary
Skiing	31	4%	Peel Inlet, Harvey Estuary, Murray River.

Public Comments

Car park needed; Toilets too small; I'm here because there's no room on ramps in Mandurah; Parking area should be sealed and marked in bays; Rubbish bins full, need more; Too crowded; Boat washing point needed near ramp; Need more ramp space; No room to move about with vehicles and boats; Should be one ramp in and one ramp out; Available parking badly used; Chaos at weekends; Ramp too rough, Charge a fee for launching boats; Extend ramp further out; Dredge a channel; Move power line from over ramp.

Official Observations

The 29th January appeared to be the busiest day. At 8.50 a.m. 100 boats had been launched. Twelve boats on trailers were counted waiting to launch, 92 vehicles with trailers were parked on and around the area, along road verges and in the picnic area. There were also many vehicles without trailers taking up valuable room. More trailers could have fitted into the parking area had they been properly parked. The launching ramp was choked with both in-coming and out-going boats. It was difficult to find the picnic area, as there were 40 vehicles scattered throughout it, including 14 with boat trailers attached. The leach drain from the toilets was overflowing and the concrete slabs on top had been displaced by a vehicle. Boats were being launched across the bank. Between the Caddadup ramp and Dawesville ramp 40 vehicles were parked on the reserve, some with small boats on trailers. All persons were crabbing.

9.1.2 Mary Street Lagoon Ramp

This ramp, with careful parking, can accommodate 10 boats on trailers at the same time, and is said to be the largest ramp in the state. There are toilet facilities and two boat washing points, one each side of the ramp. Projections on each side are tie-up points to load passengers. The parking area is limestone and sand and is part of a Reserve. There is a paved section on the eastern side on the high ground. Sufficient parking is available for present usage with the need for paving or sealing. Barbeque facilities are available.

Boat Launchings during the Census Period

26 January	A.M.	52	81	3.6m to 7m
	P.M.	29		3.6m to 6m
27 January	A.M.	52	81	3.6m to 7m
	P.M.	29		3.6m to 6m
28 January	A.M.	102	198	3.6m to 7m
	P.M.	96		3.6m to 6m
29 January	A.M.	191	241	3.6m to 7m
	P.M.	50		3m to 6m
30 January	A.M.	136	156	3.6m to 7m
	P.M.	20		4.9m to 6m
Total	A.M.	533		
	P.M.	224		
Grand Total		757		

Origin of Users

Holiday makers	467	62%
Local	152	20%
Day Visitors	138	18%

Frequency of Use Per Year

11-50 times	432	57%
Over 50 times	213	28%
2-10 times	67	9%
First time	45	6%

Purpose			Destination
Fishing	348	46%	Ocean
Crabbing	205	27%	Peel Inlet
Cruising for pleasure	121	16%	Ocean, Inlet, Rivers
Skiing	39	5%	Ocean
Retrieving Craypots	11	2%	Ocean
Diving	6	1%	Ocean
Miscellaneous	27	3%	

Public Comments

Wonderful ramp, should be more like it; Boat washing points in wrong place; Ramp needs to be bigger; Need one like it at Miami; Should be a ramp like it in the new lagoon; Not enough shade trees; Need lights for night users.

Official Observations

Parking is random and largely left up to individual choice. Tracks into the parking area are being eroded by vehicles. Boat washing points should be away from the ramp, with two taps needed to each point. Too many vehicles without trailers take up parking space best suited for trailers. The beach nearest the entrance to the lagoon is being eroded badly by foot traffic and by boats pulling up onto the sand while waiting to retrieve. The two concrete projections, (one on each side of the ramp) where boats load passengers should have more tyres attached to them and more tie-up points. The boating public need educating regarding boat wash adjacent to the launching ramp, as many people are very inconsiderate.

9.1.3 Fremantle Road Ramp

This is a concrete two-boat ramp with bitumen and grassed areas, washing down facility, and toilets.

The paved parking space, is inadequate for the number of boats that used the area over the census period. The grassed section was used to capacity on the 29th January, with 97 vehicles (20 without trailers) occupying the whole area, including a part of the grassed section adjacent to the Shire Office. Too many vehicles without trailers used the parking space.

Boat Launchings during the Census Period

26 January	A.M.	50		3.6m to 5.5m
			75	
	P.M.	25		3.6m to 6m
27 January	A.M.	32		4m to 6m
			56	
	P.M.	24		3.6m to 5.2m
28 January	A.M.	59		3.6m to 6.4m
			88	
	P.M.	29		3.6m to 6m
29 January	A.M.	62		3m to 6.7m
			81	
	P.M.	19		4 m to 5.8m
30 January	A.M.	34		3.6m to 5.8m
			45	
	P.M.	11		4.5m to 7.3m
Total	A.M.	237		
	P.M.	108		
Grand Total		345		

Origin of Users

Holiday makers	152	44%
Day Visitors	98	29%
Local	95	27%

Frequency of Use Per Year

11-50 times	222	64%
2-10 times	100	30%
Over 50 times	12	3%
First time	11	3%

Purpose			Destination
Crabbing	185	54%	Peel Inlet
Fishing	79	23%	Ocean
Pleasure	71	20%	Ocean and Inlet
Skiing	10	3%	Ocean, Halls Head

Public Comments

Dirty toilets; Need more ramps; Boat washing facilities should be away from the ramp where it does not cause blocking of in and out-going traffic; There should be more than one hose outlet; Washing areas should have drained concrete pad; Toilet facilities could be improved; Parking is without direction and leaves too much to the individual choice and method; The grassed area should be paved and marked; and the whole area should be regulated by "In" and "Out" signs; The adjacent area to the end of the ramp needs deepening, as it has silted up; Vehicles without trailers should not be permitted to park in the ramp area.

9.1.4 North Yunderup Ramp

This is a concrete, single-boat ramp, with limited gravel parking for approximately 14 vehicles with trailers. A public jetty is next to the ramp on the downstream side. The ramp sides are of cemented gravel and stone and the pathway of loose gravel is steep and dangerous. Erosion is evident along the bank at the foot of the ramp on the upstream side. The jetty needs extending several feet into the river and should have buffer piles and tie-up points.

Boat Launchings During the Census Period

26 January	A.M.	6		Under 5.5m
			8	
	P.M.	2		Under 5.5m
27 January	A.M.	4		Under 5.5m
			11	
	P.M.	7		Under 5.5m
28 January	A.M.	20		3.6m to 5.8m
			33	
	P.M.	13		Under 5.5m
29 January	A.M.	28		3.6m to 5.8m
			43	
	P.M.	15		3.5m to 5.8m
30 January	A.M.	17		3.6m to 5.5m
			23	
	P.M.	6		Under 5.5m
Total	A.M.	75		
	P.M.	43		
Grand Total		118		

Origin of Users

Holiday Makers	56	47%
Day Visitors	32	27%
Local	30	26%

Frequency of Use Per Year

2-600 times	95	80%
First time	23	20%

Purpose			Destination
Pleasure	58	49%	River and Peel Inlet
Crabbing	51	43%	Peel Inlet
Skiing	2	2%	Peel Inlet
Others	7	6%	

Public Comments

Nice launching spot; Poor jetty: Poor parking area; Too small; Not enough ramps.

