Sub 128

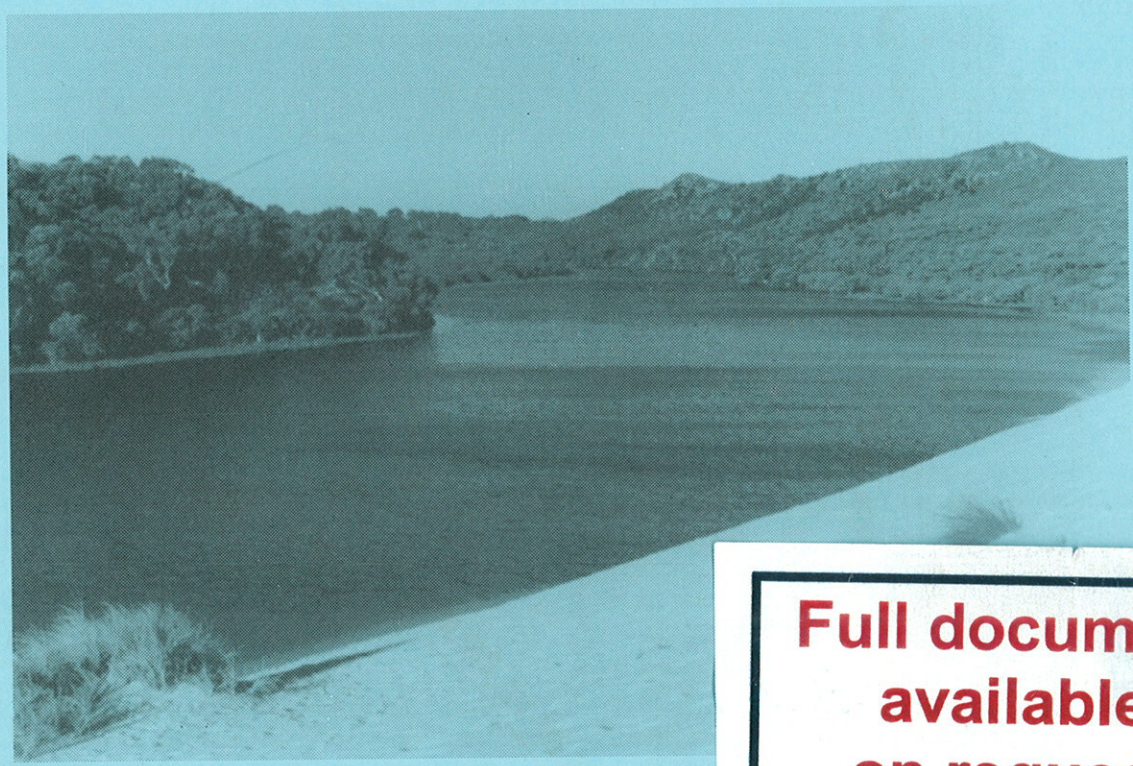
Friends of Moore River Estuary and Bushland

CONFIDENTIAL

Proposal for

Guilderton Regional Park

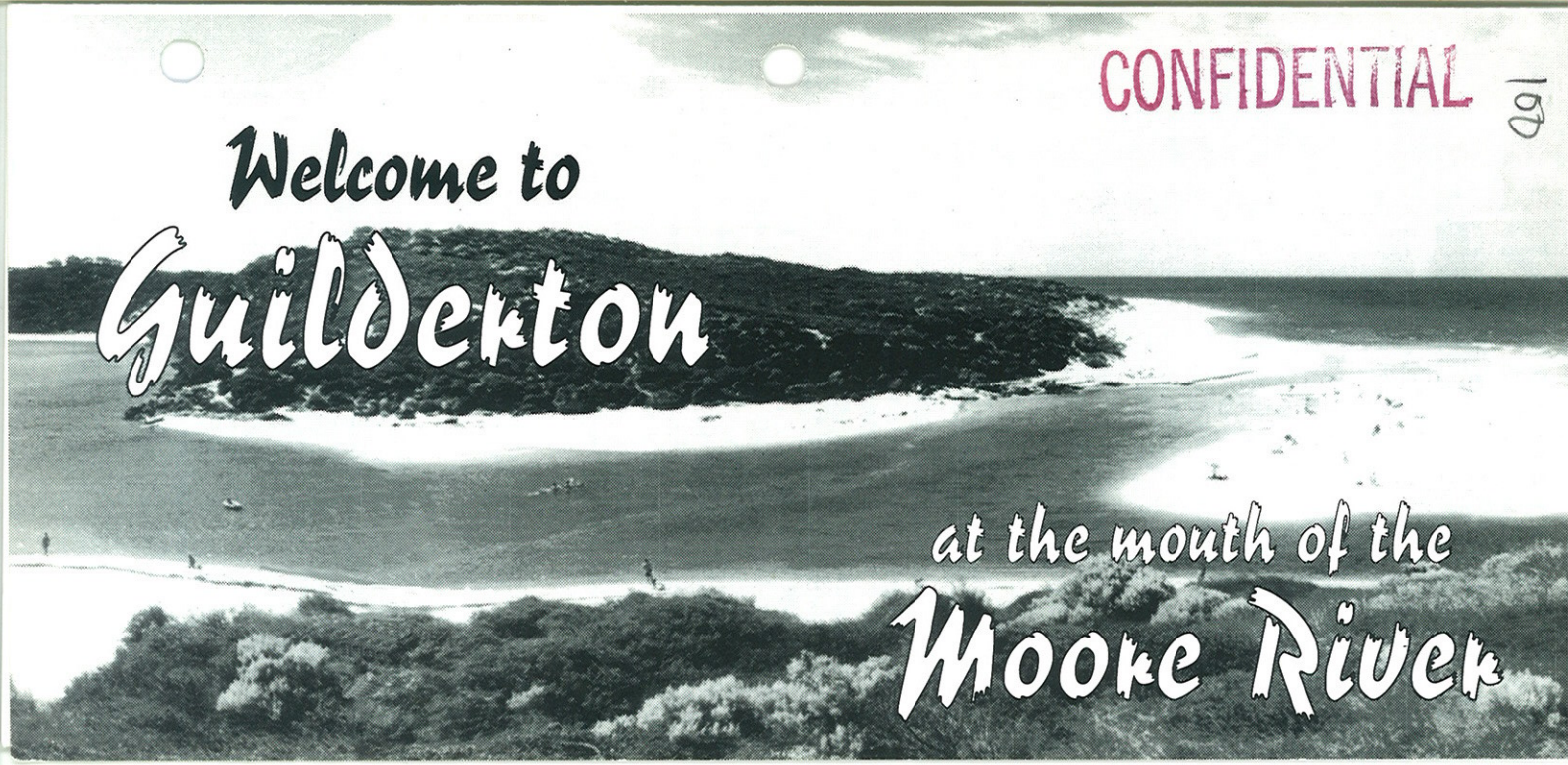
- south of the Moore River



According to the Waugal story, Moore River represents a mythological site for Aboriginal people. Those who fished the estuary and hunted in the surrounding bushland called the area "Gabbadah", meaning mouthful of water.

Today it is an important place for recreation. We have the opportunity to retain the natural beauty of the estuary and bushland for generations to come, through this Regional Park proposal.

CONFIDENTIAL



LOBBYING

Now is the time to act. As responsible citizens we have to protect future generations from environmentally destructive decisions made for short term gain. In the face of powerful forces motivated by money, the voice of the community must be heard loud and clear.

If Guilderton is destroyed, we shall only have ourselves to blame, because we have failed to make the necessary effort. The power of the pen is mighty, if it is well used at the right time. That time is NOW.

The Guilderton Community Association suggests that you write to the following, politely but firmly letting them know how you feel about the possibility of Guilderton expanding over the river, becoming a busy centre, even part of the urban sprawl:

- Gingin Shire Council President and all Councillors, Gingin Shire Offices, 7 Brockman Street, Gingin, 6503.
- Hon. Kevin Minson, Minister for the Environment, Dumar House, 2 Havelock Street, West Perth, 6005.
- Hon. Richard Lewis, Minister for Planning, May Holman Centre, 32 St. George's Terrace, Perth 6000.

It's also a good idea to take any opportunity to phone a talk-back session on any radio station about the importance of protecting the Moore River.

Something else you can do is buy some Protect Moore River stickers, available at the roadhouse.

And join our association.

GUILDERTON ATTRACTIONS

Guilderton offers a great deal to residents, regular holiday-makers and day visitors.

The Guilderton Community Association, a voluntary group of permanent residents and regular visitors, aims to look after the natural features of Guilderton and to co-operate with the Gingin Shire to ensure smooth operation of amenities provided for the benefit of everyone who comes here.

We hope you will appreciate this beautiful area as much as we do and we recommend that you explore and enjoy:

- the ever changing river
- the surf beach
- fishing
- boating
- barbecue facilities
- the "desert"
- boat launching at the groyne
- the park
- the golf course and tennis courts
- trampolines and mini-golf
- the Country Club and Community Hall
- lawn bowls
- walks to the lighthouse and various bush tracks
- gorgeous wildflowers
- stunning sunsets over the ocean
- magnificent moonrises over the river.

We love this place. We treasure its tranquility and beauty and the sense of real recreation it gives us. We want to share its joys without destroying its essential elements.

FUTURE PLANS

Unfortunately this idyllic holiday place can't stay unchanged forever. More and more people are wanting to come here, so the town must expand. How can it do so without spoiling the lovely environment?

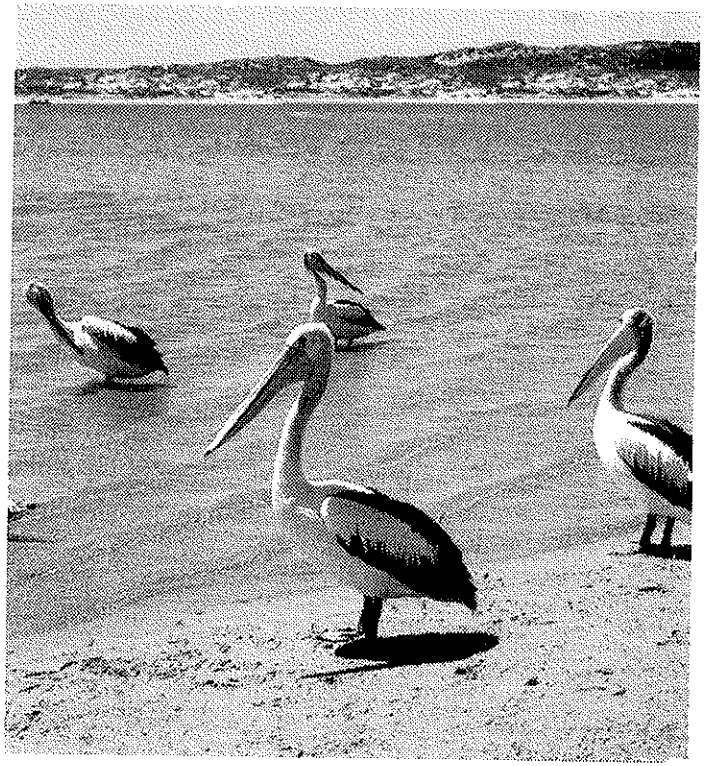
The Shire of Gingin has approved the rezoning of a large tract of land on the south side of the river from rural to urban. The first concept plan showed a town the size of Cottesloe, complete with shopping centre, schools, a tavern, caravan park and lots of housing.

This controversial Amendment 22 would seriously affect the river, destroy the desert, the coastal dunes would be at risk, and by allowing development of most of the recreation areas south of the river mouth, would drastically alter the casual lifestyle which Guilderton now offers.

The Guilderton Community Association has argued against the rezoning, since no adequate safeguards have been offered either by the council or the developers. Planning disputes in other places have shown that once planning approval has been given it is very difficult to get a hearing for local voices.

The Environment Minister has already turned down the request for a full environmental study by the E[illegible]A., despite the attention focussed on the Moore R[illegible]r in the 1983 System Six report. Yet it has a lower flow and its estuary has a more fragile environment and is less degraded than the Swan and Peel-Harvey estuaries which are receiving close attention and care.