This is the only public ramp on the north side of the Murray River It has no facilities apart from drinking water. Passing boat wash at times makes it difficult to retrieve boats. This lack of consideration by passing boat drivers needs to be brought to their attention.

9.1.5 South Yunderup Ramp

This is a single-boat, concrete ramp with limited gravel parking for about 15 vehicles with trailers.

A Foreshore Reserve on the downstream side could provide more parking. Local residents maintain that ramp users are inconsiderate, noisy and dirty. The ramp is used by island dwellers for access and trailers are often left parked for several days. The rubbish bin provided is often filled and piles of bottles and household rubbish are often left there.

The ramp is the only public one on the southern side of the Murray River and there are no facilities. Many vehicles without trailers use the parking area. There is no public jetty next to the ramp and the owner of a structure on the downstream side has had his licensed jetty damaged several times by ramp users.

Boat Launchings during the Census Period

26 January	A.M.	1		5.5m
			7	
	P.M.	6		3.6m to 4.9m
27 January	A.M.	3		3.6m to 4.6m
			7	
	P.M.	4		3m to 6m
28 January	A.M.	20		3.6m to 5.8m
			32	
	P.M.	12		3.6m to 5.8m
29 January	A.M.	21		3.4m to 6m
			32	
	P.M.	11		3.6m to 5.8m
30 January	A.M.	18		3.6m to 6m
			23	
	P.M.	5		3.6m to 5.5m
Total	A.M.	63		
	P.M.	38		
Grand Total		101		

Origin of Users

Local	46	46%
Day Visitors	34	34%
Holiday makers	21	20%

Frequency of Usage Per Year

Regular	69	69%
Seldom	24	24%
First Time	8	7%

Purpose			Destination
Crabbing	51	50%	Peel Inlet
Pleasure	30	30%	River and Peel Inlet
Access	9	9%	Island House
Access	5	5%	Private Jetty

Murray Shire intend to extend the bottom end of this ramp.

9.1.6 Murray Bend Ramp (Murray River)

This ramp is steep concrete from just below the top of the bank to the water level. The bottom of the ramp has a drop-off of about 20cm which, at low water, requires boat trailer wheels to go over the edge to launch or retrieve boats. This makes retrieving especially difficult.

There are many large stones in the water around the ramp which pose a threat of hull damage. There is only sufficient room to launch one boat at a time.

The bank top is of gravel and is eroding rapidly. Parking facilities are very limited, sufficient for perhaps 12 - 15 vehicles with trailers. The area is very popular with swimmers.

There are toilets available and a play area for children. There is no public jetty and all private structures are used by picnic or swimming parties.

The ramp is used by several local residents and persons wishing to travel the river only. This ramp is only suitable for small craft, and a warning sign to this effect should be displayed.

Boat Launchings Over the Census Period

26/27 January			0	
28 January	A.M.	4	8	4.2m to 5.8m
	P.M.	4		3.6m to 4.9m
29 January	A.M.	11	20	3.6m to 5.6m
	P.M.	9		3.6m to 5.8m
30 January	A.M.	2	5	4.6m to 5.2m
	P.M.	3		3.6m to 4.6m
Total	A.M.	17		
	P.M.	16		
Grand Total		33		

Origin of Users

Local	12	36%
Day Visitors	12	36%
Holiday makers	9	28%

Frequency of Use per Year

Seldom	20	60%
Regular	9	27%
First time	4	13%

Purpose

Most of those surveyed were launching boats for pleasure. This included some crabbing. Their destinations were both upstream and downstream of the ramp.

Public Comments

Ramp length into river needs extending. Not enough parking. No lights at night. No toilets. Public jetty needed. Ramp base too rocky and too steep. Swimmers are a hindrance. Ramp too narrow. Lengthen ramp. Ramp needs improvement all over. Adequate and satisfied. Needs public jetty.

9.1.7 Public Ramps not included in Census

	Estimated daily launchings x 5 days	
Olive Road (Placid Waters) (Hire Craft)	35 x 5	165
Traffic Bridge, Western Foreshore	30 x 5	150
Furnissdale, Serpentine River	30 x 5	150
Nairns, Serpentine River	15 x 5	75
Caddadup Reserve, Harvey Estuary	12 x 5	60
Novara	15 x 5	75
Wannanup	10 x 5	50
Others		
Beam Caravan Park	15 x 5	75
New Lagoon	30 x 5	150
Hire-Boats (Mandurah)	51 x 5	255
Midstream Marina	50 x 5	250
Western Foreshore (Banks)	10 x 5	50
Novara (Falcon Yacht Hire)	30 x 5	150
Reserves		
Riverside Gardens	10 x 5	50
Novara	10 x 5	50
Riverview	10 x 5	50
Furnissdale	10 x 5	50
Nairns	5 x 5	25
Dawesville	40 x 5	200
South Yunderup	20 x 5	100
North Yunderup	20 x 5	100
Murray River Caravan Park	35 x 5	165
Tathams Cottages, Murray River	20 x 5	100
Private Ramps and Slips	25 x 5	125
	Estimated Total	2,670

9.1.8 Discussion

The number of boats launched off public ramps during the census period, particularly the three main ramps, Mary Street, Fremantle Road and Dawesville only represent those launched between the hours of 5.30 a.m. and 7.00 p.m. It is reasonable to assume that launchings did take place outside these hours and that the census results may be a little low. However the possibility that a single boat may have been launched more than once during the daily census period (and therefore be counted twice) may tend to compensate for this.

All in all, the results give a good indication of the usage of these more popular public boat ramps.

9.2 Public Jetties

9.2.1 Mandurah Professional Fishermans Service Jetty

Location: Approximately 150 metres downstream of the Peninsula Hotel.

Purpose: This is a service jetty with fuelling facilities for professional fishermen, built by Public Works Department and vested in the Mandurah Shire Council for care, control and management. Overnight mooring is available for professionals only.

Capacity: A maximum of 8 fishing vessels can berth alongside, providing each owner shows consideration. During the height of the season vessels are often doubled up.

Maintenance and Cost: Minor repairs by the Shire. Major repairs on a share basis with Public Works Department.

Usage: The jetty is seldom used by private vessels unless during the day, when professional boats are out fishing or during the closed season for crayfish. Private vessels are not encouraged to use the jetty. On many occasions during the fishing season there is not sufficient space for professional boats alongside private boats.

Depth Alongside: This varies from 3 to 5 metres and any vessels which can enter through the groynes over the bar can berth alongside.

Condition: The jetty was constructed by Public Works Department and is in very good condition.

Disadvantages: Being in the main stream, vessels moored alongside are subject to damage resulting from passing boat wash, especially during Christmas and long holiday weekends. When moored vessels are doubled up the risk of this damage increases.

The amount of space available in Mandurah for professional fishing vessels is such that arguments often occur between transients and locals.

There would be more professionals operating from here if berthing and mooring facilities were improved. There are two choices. Firstly, a berth at the Marina, or secondly, alongside the Service Jetty. At the moment no charge is made for the Service Jetty though this is being investigated by the Shire.

9.2.2 Ampol Jetty

This is located opposite the Brighton Hotel at the upstream end of the reserve fronting Mandurah Terrace, next to the Ampol Service Station.

Purpose: This jetty is for use of vessels and unloading passengers or persons wishing to use the nearby toilets or visit the shops.

Permanent or overnight stops are not permitted.

Capacity: There is berthing space for 5 small craft.

Maintenance and Cost: The jetty is vested in the Mandurah Shire Council who are responsible for minor works, while major repairs are on a cost-share basis with Public Works Department.

Usage: It is in constant use by small craft during Christmas and holiday periods, and is a very popular jetty with tourists and locals for fishing, crabbing and prawning. The jetty is usually crowded whenever fishing is good. Persons wishing to moor boats often find it difficult because of the number of fishers on the jetty and many arguments have developed.

Vehicle access is not permitted.

Depth Alongside: Depth varies from 3 to 6 metres, ample for any vessels which can negotiate the bar.

Condition: Repairs were recently carried out by the Shire. The wooden decking was covered with asphalt, however, several buffers at the jetty sides need refastening or replacing. It is generally in good condition.

Disadvantages: Vessels moored alongside are buffeted by passing boat wash.

It is difficult to climb to the jetty deck from small craft, as there are no ladders provided at the sides.

It is more popular for fishing than boat mooring.

The earth boat launching ramp on the upstream side of the jetty is suitable for small boats, however the parking of vehicles usually blocks any access to it. Parking is permitted by the Shire.

It would not be sensible to encourage launching from the ramp as there is not enough parking space for the boat trailers.

9.2.3 Robert Day Memorial Swimming Pool Jetties - Two for Public Use

Location: These are approximately 150 metres downstream of the Ampol jetty fronting the reserve along Mandurah Terrace.

There are 2 jetties approximately 150 metres apart forming a public swimming area.

The Southernmost is 15.8 metres in length and 3.68 metres in width, the other is 12.9 metres by 3.66 metres average width.

Purpose: These jetties are for swimming only. Boats are prohibited from entering between the jetties since this area of water has been gazetted by Harbour & Light Department as a swimming area only.

Maintenance and condition: Both jetties are vested in Mandurah Shire who are totally responsible for their maintenance. The two jetties were recently repaired and are in good condition.

Usage: The pool and jetty are used by the schools for competitions and training during the summer months and for holiday period swimming classes.

The public, mainly young people, use the pool throughout the holiday and summer period, especially on weekends.

There have been many complaints during the past several years about rubbish, dirty water and stinging jellyfish and it is planned to build an inland pool for training, school competitions and public use. However Robert Day pool and jetties will probably be maintained. Whenever the pool is not used by swimmers it is used by crabbers and fishermen.

9.2.4 Murray River Jetty

Location: This is at North Yunderup, on the Wargoorloo branch at the bottom end of Culleenup Road.

Purpose: It was originally erected many years ago for use by professional estuarine fishermen, and is now used mostly by people for access to Culleenup Island opposite the jetty.

Capacity: One or two small boats only can be moored.

Maintenance and Cost: The jetty is vested in the Murray Shire Council who are responsible for minor repairs, major repairs being on a cost-share basis with Public Works Department.

Usage: It is used by island people or occasional visitors during the summer and holiday periods. It does not receive a great deal of use.

Depth Alongside: The water is very shallow (about 0.7 metre) with rocks beneath part of the jetty. These can damage larger craft propellors.

Condition: The condition is good since it was recently repaired by the Shire. The dimensions are 5.61 metres in length by 3.53 metres in width, built of heavy timber. Deck planks are held down by kerbing.

The river bank has been eroded badly on the downstream side by boats being nosed into the shore and passengers and equipment loaded over the bank.

Disadvantages: The water is shallow alongside and rocks in water. There are no tie up points, no buffers for craft and limited parking facilities.

People tend to use the eroded bank as a ramp and mooring area in preference to the jetty because of the shallow water and rocks near the jetty.

9.2.5 North Yunderup Public Jetty and Ramp

Location: Southern end of North Yunderup road.

Purpose: This jetty facilitates the launching and retrieving of boats in conjunction with the adjoining concrete ramp and for loading and disembarking of passengers.

Capacity: One small boat only can moor alongside at the outer end.

Maintenance and Cost: Murray Shire Council is responsible for maintenance and cost.

Usage: It is used mainly during the summer holiday period. Boats have often been seen lined up waiting for another to be launched or retrieved from the jetty.

Depth Alongside: About 0.7 metre average depth with rocks on the bottom at the outer end.

Condition: Condition is fair. Deck planks are loose and held only by kerbing whilst piles are very old with possible worm damage below the water.

Dimensions are 6.1 metres in length by 2.65 metres at the widest point.

There is erosion on the downstream side of the jetty and on the upstream side of the ramp. Both need attention.

Disadvantages: The water is shallow with many rocks. The jetty could be extended and modified to take more than one boat at a time.

There are no tie-up points or buffers at the jetty sides or end. Passing boat wash often causes damage to vessels alongside the jetty. As a boat jetty it is very poor.

The steep, loose, gravel path to the jetty could be dangerous.

The landward end of the ramp on the upstream side is eroding badly and should be rock-walled in the same way as the downstream side.

9.2.6 South Yunderup Public Jetty

Location: This jetty is approximately 50 metres downstream of the South Yunderup Post Office and shop at the river end of Banksia Terrace.

Purpose: It provides access for Island residents and the public to the Post Office and shop.

Capacity: Two 4.6m (14ft) boats can tie up alongside.

Maintenance and Cost: The jetty is maintained by the Murray Shire, who bears the cost. Major works are carried out by Public Works Department.

Usage: This jetty receives much use during summer and holiday periods A professional fisherman is using the jetty at present. The public usually prefer to use the private Post Office jetty because it provides better facilities and less likelihood of damade to their boats.