Many people suggest that the best use of the land owned by the Moore River Company (Plunketts) would be to include substantial parts of it in a proposed Wilbinga/Moore River Regional Park.



DRAFT

An Assessment of Aspects of Vegetation of the South Guilderton Project

prepared for

Department of Environmental Protection

by

AGWEST Land Management

E. A. Griffin

February 25, 1998

to be quoted as

E.A. Griffin (1998) An assessment of aspects of vegetation of the south Guilderton Project. Unpublished report for Department of Environment Protection. AGWEST Land Management Job 9837.

Summary

This report is prepared to assist the Department of Environmental Protection in providing advice to the Shire of Gingin as to the adequacy of the foreshore reserve proposed for the South Guilderton development. In so doing it describes the vegetation adjacent to the foreshore south of the Moore River and places the plant communities into a regional context. It considers what land would be necessary to protect the river environment and the adequacy of the reserve proposed by the proponent.

The floristic composition of vegetation of the Quindalup dunes has been recognized to vary in composition in response to geomorphology and also follows a regional pattern (Griffin, 1993 and Griffin and Trudgen, 1994). The Moore River was nominated as a boundary between sectors of the coast with suites of vegetation with different floristic composition. The vegetation of the South Guilderton area fits well into these geomorphological and regional patterns. There is some evidence of a zone of overlap between the regional sectors.

While the vegetation fits into this regional pattern, some elements are localized in character. In particular the floristic composition of the vegetation west of the mobile sand sheet (deflated areas) is different from other vegetation in the data sets south of Lancelin. These areas relate to vegetation of similar age north of Lancelin. It is different from and older than that of the deflated areas of the mobile sand sheet between Burns Beach and Mindarie.

Like the Hill and Swan Rivers, the Moore River truncates the Tamala Limestone. Quindalup dunes are perched on the limestone but not covering all of it. The vegetation adjacent to the southern boundary of the Moore River is diverse both in floristic composition and structure and reflects the diversity of landforms. *Melaleuca raphiophylla* dominates a narrow strip immediately adjacent to the river, *Melaleuca cardiophylla* and *M. huegelii* dominate areas of limestone outcrop. The vegetation of the calcareous Quindalup dunes reflect different geomorphological sere. There are areas of partially vegetated sand, older areas with *Spyridium globulosum* and *Allocasuarina lehmanniana*, areas of Tuart woodland and a number of different types dominated by *Melaleuca acerosa* and allies.

The steep areas of the Moore River adjacent the estuary is highly vulnerable to degradation. Some areas are above the angle of repose, being held together by the sparse vegetation. Other areas, some bare sand and some well vegetated, are moderately to steeply inclined. Even the well vegetated areas are highly vulnerable and it takes as little as a heavy rain storm to initiate erosion. Development as low key as tracks and firebreaks could initiate degradation affecting the character of the river and its environment.

Introduction

The privately owned land south of the Moore River at Guilderton has been proposed for urban development. Most aspects of the rezoning the area from rural to urban have been through a review process. The requirements for an area to protect the Moore River is currently being considered.

The Department of Environmental Protection requested advice on the character of the natural areas adjacent to the River and to place the vegetation composition into a the regional context.

Griffin and Trudgen (1994) recognized several broad floristic clusters and sub clusters (Table 1). Griffin (1993) and Griffin and Trudgen (1994) demonstrated regional floristic patterns in detailed site studies of Quindalup dune vegetation. A number of coast sectors which had particular suites of floristic types were identified (Table 2). Gibson et al (1994) demonstrated distinct differences between Quindalup and other dune systems. The also recognized some variation within broad geomorhpological types.

Table 1 Broad floristic clusters Griffin and Trudgen (1994)

A	older dunes
Aa	included most of the older dune sites from Alkimos, Wilbinga, Manakoora and the two reserves from Ledge Point
Ab	mostly from the Burns Beach and Mindarie areas with a few sites from Alkimos and Trigg
Ac	mostly from Swanbourne with one site from Trigg
B	a grouping of dunes and shallow plains mostly sampled in 1991, somewhat artificial group, mostly from Breton Bay, Mindarie and Burns Beach
Ba	principally plains (Qs, Qp and Kls) and a few dunes, more calcareous sand than other plains with limestone close to the surface
Bb	mostly dunes between Ledge Point and Breton Bay
Bc	lacked the annual species typical of the rest of group B
C	exposures of Tamala limestone and yellow siliceous sand, Ledge Point and Wilbinga
D	incipient foredunes and very young dunes
E	young dunes and very young plains
Ea	young dunes and foredunes
Eb	almost entirely recently deflated plains (Qs, Qp and Qb). They occurred close to the coast throughout the study area

Table 2 Floristic sectors of Quindalup dune vegetation (Metropolitan area).

1	Lancelin to Moore River,
2	Moore River to Quinns Rock,
3	Quinns Rock to Sorrento, and
4	South of Sorrento

Methods

The areas bordering the south of the river were visited on two occasions; one in October 1997 and one in January 1998. The vegetation was described and species lists were made at 17 releves of about $100m^2$ (Figure 1). Neither time was ideal for collecting this data but from experience in this vegetation little appears to have been missed.

This data was combined with comparable data from four other sets, Griffin (1993), Griffin and Trudgen (1994), Gibson et al. (1994) and DEP (1996). These 344 sites with 483 plant taxa ranged from south of Lancelin to south of Busselton. These were subjected to a number of numerical analysis techniques from the package PATN (Belbin et al 1984). This involved classification, ordination and a number of summary programs. A number of clustering levels were assessed, but no attempt was made to define floristic units such as associations.

Aerial photo interpretations were made of the vegetation of the southern fringe of the river. The units, mainly soil-landscape phases were described. Risks of land degradation were assessed.