Depth alongside: The average depth is 1.5 metres with the shallowest part being about 1.2 metres. This is quite a suitable depth for nearly all river craft.

Condition: The condition is fair. A reinforced concrete deck has been installed by the Shire over the old wooden decking which has now partly collapsed underneath so that thickness of concrete varies from about 7.5 - 10 cm. Piles are old and their condition suspect.

Dimensions are 4.35 metres out from the bank 9.25 metres along the frontage.

The shoreline is very badly eroded on the downstream side.

Disadvantages: The tie-up points are inadequate (too low) and no buffers exist outside of the low platform.

Passing boat wash can easily cause damage to the hulls of moored vessels.

9.3 Private Boatsheds and Jetties

9.3.1 Boatsheds

(i) Mandurah: here there is one only. It is licensed, owned by licensee of the Peninsula Hotel and leased to a hire-boat operator, known as "Pen Hire-Boat Service".

(ii) Murray River: (including the Delta channels)

Unlicensed	11
Licensed	72
Total	83

9.3.2 Jetties, Slips, Ramps and land-backed wharves, in all areas

Jetties (licensed)	346
Jetties (unlicensed)	187
Boatsheds	84
Total	617

9.4 Commercial Marinas and Boat Hiring Establishments

9.4.1 Private Marinas

One only: Midstream Marina, Old Coast Road, Mandurah.
Dry storage for 42 boats up to 6.5 m (22ft).
Wet pen storage for 86 boats up to 13 m (44ft).
Proposed additions for 150 wet and 26 dry storage areas.

Ramp usage: 180 permanent and 780 yearly and occasional use.
Facilities for slipping, 11.5 m (38ft).
Maximum of 13.5 tonnes allowed on slip.
Engine workshop, shipwright shop plus boat sales new and used and brokerage.

9.4.2 Mandurah Hire-Boat Operations

(i) Mandurah Hire and Marine, Mandurah Terrace: 8 x 3.6m (12ft) dinghys, powered (6 h.p.).

(ii) Terry's Hire Service, Administration Bay: 10 x 3.6m dinghys, powered (6 h.p.).

(iii) Peninsula Hire Service, Administration Bay: 8 x 3.6m dinghys, powered (6 h.p.).

(iv) King's Parking, Peninsula Caravan Park: 10 small canoes.

(v) Byrne's Paddle Boats, Administration Bay: 20 paddle boats.

(vi) Midstream Marina: 12 Dinghys, 3.6 to 4.9m (12-16ft), powered.
All hire boat operations are restricted to between the Peninsula Hotel and beacon No. 12 in the Sticks channel (bottom end of Creery Island).

9.4.3 Peel Inlet Hire-Boat Operations

(i) Falcon Yacht Hire, Dampier Avenue, Novarna: 12 canoes,
1 kilometre radius from point of hire.
Dinghys 3.6m, 1.5 km radius for use
15 surfcats, Peel Inlet triangular course.

(ii) Estuary Caravan Park, Olive Road, Placid Waters: 10 x 3.6m power dinghys, 1.5 km radius.
10 canoes, 1.5 km radius for use
10 surfcats, Peel Inlet course.

9.4.4 Harvey Estuary Hire-Boat Operations

(i) Florida, Margery Dawe Store: 4 x 3.6m powered dinghys.
1.5 km radius for use.

(ii) Sundowner Caravan Park. Midway down Estuary: 3 x 3.6m powered dinghys. 1.5 km radius for use.

9.4.5 Murray River Hire-Boat Operations

(i) South Yunderup, Winsmia Hire: 12 x 4.9m (16ft) canoes, river only.
8 powered dinghys, river only.
8 rowboats, river only.

(ii) Tatham's Hire-Boats: 6 powered dinghys, river only.

9.4.6 Mandurah Yacht Club

Sailing venue. Triangular sailing course, Peel Inlet.
Type of craft: Catamarans - 4.3 to 4.9m (14-16ft).
Number sailed: (club members) about 15.
Visitors sailing on invitations: up to 40.
Permanent Members: 15. Did have in excess of 120 but lack of club room and sailing headquarters has reduced membership.

9.5 Fully Developed Recreational Areas

The following account is based on observation of foreshore usage on Saturday, 28th January (Australia Day long weekend), 1978.

9.5.1 Mary Street Ramp

This is used by people for launching boats into the Inlet or who are heading for the sea. The facilities are excellent, the water clear and the setting is very pretty with trees, grass and pelicans. There are toilets and there is plenty of room for expansion. Moorings can be leased from the shire at $20 per year at Mary Street, but good mooring space is very scarce. About 200 boats were launched during the day (see Section 9.1.2).

9.5.2 Fishing Wharf under Mandurah Bridge (eastern end)

This cool area was busily used by people of all ages for fishing and laying of crab nets.

Time	Numbers
11.00 a.m.	55
12.45 p.m.	65
2.15 p.m.	85

9.5.3 Dalrymple Park (east end of Mandurah Bridge).

This pleasant, shady park with toilet facilities is surprisingly under-utilized.

Time	Numbers
11.00 a.m.	11
12.50 p.m.	12
2.00 p.m.	15

9.5.4 Robert Day Memorial Park

This park is opposite the Mandurah shopping centre and was very busy throughout the day. There are toilets and a carnival was in progress, the wood-chopping event during the afternoon being very popular. Recreation activities were of a passive nature. Children were swimming from the beach and off the three jetties.

Time	Numbers	Cars
11.30 a.m.	250	
12.30 p.m.	400	180
1.30 p.m.	800	190
3.00 p.m.	880	
4.30 p.m.	600	

9.5.5 Under Mandurah Bridge at Western End

Once again this was quite popular with elderly and young people who were after crabs and whitebait.

Time	Numbers
11.30 a.m.	30
12.55 p.m.	30
2.15 p.m.	50

9.5.6 Foreshore on Western side of the inlet channel near Mandurah Bridge

This Shire reserve was used much less than the foreshore area on the opposite side. On Saturday the go-boats were operating from here and on Sunday there was power-boat racing. Sunday was much busier than Saturday. There are toilet blocks, but very little shade.

Time	Numbers	Cars
11.45 a.m.	60	50
1.00 p.m.	110	80
2.15 p.m.	125	65

The foreshore area further north past the toilet block, was not used as much.

Time	Numbers
11.50 a.m.	30
1.00 p.m.	50
2.15 p.m.	60

People here were mainly resting in their cars or swimming.

9.5.7 Soldiers' Cove

Here, there is a public reserve along the foreshore with several private, licenced jetties. This stretch of foreshore was very quiet during the Australia Day long weekend.

9.6 Partly Developed Recreational Areas

9.6.1 Western Foreshores

9.6.1.1 The Chimneys

This area is privately owned by a Development Company and parts of it have been cleared. Camping was permitted during the long weekend in January, 1978, and there were about 100 cars in the vicinity. Although the water is fairly deep offshore, boats aren't launched. This may be because of the proximity to the Sticks Channel. The wash from the channel is strong, and serious erosion is occurring all along the foreshore. No rubbish tins or toilet facilities are provided.

9.6.1.2 Novara (Coastal or Estuary Gardens).

This area is very shallow with a sandy boat ramp, and boats have to be dragged out a long way before they begin to float.

The area is a Shire Reserve. Toilets and rubbish containers are provided, with parking for 50 cars. The Shire leases some land for a boat-hire business.

There is an "unofficial" launching ramp between here and Placid Waters. This is a more suitable site to launch a boat.

9.6.1.3 Placid Waters (Olive Road).

This area is a Shire Reserve which is leased to the caravan park, who in turn lease a small area for boat hire operations. A sandy boat ramp is present and the area is popular for crabbing. The water is extremely shallow with limestone boulders protruding above the water, making launching difficult. Parking is limited to 30 - 40 cars. Garbage is a problem.

There is a peninsula to the south of this area, where the Shire has plans to built a yacht club.

9.6.1.4 Wannanup

This area is very shallow and the launching ramp seemed to be little used over the January long weekend in 1978. The Shire has provided parking for 30 - 40 cars. There are no toilet facilities, though some are planned.

9.6.1.5 Caddadup

The water here is shallow and often chocked with weed (Cladophora algae). There is a concrete launching ramp and a car park, although the area is not really suitable for launching.

Much of the reed beds along the shore have been removed, and serious erosion is occurring. There are barbeque facilities but no toilets.

9.6.1.6 Dawesville barbeque area (Iluka Road).

The shoreline from here to the point at Dawesville is all Foreshore Reserve. The Shire has levelled much of it and plans to make it available for use by caravans. The barbeque area has an inadequate launching ramp and parking for 30 cars. Many holes have been forced through the shoreline reed beds by persons launching their boats. This has caused shoreline erosion (Figure 8).

9.6.1.7 Dawesville

This is a very popular and busy Foreshore Reserve with toilet facilities and parking area. There are two boat ramps of different sizes, though there are problems launching the large 5.5 m (18') boats. The council plans to dredge and deepen the area. There are boats for hire here. Water skiers, crabbers and fisherman use the area extensively. The parking often becomes unorganised and confusing.

The picnic area is well shaded, but usually covered with cars and boat trailers. There is a shop opposite the picnic grounds.

A little south of here is another area with parking for about 20 cars. The whole Foreshore Reserve between Dawesville and Estuary Road is often flooded in winter.

9.6.1.8 Warrangup Springs

This small peninsular is lined with thick beds of reeds which offer protection to waterfowl. Although camping is prohibited the area is popular with campers, the only facility available being a tap. There have been problems with bush fires being started from this area and the surrounding bush was burnt out in January of 1978.

Several holes had been cut in the reed bed and an illegal jetty constructed for launching boats. Further south of here past Hardy Cottage there is another popular camping area which is privately owned and fenced off.

9.6.1.9 Island Point

This area is beautiful and unspoilt with shady Peppermint gums (Agonis flexuosa) and a white, sandy beach. Fisheries and Wildlife Department have a Reserve of 260 hectares and the council have a reserve of 9 hectares here. The birdlife is rich at this end of the estuary and in April, 1978, over 600 pelicans were counted between Island Point and Herron Point. There is a poor launching ramp, though it is sufficient to launch a 3.6m (12') boat.

9.6.2 Eastern Foreshore of Harvey Inlet - Herron Point

The only partly developed recreation area here is Herron Point. This area has road access and is used by fisherman and crabbers. There are no facilities available. There is a Recreational Reserve to the south of here with pan toilets, but no water.

A few people camp here on the weekends. The remainder of the eastern foreshore of the Harvey Inlet is fairly inaccessible and seldom used.

9.6.3.1 Serpentine River

9.6.3.1 Riverside Gardens

This area is a quiet, potentially pretty Foreshore Reserve with a few neglected jetties. The area is used mainly for swimming and one well-maintained jetty would probably suffice. The existing jetties are causing erosion along the steep banks. A serious problem in this area is "worm digging". This activity has caused serious damage to the banks and will be difficult to repair. The area is in need of immediate rehabilitation and revegetation. Figure 7 shows the destructive effect of worm-digging on the riverbanks.

9.6.3.2 Riverview

This is an old established recreation area with big, shady trees and many dilapidated jetties. Extensive erosion has been caused around the jetties by trampling. Further erosion results from winter flooding and boat wash. The area is mainly used for swimming and fishing for cobbler and mulloway, so that one good public jetty is possibly all that is needed. The effect that trampling around jetties has on foreshore vegetation is indicated clearly in Figure 9.

9.6.3.3 Furnissdale

All this area has interesting wetlands. At the riverside Reserve there is one boat ramp used mainly by crabbers for access to the Peel Inlet. The erosion here is not serious, though the facilities are primitive and increased use without propper planning would result in damage to the banks. There is an occasional "weed" problem here. Murray Shire is interested in subdivision and development of the Furnissdale area.

9.6.3.4 Coodanup

The whole of this area is badly affected by Cladophora algae which is banked up along the beach by south-westerly winds. The area is almost continuously raked, the weed being removed by bulldozers and trucks (Figure 5). Most of the foreshore is now graded and unprotected by vegetation. The area is very popular with crabbers wading in the still water, however the trees have been stripped of branches by people for making fires. The area has no toilets or rubbish containers.

9.6.3.5 Nairns

The majority of the professional fishermen live here, there being only about 100 permanent residents. The banks on the riverside are very steep and erosion around the numerous jetties is bad. The trees and other vegetation are falling into the water. There is one small boat ramp and limited car park. The headland area of the Serpentine River is mostly Samphire flats. There is also a big car park and a temporary ramp for launching small boats.

9.6.4 Murray River

9.6.4.1 North Yunderup

There are about 400 private jetties which are usually covered by water in winter, many needing repair. The wash from boats is undercutting the clay banks and the vegetation is falling into the Murray River. The public launching ramp is very steep and inadequate. Parking is limited and there are no other facilities. This is the only public launching ramp on the northern side of the Murray River.

9.6.4.2 South Yunderup

This boat ramp is quiet although it is the only public lanching ramp on the southern shore of the Murray River. The end of the ramp is eroded. The banks are very steep here, and the river narrow.

9.6.4.3 Murray Bend

This is a beautiful spot used mainly by swimmers. There is a concrete launching ramp which is eroded at the bottom end. The banks are in good condition. Toilet and parking facilities.