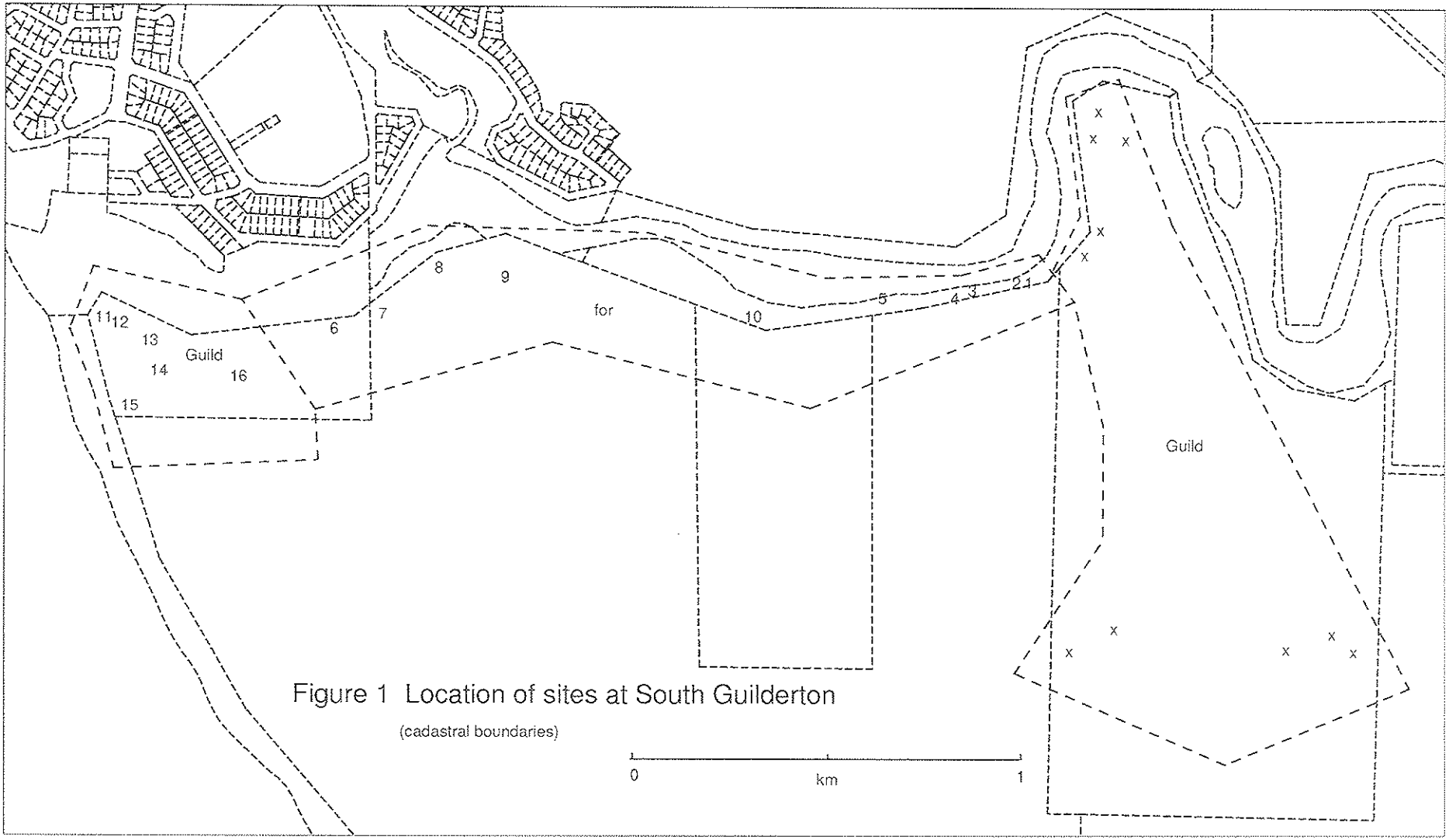


Figure 1 Location of sites at South Guilderton

(cadastral boundaries)

Results

Floristic data

Despite being mostly from Quindalup dunes, the data set was diverse. Over 40 % of the species occurred in just one or two sites (<1% sites), e.g. Centella asiatica, Pimelea calcicola, Thomasia triphylla, Schoenus pleiostemoneus, Eucalyptus argutifolia and Patersonia occidentalis. In part this was because some sites were from damplands or Spearwood dunes. This has meant that some sites were very different from the rest. Falling into this class were 18 sites that had similarity coefficients of greater than 0.55 to any other site. Many of these tended to form clusters of 3 or fewer sites.

On the other hand Melaleuca acerosa, the most common species was in 234 sites (68%). Other more commonly occurring species included Conostylis candicans subsp. calcicola, Lomandra maritima, Loxocarya aspera, Stipa flavescens and Acanthocarpus preissii. Some sites were very similar with having similarity coefficients of less than 0.2 to at least one other site. These tended to fall in cluster 1 (of 20 level clustering).

There was a wide range of species richness. Twelve sites had less than 10 species. These were mostly areas of strand and very young regeneration on the deflation basins. The maximum richness was 63 with 3 others having greater than 50 species. These data also confirm the diversity of the data set. Potentially the analysis will be affected by the diversity, not so much because of the wide range of variation but more because of the disproportionate representation (odd sites). At the 20, 50, and 100 cluster levels there were 2, 8 and 37 singleton clusters respectively. The affects of these singletons are minor at the lower levels of clustering (100 or 50 cluster levels). At the higher (20 or 7 cluster levels) it is common for many of the disparate clusters to be joined together and the product cluster to have little meaning.

The minimum spanning diagram joins all sites to their nearest possible neighbor to form a tree (Figure 2). The minimum number of inter-cluster linkages is one less than the number of clusters. The number of inter-cluster linkages in relation to this minimum is an indication of how tight the clusters are. It can also be used to give an indication of how many 'real' clusters there are in the data set. This method of analysis demonstrates that the 7 cluster level is not particularly meaningful since there is over five times the minimum number of inter-cluster linkages (Table 3). This percentage drops significantly as the number of clusters increase. The number of 'real' clusters in this data set is probably greater than 50. At this level of clustering there is good correspondence between the clustering and the minimum spanning analysis.

Table 3 Minimum Spanning Diagram linkages

	Cluster level			
	7	20	50	100
min # inter-cluster linkages	6	19	49	99
# inter-cluster linkages	41	72	100	142
% of min#	583	279	204	143

Homotoneity can be used as a measure of how homogeneous clusters are. Values of at least 1 are considered homotonous. The whole data set has a homotoneity value of 0.00. Table 4 demonstrates clusters become more homotonous as the data set in divided into more clusters. It also demonstrates that the clusters at the 7 and 20 cluster levels and probably also the 50 cluster level are not homotonous. This suggests also that there should be more than 50 "natural" clusters in this data set.

Figure 3
Minimum Spanning Tree

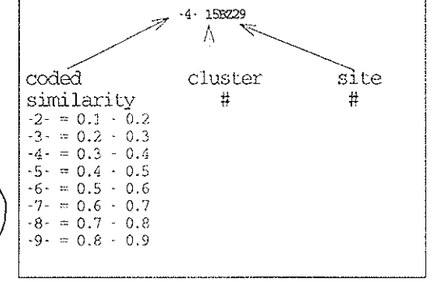


Table 4 Homotoneity values for 7, 20 and 50 cluster levels

Homotoneity = CIV+CV/CII+CIII, where

CII number of species occurring in 20 to 40% of sites in cluster
CIII number of species occurring in 40 to 60% of sites in cluster
CIV number of species occurring in 60 to 80% of sites in cluster
CV number of species occurring in 80 to 100% of sites in cluster

7	H	20	H	50	H
1	0.27	1	0.63	1	0.63
		2	0.58	2	0.57
				3	0.29
				4	1.00
		3	0.50	5	0.58
				6	0.42
				7	0.41
2	0.20	4	0.23	8	0.48
				9	0.26
				10	0.26
				11	0.34
				12	0.31
		5	0.29	13	0.45
				14	0.84
				15	0.45
				16	0.67
				17	0.31
		6	0.58	18	0.58
		7	0.38	19	0.50
				20	0.39
				21	0.55
3	0.85	8	0.85	22	0.85
4	0.15	9	0.27	23	0.40
				24	0.46
				25	0.50
		10	0.44	26	0.44
5	0.35	11	0.43	27	0.68
				28	0.79
				29	0.46
		12	0.18	30	0.93
				31	na
6	0.06	13	0.24	32	0.93
				33	0.79
				34	0.41
		14	0.09	35	0.35
				36	0.18
				37	0.50
				38	na
				39	0.61
		15	0.17	40	0.41
				41	0.64
		16	0.22	42	na
				43	na
				44	na
		17	0.15	45	0.50
				46	0.38
		18	0.37	47	na
				48	0.23
		19	na	49	na
7	na	20	na	50	na

na not applicable, only one site in cluster group

There were some patterns of clusters on the ordination diagram (not presented) which tends to support the clustering. However, the diversity of the data set was too great to be portrayed reasonably on 2 or 3 ordination axes. More involved analysis of subsets would be necessary to achieve more from ordination techniques. This was not possible in the current time frame or considered necessary in light of the data from the classification.

Appendix 1 provides a dendrogram illustrating the fusion of sites into clusters. Cluster numbers from 4 different levels of clustering are indicated for each site. An obvious feature is wide range of size of clusters. This supports the earlier comments about how these data included a number of "odd" sites and how these were treated in the analysis.

Appendix 2 is a tabulation of species by the 20 clusters. The species are ordered and grouped by a dendrogram derived from the classification of species. Only species which were present in more than 30% of sites in at least one cluster have been included. This table is presented as a way of illustrating the degree of overlap of species in cluster groups. There are some small groups of species which are only present in one or two clusters, frequently singleton clusters. Most other species are present in several to many clusters. Tables 5 and 6 are derivations of this appendix. They show respectively the species which are faithful to the 7 and 20 clusters. Most of these are faithful to the small and relatively small site clusters.

Table 5 Faithful species to 7 clusters in data set
(Species present in less than 30% of any cluster have been omitted.)
(Species ordered to emphasize the association of species with site clusters.)
(Number prefix to name is 50 cluster number from classification of species.)

	clusters -->	1	2	3	4	5	6	7
	name # sites -->	154	87	6	18	39	39	1
20	Mesomelaena pseudostygia			67			7	
20	Hibbertia hypericoides			50			10	
30	Daviesia divaricata		3	50				
34	Anigozanthos humilis subsp. humilis		2	33				
36	Allocasuarina humilis		2	67			2	
36	Bossiaea eriocarpa			67				
36	Hakea trifurcata			83		2		
36	Petrophile serruriae		2	83				
36	Hakea lissocarpha		6	83				
36	Hakea prostrata	1	4	67			2	
36	Jacksonia stricta			50				
36	Olearia rudis		2	50				
36	Grevillea thelemanniana subsp. preissii		12	67			2	
36	Dryandra lindleyana	1	12	83			2	
36	Dryandra sessilis var. cygnorum	1	12	83		5	12	
10	Spinifex hirsutus				27			
10	Cakile maritima				38			
11	Calocephalus brownii				55	9		
11	Myoporum insulare	4	7		5	45	7	
25	Caladenia latifolia		7				33	
25	Carex preissii		5				34	
25	Oxalis perennans						27	
25	Agonis flexuosa		2				30	
42	Melaleuca rhaphiophylla						2	100
43	Triglochin procerum							100
43	Baumea arthrophylla							100
43	Baumea articulata							100
43	Baumea juncea							100
43	Lepidosperma longitudinale							100
46	Samolus repens						3	100
13	Gahnia trifida						3	100

Table 6 Faithful species to 20 clusters in data set
(Species present in less than 30% of any cluster have been omitted.)
(Species ordered to emphasize the association of species with site clusters.)
(Number prefix to name is 50 cluster number from classification of species.)