9.6.4.4 Ravenswood Boatel

This is a very popular spot especially during licenced trading hours on Sundays when there may be up to 50 boats moored outside the hotel. It is often dangerous for swimmers.

9.6.4.5. Murray River Caravan Park

There is a boat ramp and retaining wall along the bank and the narrow river is very busy with power boats and swimmers together. Murray Shire is interested in developing the area nearby, but the increased use would place heavy pressures on the foreshores and the river.

9.7 Potential Recreation Areas

Bailey (1977) carried out a recreational survey of three metropolitan lakes which are relevant to the Peel-Harvey System. His study showed that people favoured development of existing sites and that the form of development was to be harmonious with the environment and with conservation in mind. Comments such as "stop shooting" and "retain natural beauty" were common while activities such as canoeing, swimming and hiking were favoured so as not to unduly disturb the fauna or the habitat. Public submission to the Town Planning Department's Peel-Preston Study (1975) showed the over-all need to preserve rather than develop the area.

The following areas are presented as areas of potential recreational importance.

9.7.1 Harvey River

This stretch of water is of importance to waterfowl and its natural beauty make it of great potential importance for passive recreation.

The Harvey River of the 1900s was the outlet to the Harvey Estuary for all water from the escarpment and coastal plain from Harvey to north of Waroona. Due to gradual clearing of the rich agricultural land, flooding became a big problem and the Harvey River at Harvey was diverted to the ocean in 1932.

After World War II the expansion of irrigation and increased runoff again increased flooding and a survey by Public Works Department of 26km of river from the delta, showed that clearing of the river and widening by 50% upstream of Lot 2986 would provide adequate flow and decrease flooding.

Clearing commenced downstream and by 1977 had proceeded well beyond Lot 2986 when the flood mitigation programme was halted by a request from Fisheries and Wildlife Department. Clearing involved bulldozing of the vegetation into piles about 20 metres from the banks and battering back the banks to about 45°. Only about 3 km of the river remains in its natural state.

The delta area is thickly wooded with paperbarks (Melaleuca hamulosa) and lined with reeds (Juncus kraussii). This area is important to Grey Teal and Black Duck and also as a refuge for sick birds of all sorts from the estuary. Further upstream there are healthy stands of swamp paperbark (Melaleuca rhaphiophylla) flooded gum (Eucalyptus rudis), sheoak (Casuarina obesa) and native pines (Actinostrobus pyramidalis)

This vegetation is in good condition apart from erosion and denudation caused by cattle on the western bank.

The cleared section of the river is a great contrast as it still looks very raw. Dense growths of weeds, the Watsonia sp, Mensa pulegium and Iripteris clandestina are taking hold and many small seedlings of flooded gum are appearing at the water's edge, Paperbarks are colonising on banks built up by deposition of sediment from upstream clearing. With protection from fire, cattle and further clearing, this stretch of river may revegetate back to flooded gum. If this was allowed to happen, the weeds present may gradually disappear, though a big problem is the "bamboo" grass which has already become established further upstream.

The tidal influence in the Harvey River is small, but the saltwater "wedge" may extend as far as Doman's Bridge. Lands and Surveys Department maps show the western bank is largely freehold and the eastern bank has a Foreshore Reserve of Crown Land along this section. The river water is fresh, though sometimes high in nutrients.

9.7.2 Little Harvey River

This unspoilt stream lies to the east of the Harvey River, and in April, 1978, consisted of a string of water holes. The water holes contained the native water plant, Hydrilla verticillata, and some medium sized fish. The whole area was thickly wooded with considerable birdlife. The area is within the Fisheries and Wildlife Reserve, but may be of interest for passive recreation and bird-watching.

9.7.3 Island Reserve

Lands and Surveys maps show a small island reserve opposite lot 852 in the Shire of Murray on the Harvey River.

9.7.4 Encounter Island

This is Vacant Crown Island south of Pinjarra on the Murray River which may have some potential as an island reserve.

9.7.5 Small Island

This naturally wooded island between Island Point and Herron Point on the Harvey Estuary might be considered as a recreational area for canoists. The island has significance in Aboriginal culture described by Novak (1975).

9.7.6 Lake Goegrup

This is a brackish to saline stretch of water which is an important feeding and breeding area for crabs, prawns, mullet and many species of birds. Most of the lake and foreshore is a Recreational Reserve.

The foreshore property is mainly privately owned, however Mandurah Shire has already allowed the 10 meter Foreshore Reserve to be protected from any future subdivision. One resident on the western foreshore has built a dam on their property and dug a channel from the lake onto their property. This is a welcome, sheltered refuge for many birds. As many as 200 ducks regularly use this freshwater pond in the evenings. The Environmental and Planning Authority have made proposals to Mandurah and Murray Shires to make this lake a sanctuary for birds. Flies and mosquitoes pose a big problem for the residential areas planned for the vicinity. Mandurah Shire already spends $25,000 per annum on mosquito control using Dibrom. Murray Shire has no mosquito control programme.

9.7.7 Lake North Goegrup

This lake stretches north of Stake Hill Bridge. It was dry in January, 1978, though it normally contains fresh water and maintains a good population of birds and kangaroos.

10. CONTROL OF WATERWAYS AND ADJACENT LAND

This section outlines the legislation of the Waterways Conservation Act, 1976, associated with the control of waterways and adjacent land as well as a discussion on the limitations of it.

10.1 Recreation Activities

All activities such as boating, water-skiing and swimming and private and public jetties are controlled by the composite Navigable Waters Regulations under the Shipping and Pilotage Act, 1967, Jetties Act, 1926 and the Western Australia Marine Act, 1948.

10.1.1 Private pleasure boats

All matters concerning registration, equipment to be carried, speed limits etc., are covered by regulations 45a - 45f (inclusive), 48, 51, 51a, 51b and 52a - 53 (inclusive).

10.1.2 Water Skiing

Areas to be set aside for this sport, control of speeds, manning of boats etc., are covered by regulations 46 - 50 (inclusive).

10.1.3 Organised races and regattas

Control of these are covered by regulation 12 and 51c.

10.1.4 Swimming

Areas to be set aside for swimming and conduct of swimmers near public jetties and bridges are covered by regulations 10 - 11 (inclusive).

10.1.5 Public Jetties

Regulations 22 - 36 (inclusive) cover use and control of public jetties generally. It should be noted that most of these concern commercial cargo or ferry jetties, however, some are applicable to small public jetties within the area under Waterways Commission control.

10.1.6 Private Jetties

These are defined under Section 3 of the Jetties Act and the requirement that they be licensed by the Harbour and Light Department is covered by Section 8 of that Act. Portions of the waters are within the boundaries of the Bunbury Port Authority and registration and licensing of jetties is carried out by that Authority.