	7 clusters -->	1			3	2				4		5		6							7
	20 clusters -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	name # sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
30	Daviesia divaricata				50	7															
36	Bossiaea eriocarpa			6	67	2															
36	Petrophile serruriae	2			83	5															
36	Hakea prostrata	2		6	67	9								8							
36	Jacksonia stricta			6	50	2															
36	Olearia rudis				50	5															
10	Spinifex hirsutus									7	100										
10	Actites megalocarpa										50										
1	Banksia prionotes												50								
25	Geranium retrorsum								7					58							
25	Hibbertia cuneiformis													83							
19	Drosera erythrorhiza															50					
19	Conyza albida															50					
20	Sowerbaea laxiflora													8		50					
20	Urospermum picroides															50					
20	Podotheca gnaphalioides							5								50					
26	Thysanotus manglesianus													8			33				
29	Pelargonium littorale					5								8			67				
42	Alyogyne huegelii var. glossulariaefolius					2											67				
47	Lolium sp.																		67		
47	Hydrocotyle diantha																		100		
47	Triglochin mucronatum																		67		
47	Plantago exilis																		67		
41	Spergula sp. scps																			100	
41	Crassula sp.																			100	
41	Siloxerus sp.																			100	
41	Hydrocotyle medicaginoides																			100	
41	Ranunculus pumilio													8						100	
41	Lolium perenne	3										3								100	
43	Triglochin procerum																				100
43	Baumea arthrophylla																				100
43	Baumea articulata																				100
43	Baumea juncea																				100
43	Lepidosperma longitudinale																				100

The constant (most frequently occurring) species in each of the 7 and 20 level clusters are provided in Appendix 3. This is nested to show what species are constant in the 7 level clusters and the corresponding 20 level clusters.

The sector of the coast in which the site falls, the floristic clusters of Griffin and Trudgen 1994 and of Gibson et al (1994) are provided in the dendrogram in Appendix 1. The clusters in this analysis show significant correspondence with these other data.

Table 7 indicates the association of the present clustering with that of Griffin and Trudgen (1994). This association is good, however, it illustrates that additional sites can influence the clustering, particularly at the higher levels (larger clusters). Griffin and Trudgen (1994) noted that their cluster B was diverse and this is borne out in this table. The other clusters show a stronger association. Although all subdivisions of their cluster Aa was within cluster 1 (at 50 cluster level), there was good association with the subdivisions were each associated with one or two distinct clusters at the 100 cluster level.

Table 7 Comparison of clustering with that of Griffin and Trudgen (1994)
Sites not in both data sets have been omitted from this table, so too are clusters to which some of the omitted sites belong.

gp cluster from Griffin and Trudgen (1994)# 40 cluster number from Griffin and Trudgen (1994)

7 clusters ->		1						2										3	4				5		
20 clusters ->		1	2		3			4				5			6	7		8	9			10	11		
50 clusters ->		1	2	3	5	6	7	8	9	10	11	13	14	17	18	19	20	22	23	24	25	26	27	28	29
gp*	#																								
Aa	1	22			1																				
Aa	2	18				1																			
Aa	3	4																							1
Aa	4	34																							
Ab	5				26	1							1												
Ab	6					19																			
Ab	7						2																		
Ab	8						3																		
Ab	9						1																		
Ac	10															7									
Ac	11																1								
Ba	12							2																	
Ba	13								1																
Ba	14								2																
Ba	15														1										
Ba	16									2															
Ba	17														5										
Ba	18					4																			
Ba	19														2										
Bb	20											11													
Bb	21											4													
Bc	22		4																						
Bc	23		4																						
Bc	24			4																					
C	25																	1							
C	26																	5							
D	27																		5						
D	28																			2					
D	29																			1					
D	30																					4			
Ea	31																						8		
Ea	32																						8		
Ea	33																							8	
Ea	34																						1		5
Eb	35										2														
Eb	36																								
Eb	37																				1				
Eb	38																		2						
Eb	39																								2
Eb	40																				3				

There is some correlation of the clusters between the current study and that of Gibson et al (1994) (Table 8). This shows that the association is moderate at the 7 cluster level but declines at more detailed levels. The low correspondence may be associated with the analysis of Gibson et al (1994) being of a much wider range of vegetation types and the relatively small number of sites in their data from the Quindalup dunes.

Table 8 Comparison of clustering with that of DEP (1996).

f_type floristic type from DEP (1996).

7 clusters ->	1			2				3	4		5		6							7
20 clusters ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
f_type																				
29a	1			10	1				1				3	1			1		1	
29b	5		7	3	18	1	7													
s11							1													
30a1																	2			
30a2														6	2	2				
30b													9			1				
other sites	73	16	52	8	24	7	7	6	13	4	35	4		5	2		1	3		1

Tables 9, 10 and 11 show that there is broad and significant correspondence between the site clustering and the sector of the coast in which the sites fall. Most site clusters from the 7 and 20 cluster levels fall into sites in more than one sector. However, when the 50 cluster levels are considered the correspondence with sectors is much stronger. Sectors are characterised by one or several clusters which are confined to one (or two adjacent) sectors. This analysis supports the division of the coast into sectors suggested by Griffin and Trudgen (1994). The clusters which are more wide spread tend to be those from the strand and young foredunes. The more confined clusters are older dunes and restricted habitat types such as damp lands etc.

Two additional sectors are tentatively proposed, these for south of the Swan River. The existence of these additional sectors is clear but the data is too few to define them in any detail. These will need to be reconciled with those sectors suggested by Searle and Semeniuk (1985) and Semeniuk et al (1989) from geomorphological characteristics.

The existence of sectors can be explained in overlapping distribution patterns of species. Griffin (1994) documented the range of a wide range of species which contribute to this phenomenon. This aspect has not been investigated in this study but would be worth further study.

Guilderton sites

The 26 sites sampled in this study are highlighted in the dendrogram (Appendix 1). While these were from 5 of the 7 level clusters, they were concentrated in relatively few of the higher (e.g. 50) level clusters. Plant communities which belong to other clusters were noted but not sampled. These include the strand vegetation, the foredunes and the early stages of regeneration after the passing of the sand sheet. The nearest neighbor to these 26 sites were mostly sites from close by such as at Wilbinga. These data indicated local consistency in floristic composition. This can also be seen in the minimum spanning tree.

Further investigation showed that the sites from the Guilderton South area fitted well into the regional patterns. From Table 10 it can be seen that most of the sites belonged to 20 level site clusters which were from combinations of sectors 1, 2 or 3; not strongly confined at this level. However, from Table 11 it can be seen that 11 of the sites belonged to 50 level site clusters which were confined to sector 2. All but one of the other sites belonged to 50 level site clusters which were confined to sectors 1 and 2.

The level 50 clusters which were confined to the south Guilderton area were mostly associated with the regeneration of deflated areas after the passing of the mobile sand sheet. These areas were typically dominated by a suite of species including *Spyridium globulosum* and *Allocasuarina lehmanniana*, with a range of faithful species. These clusters are contributing to a localized characteristic suite of floristic communities. This is in part because there are virtually no other deflated areas within the study area with vegetation at this stage of re-establishment. There are very young areas in the deflated areas at Mindarie and Manakoora. The nearest that vegetation of similar development occurs is in the Nilgen Nature Reserve (north of Lancelin). However, there are species in these areas at south Guilderton not in corresponding parts of Nilgen, e.g. *Billardiera* sp. Seabird (G.J.Keighery 12977), *Dryandra sessilis* and *Banksia prionotes*. These differences are probably due to the differences in the nature of the deflated areas. At Nilgen the deflated area is mainly weakly cemented Holocene limestone with calcareous sand. At south Guilderton the deflated area is Tamala limestone with its yellow sand and added calcareous sand.

The areas of Tuart in the South Guilderton area are associated with the species favouring post sand sheet regeneration *Spyridium globulosum* and *Acanthocarpus preissii.*

The occasional presence of *Allocasuarina lehmanniana* in a number of sites along the foreshore tended to contribute to these being different from other sites in the data set with *Melaleuca acerosa* and *Acacia lasiocarpa.*

Table 9 Clusters by area and sector

(areas sorted roughly from N to S)

1 Lancelin to Moore River,
2 Moore River to Quinns Rock,
3 Quinns Rock to Sorrento,
4 Sorrento to Swan River,
5 Swan River to Mandurah,
6 Mandurah to Busselton

	7 cluster -->	1			2				3	4				5							6
	20 cluster -->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
S	area																				
1	LS	6	1							3		5									
1	PS	13	2						2												
1	MAN	21	6						2												
1	LP					4															
1	BB	6	1		3	11	6		1	3		8									
1	SEAB				3	3											1				
2	for	1	4		1								3		1						
2	Guild				1	10							1		1	2					1
2	NWIL					2															
2	WIB	21	1	2	1				1			1									
2	wilb				2	3						2									
2	tokyu				1	2															
2	xyan																1				
2	pip																1				
2	ALK	7		8	1																
3	MI			17			2			6	2	8									
3	BZ	4	1	29		1				1		7									
3	BU				4																
3	BURN				2																
3	Pinn					1															
4	TR			2				1		1	1	1			2						
4	TRIG							1							1						
4	SW							7			1	3									
4	bold							4							1						
4	m46							2													
4	PEPGRV														2						
5	MHENRY															2					
5	NAVB				1																
5	WOODP														2						
5	rich				1																
5	GARDEN														2			2			
5	rotto																	2	3		
5	PB					4															
6	NPRES					1															
6	PRES																			1	
6	WHILL			1		1															
6	LESCH													5							
6	BMaid													1							
6	NMaid													3							
6	PEPB													1							
6	Possum													2							

Table 10 Clusters by area and sector
(areas sorted roughly from N to S)
Clusters ordered to emphasize relationships with areas

1 Lancelin to Moore River,
2 Moore River to Quinns Rock,
3 Quinns Rock to Sorrento,
4 Sorrento to Swan River,
5 Swan River to Mandurah,
6 Mandurah to Busselton

	7 cluster -->	3	1	1	5	2	4	4	2	2	6	4	1	4	5	2	5	5	5	5	5
	20 cluster -->	8	2	1	16	6	9	11	4	5	20	12	3	10	14	7	15	17	18	19	13
S	area																				
1	LS		1	6			3	5													
1	PS	2	2	13																	
1	MAN	2	6	21																	
1	LP									4											
1	BB	1	1	6		6	3	8	3	11											
1	SEAB				1				3	3											
2	for		4	1					1			3			1						
2	Guild								1	10	1	1			1		2				
2	NWIL									2											
2	WIB	1	1	21				1	1				2								
2	wilb							2	2	3											
2	tokyu								1	2											
2	xyan				1																
2	pip				1																
2	ALK			7					1				8								
3	MI					2	6	8					17	2							
3	BZ		1	4			1	7		1			29								
3	BU								4												
3	BURN								2												
3	Pinn									1											
4	TR						1	1					2	1	2	1					
4	TRIG														1	1					
4	SW							3						1		7					
4	bold														1	4					
4	m46															2					
4	PEPGRV														2						
5	MHENRY																2				
5	NAVB								1												
5	WOODP														2						
5	rich								1												
5	GARDEN														2			2			
5	rotto																	2	3		
5	PB									4											
6	NPRES									1											
6	PRES																			1	
6	WHILL									1			1								
6	LESCH																				5
6	BMaid																				1
6	NMaid																				3
6	PEPB																				1
6	Possum																				2

Table 11 Clusters by area and sector

(areas sorted roughly from North to South) Clusters ordered to emphasize relationships with areas. **Sectors (S)-->** 1 Lancelin to Moore River, 2 Moore River to Quinns Rock, 3 Quinns Rock to Sorrento, 4 Sorrento to Swan River, 5 Swan River to Mandurah, 6 Mandurah to Busselton