10.1.7 Rubbish

Regulation 8 prohibits throwing of rubbish or any other matter into the waters without approval.

10.2 Dredging

Regulation 9 of the Navigable Waters Regulations prohibits removal of sand or other material from below high water mark without the permission of the Lands Department.

Subsection 2 (i) of section 5 of the Waterways Conservation Act, retains ownership of the bed of the waters with the Crown, (under section 6 of the Land Act, 1933) hence approval must be obtained from the Lands Department before dredging work can be carried out. Any royalties that may be charged for removal of sand by any person must be remitted to the Lands Department.

10.3 Control of Discharges into the Waters

The Rights in Water and Irrigation Act, 1974, gives the Minister for Water Supply Sewerage and Drainage rights to grant or refuse disposal licenses. Under Sections 7 - 11 (inclusive) of the 1974 amendment to that Act the terms and conditions of these Sections are similar and in some portions identical, with those in Section 47 of the Waterways Conservation Act.

Under Section 3 of the Waterways Conservation Act "waters" means the rivers, inlets and estuaries within the gazetted boundaries while the Rights in Water and Irrigation Act, 1974, under Section 7 refers to discharges into the waters of any watercourse, lake, lagoon, swamp, marsh or subterranean water source.

10.4 Controls by Local Government Authorities under Local Government Act, 1960-1973

10.4.1 Jetties

Under Section 301 (a) of this Act a council may make by-laws for regulating the management and use of jetties - and shall cause a copy of these by-laws to be conspicuously displayed on the jetties.

10.4.2 Foreshores

Under Section 214 a council may make by-laws for regulating the use of the foreshores of the sea and of rivers, of watercourses and of tidal and non-tidal waters. (The Websters Dictionary definition of "foreshore" is the sloping part of a shore between high water mark and low water mark).

10.5 Limitations of the Waterways Conservation Act, 1976

This Act does not give the Waterways Commission or the Management Authorities exclusive control of all activities or matters within the gazetted boundaries of the Authorities. Many of these are covered by existing legislation administered by the relevant Departments. In the past the Swan River Conservation Board and the advisory committees for the Peel and Leschenault Inlets have worked in close liaison with these Departments and excellent relationships achieved. Nevertheless, in the event of a disagreement the decision of a Department under its legislative powers must prevail.

11. STUDIES OF SOUTH WESTERN AUSTRALIAN ESTUARIES

11.1 Swan and Canning Estuaries

11.1.1 The Swan River - Its Development, Management and Preservation

Edited: T. L. Riggert
Research: T. A. Schwinghammer
Published by: Waterways Commission (Swan River Management Authority)

This is an account of the physical features, man-made features and the flora and fauna of the Swan - Canning estuaries, as well as an account of the activities of 25 years of management by the Swan River Conservation Board.

11.1.2 Swan and Canning Rivers Activity Study

Prepared by Forbes and Fitzhardinge for the Department of Conservation and Environment (1977).

This report contains 123 recommendations to the Swan River Management Authority, Metropolitan Regional Planning Authority, Government Departments and Local Government bodies for use of the resources subject to a growing population. The resources are studied in some detail, and the publication contains well prepared tables and maps.

11.1.3 Canning Waters Study, 1975

Prepared by Halpern Glick Pty. Ltd., for the Town of Canning. The Consultants were required to report on the methods, cost and effects of dredging the Canning River between Salter Point and Riverton Bridge. (Shelley Basin).

11.2 Peel Inlet - Harvey Estuary

11.2.1 Peel Inlet Study - Final Report to the Metropolitan Water Supply, Sewerage and Drainage Board - 1975.

Prepared by R. E. Black for WAIT - AID Ltd.

The study makes the following recommendations :

(i) To commence a full-scale interdisciplinary study on the Peel Inlet - Harvey Estuary.

(ii) Data needs to be collected in certain areas.

(iii) To institute a mathematical model of the system.

(iv) The model should be set up by local expertise, and guided by outside consultation.

11.2.2 Progress Report (1) to Metropolitan Water Supply, Sewerage and Drainage Board on Peel Inlet Study, 1974.
Progress Report (2) to Metropolitan Water Supply, Sewerage and Drainage Board on Peel Inlet Study, 1975.

Rippingale R.J.

WAIT - AID (unpublished).

These are biological and hydrological data collections.

11.2.3 Peel-Preston Planning Study (1976)

Report produced for public discussion.

Town Planning Department - Perth, Western Australia.

This report was prepared to stimulate discussion so as to help the various Authorities to set up planning goals whilst avoiding conflict of interests. The publication contains some good evaluation of resources including tables and maps.

11.2.4 Summary of Submissions from the Public Peel-Preston Planning Study 1975

Town Planning Department - Perth, Western Australia.

The overall needs are to preserve the area in its natural state for recreational rather than residential purposes.

11.2.5 Peel-Preston Planning Study

Town Planning Department - Perth, Western Australia
Bayley - Jones, C.R. (1976).

Tourism and Recreation: A study of holidaymaking in the Peel - Preston lakelands.
Clarke, S.A. and Wright A.F. (1976).

Report on Zoological Survey.
Lane, J.A.K. (1976).

Waterbird Survey - summary of findings.
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Investigations of the Sedimentology of Peel Inlet and Harvey Estuary.
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Report on Aboriginal Sites.
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Landscape Evaluation.
Urban Systems Corporation Pty. Ltd.

11.2.6 The Peel-Preston Lakelands

The National Trust of Australia, (W.A.) (1973).

Environmental areas are defined with recommendations for management. The publication has a good reference list and maps.

11.2.7 A study of the Hydrological and Meteorological Inputs to the Peel Inlet/Harvey Estuary System

Investigation by R.E. Black at the Department of Physics at W.A.I.T. This study is making an important contribution to the Environmental Protection Authority study described in item A5.2.8.

11.2.8 Peel-Harvey Estuarine System Study

Prepared by the Estuarine and Marine Advisory Committee for the Environmental Protection Authority.

The objectives of this study as stated in March, 1977, are as follows:

(i) General - to gain an understanding of the working of this estuarine ecosystem as the basis for decisions about its management.

(ii) Specific - to determine the causes of the excessive growth and accumulation of green algae, principally Cladophora in Peel Inlet and if possible to propose a method for its control.

Both these objectives are advancing and the study is the subject for a computer model at the Centre for Resource and Environmental Studies (C.R.E.S.) at the Australian National University, Canberra, A.C.T.

11.2.9 South-West Corridor Study

This is still in preparation by the working committee of the Town Planning Department.

11.3 Leschenault Inlet

11.3.1 An Environmental Appraisal of Leschenault Inlet

Prepared by Environmental Resources of Australia for United Development Corporation - 1972.

The report was compiled from the findings of a multi-disciplinary research team, and contains details of the hydrology, soils, vegetation and fauna of the whole estuary.

Residential and industrial development of the region is also discussed along with an evaluation of the proposed development. The report also contains a review of the article "The Development of Leschenault Estuary" by Dr. N.M. Morrissy, published S.W.A.N.S. 2 (1):12-19.

The proposed development, 'Leschenault Heights', is now called 'Marina Waters' and willgo ahead on the eastern side of Scenic Drive for prestige home sites.

11.3.2 Leschenault Inlet - A preliminary Environmental Investigation

Prepared by R.P. Glover as a study contract for the School of Environmental and Life Sciences at Murdoch University.

This is the best and most comprehensive work on the Leschenault to date. It also contains an appraisal of the Vittoria Bay Estate Development. The work is in first draft only.

11.3.3 Hydrological Analysis of Proposed Canal Development. Leschenault Inlet, Bunbury, Western Australia; for Marina Waters Pty. Ltd.

Sinclair Knight and Partners Pty. Ltd. in association with Cox, Pigott and Associates Pty. Ltd., Consulting Engineers. (1974).

This development is proposed on the north-eastern foreshore of the inlet.

11.4 Hardy Inlet

11.4.1 Environmental Study of the Blackwood River Estuary

Dr. E. P. Hodgkin - Estuarine and Marine Advisory Committee of the Environmental Protection Authority, (1975).

This is a working document prepared to assist the Environmental Protection Authority in its decisions concerning the mining of ilmenite in the estuary, and the effect of dredging there. This document contains a good description of the physical aspects of the estuary as well as its flora and fauna.

11.4.2 Anticipated Effects of Dredging in the Blackwood River Estuary

A report by the Estuarine and Marine Advisory Committee to the Environmental Protection Authority, 1976.

At the beginning there is a summary of conclusions given concerning the effects of dredging in the Blackwood River Estuary. This is of relevance to all estuarine dredging operations.

11.5 General

11.5.1 Guidelines to the Conservation and Management of Wetlands in Western Australia

Department of Conservation and Environment, Perth Western Australia, 1977.

This report emphasised the scarcity of wetland resources in this state and the need for protection, particularly of water quality.

11.5.2 Conservation Reserves in Western Australia

Report of the Conservation through Reserves Committee to the Environmental Protection Authority, 1974.

This book contains appraisals of, and recommendations for Systems one to five and eight to twelve and are presented in separate sections.

System Six (Darling) is complex and with conflicting demands for landuse and so has required a greater input and expertise for appraisal.

System Seven (Kimberley) has been left in abeyance because of inadequate data.

11.5.3 System 6 Study

The results of this study are due to appear late in 1978. At the moment all relevant information is available on the 2nd Floor, B.P. House, Mount Street, Perth, and is organised through several committees:

Information and map library.

Local Government and Urban Planning Committee.

Commercial and Productive Use Committee.

Conservation Reserves and National Parks Committee.

Ecosystem and Landuse Committee.

Tourism, Recreation and Demography Committee.

11.5.4 An Index to Ecological information on Estuaries and Marine Embayments in Western Australia

E. P. Hodgkin and K. Majer, 1976.

C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, Sydney.

This is difficult to obtain, though E.P.A. may help with a copy.

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Mrs. J. Coggin	Waterways Commission
Mr. P. D. K. Collins	Public Works Department
Mr. R. Dick	Waterways Commission
Mr. J. Francis	Mandurah Shire
Mr. R. P. Glover	Murdoch University
Miss S. Gibbings	Waterways Commission
Miss L. Gibbings	Waterways Commission
Mrs. V. Harding	Edwards Secretarial College
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Mr. P. Johnstone	Bunbury Town Council
Mr. J. A. K. Lane	Fisheries and Wildlife
Mr. R. C. J. Lenanton	Fisheries and Wildlife
Mr. C. Liddle	Waterways Commission
Prof. A. McCombe	University of Western Australia
Mr. P. Sewell	C.S.I.R.O.
Mr. A. Snow	Leschenault Management Authority
Dr. D. Wallace	Public Works Department

13. ORIGINAL TERMS OF REFERENCE

13.1 Introduction

A general description of all estuarine systems in the south-west of the State (including Peel and Leschenault) stressing any common features and describing in brief any studies which have been carried out and findings therefrom.

13.2 Bibliography

Collate all available reports from Departmental and any other sources relating to the Peel and Leschenault Inlets.

Examine, precis or extract relevant sections.

13.3 Physical Features

(a) Total water areas at mean tide level. Total area navigable by small craft, i.e. 1 metre or greater depths at mean tide level.

(b) Flood predictions, i.e. probability of floods occurring in 10 years and 50 years.

(c) Volumes of winter flows of rivers.

(d) Seasonal salinity changes.

(e) River water contents, turbidity, (i.e. solids in suspension) nutrients and pesticides.

(f) Volumes of tidal flow and available information on extent of sea water penetration into the inlet.

13.4 Sociological

(a) Proportion of perimeter shoreline developed residential.

(b) Proportions publicly owned.

(c) Proportions privately owned but not developed.

(d) Existing town planning schemes and zoning.

(e) Projected population growths in residential areas adjacent to waterways.

(f) Peak summer usage of fully developed recreational areas.

(g) Peak summer usage of partly developed recreational areas.

(h) Potential of any other publicly owned land for development as recreational areas.

(i) Possible light industry establishment adjacent to waterways.

(j) Composition and volumes of any waste materials currently being discharged into the waters.

13.5 Recreational Usage

(a) Boat population during summer peak periods.

(b) Proportion of boats locally owned and proportions from other districts.

(c) Location of existing public jetties and usage of same.

(d) Location of existing public launching ramps.

(e) Location of private marinas and boat hiring establishments.

13.6 Fisheries and Fauna

(a) Fish - types caught commercially.

(b) Quantities in each category over the past ten years.

(c) Birdlife - types and varieties.

(d) Periodic counts of pelicans, cormorants, gulls, etcetera.

(e) Breeding locations of birds.

13.7 Flora

(a) Plant types along foreshores. Salt water tolerant - salt water semi-tolerant.

(b) Types of above best suited for regeneration to protect foreshore banks.

(c) Tree types suitable for planting on recreational and other reserves.

(d) Algae and other sub-marine growth types. General indications of extent of these types and areas most affected.

13.8 Examine controls of water areas and adjoining lands under Acts administered by Harbour and Light Department, Department of Conservation and the Environment (Fisheries and Fauna Section) and Local Government Authorities.

13.9 Any other relevant matter which it may be considered necessary to add to the study during its progress.

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