	7 cluster -->	**1**	**2**	**6**	**1**	**5**	**6**	**7**	**2**	**5**	**3**	**2**	**2**	**2**	**1**	**1**	**4**	**5**	**2**	**2**	**4**	**1**	**1**	**2**	**5**	**5**	**6**	**6**	**6**	**4**	**4**	**1**	**2**	**2**	**6**	**2**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
	20 cluster -->	**2**	**5**	**16**	**2**	**12**	**15**	**20**	**5**	**12**	**8**	**5**	**4**	**5**	**1**	**2**	**9**	**11**	**4**	**6**	**9**	**3**	**3**	**4**	**11**	**11**	**14**	**16**	**16**	**9**	**10**	**3**	**5**	**4**	**14**	**7**	**14**	**7**	**7**	**14**	**15**	**4**	**14**	**17**	**17**	**18**	**18**	**19**	**13**	**13**	**13**
	50 cluster -->	**3**	**13**	**43**	**4**	**30**	**40**	**50**	**17**	**31**	**22**	**16**	**10**	**15**	**1**	**2**	**25**	**29**	**9**	**18**	**23**	**5**	**6**	**8**	**28**	**27**	**36**	**44**	**42**	**24**	**26**	**7**	**14**	**11**	**39**	**20**	**35**	**19**	**21**	**37**	**41**	**12**	**38**	**45**	**46**	**47**	**48**	**49**	**33**	**32**	**34**
S	**area**																																																	
1	LS	1									2				6		3	5																															
1	PS	1									2				13	1																															
1	MAN	2													21	4																															
1	LP		4								1																																				
1	BB		11										2		6	1			1	6	3					8																				
1	SEAB			1								1	3	2																																
2	for				3	3									1	1			1								1																				
2	Guild						2	1	4	1		2	1	4													1																				
2	NWIL										1			2																																
2	WIB														21	1						1	1	1	1																						
2	wilb												2	3											1	1																				
2	tokyu												1	2																																
2	xyan																											1																			
2	pip																												1																	
2	ALK														7							7	1	1																						
3	MI																	1		2	4	4	13		3	4				2	2														
3	BZ														4	1	1	2				14	10		4	1						5	1												
3	BU																		2															2												
3	BURN																																	2												
3	Pinn																																1												
4	TR																					1				1				1	1	1		2	1										
4	TRIG																																	1	1											
4	bold																																			1	4									
4	SW																									3					1						7									
4	m46																																					2								
4	PEPGRV																																						2							
5	MHENRY																																							2						
5	NAVB																																								1					
5	WOODP																										1										1								
5	rich																																								1					
5	GARDEN																										1															1	2				
5	rotto																																										2	1	2			
5	PB																																4													
6	NPRES													1																																
6	PRES																																												1			
6	WHILL													1									1																								
6	LESCH																																												5			
6	BMaid																																													1		
6	NMaid																																												1	2		
6	PEPB																																														1	
6	Possum																																														2	

Aerial Photo Interpretation

The area adjacent to the southern bank of the Moore River east of the recreation reserve was interpreted using stereo aerial photos. Several distinct units were recognized. This was done to give an areal extent to the vegetation recognized during the inspection and as a basis for assessment of degradation risk.

The Moore River truncates the Pleistocene Tamala Limestone which along its banks is exposed as gently to steeply inclined slopes. This truncation probably occurred prior to the Holocene since the Holocene dunes terminate at its southern margin.

Typical of this portion of the west coast, the areas south Guilderton area is dominated by Holocene dunes perched on an undulating surface of Tamala Limestone. These are parabolic dunes which originated on the coast and travelled in a north-easterly direction. Their age varies greatly with most being deposited in early to mid-Holocene and others still mobile. These dunes have not been able to pass over the Moore River.

Characteristic of the these landforms is the leading and trailing dunes which contain a deflated surface. In this sector of the coast the deflated surfaces are usually small and have small dunes (chaots). These chaots appear to have developed either in association with re-establishing vegetation or by a small parabolic dune following on the same path.

It is common for a mobile sand sheet to be the product of the coalescence of several sand parabolic dunes. This appears to be the case for the one at south Guilderton. From the form of the stabilized dunes and the vegetation types there appears to have been a sand sheet which terminated approximately at the NW corner of the sandsheet. The vegetation south west of that point is the re-establishment since that earlier sand sheet stopped. The present sand sheet followed a parallel route slightly to the east. It has modified the eastern trailing arm of the earlier parabolic dune. This an important to understand the vegetation patterns which exist west and south-west of the sand sheet. Griffin (1994) demonstrated seral development of vegetation re-establishing after the passing of the sand sheets. Vegetation in the south Guilderton area follow this model.

Twelve soil-landscape units were recognized in the mapping (Table 12, Figure 3). The major vegetation types associated with these are listed. The surrounding area is mostly older dunes (Q1 and Q2 of McArthur and Bartle (1980). The leeward slopes of these dunes are typically moderate to steeply inclined and even on the older dunes these slopes are less well vegetated than the rest of the dune. The mobile sand sheet is level to gently undulating with a moderate to steeply inclined leeward face. This face has in part been truncated by the river. The sandsheet is slowly moving and discharging only relatively small quantities into the river.

A number of units characterize the area lying in the wake of the mobile sand sheets. The most recently vegetated areas are a mixture of plains and small chaots. There is an older areas which is gently undulating following the shape of the underlying Tamala limestone surface. Small dune remnants are common. The other main unit is an area of short axis dunes with moderate to steeply inclined slopes. Typically these are vegetated by Tuart woodlands.

Small areas of exposed limestone and limestone with shallow calcareous sand occur along the bank of the river.

Mobile sand sheet

While the sandsheet is slowly filling parts of the river, it is unlikely to extend much further and certainly will not block the river. This conclusion is drawn from several features of the sand sheet. Firstly the amount of available sand has nearly been exhausted. The majority of the area is a deflated surface with very little in the way of a frontal dune. Secondly the progress of the frontal dune has declined because it has moved down the slope of the Moore River and is less exposed to the prevailing south-westerly winds. Finally, the Moore River has shown the ability to remove and truncate these sandsheets. This will inevitably occur in the next flood.

Land degradation risks.

The major land degradation risk is wind erosion. All areas with calcareous sand are vulnerable because of the loose surface. The risk for dune crests is extreme because of their exposure to the wind. The sand sheet and the upper portions of the old dunes are the areas where the risk is greatest.

Soil erosion is normally not associated with the rapidly draining calcareous sands. However, there is a combination of factors in some of the units mapped with brings this to importance. The factors of significance are slope and water repellent soil surface. Even in natural areas a storm event will cause erosion on moderate to steep slopes of calcareous sand dunes. Recently burnt areas suffer much more. Animals and people moving on these slopes are a major cause of erosion.

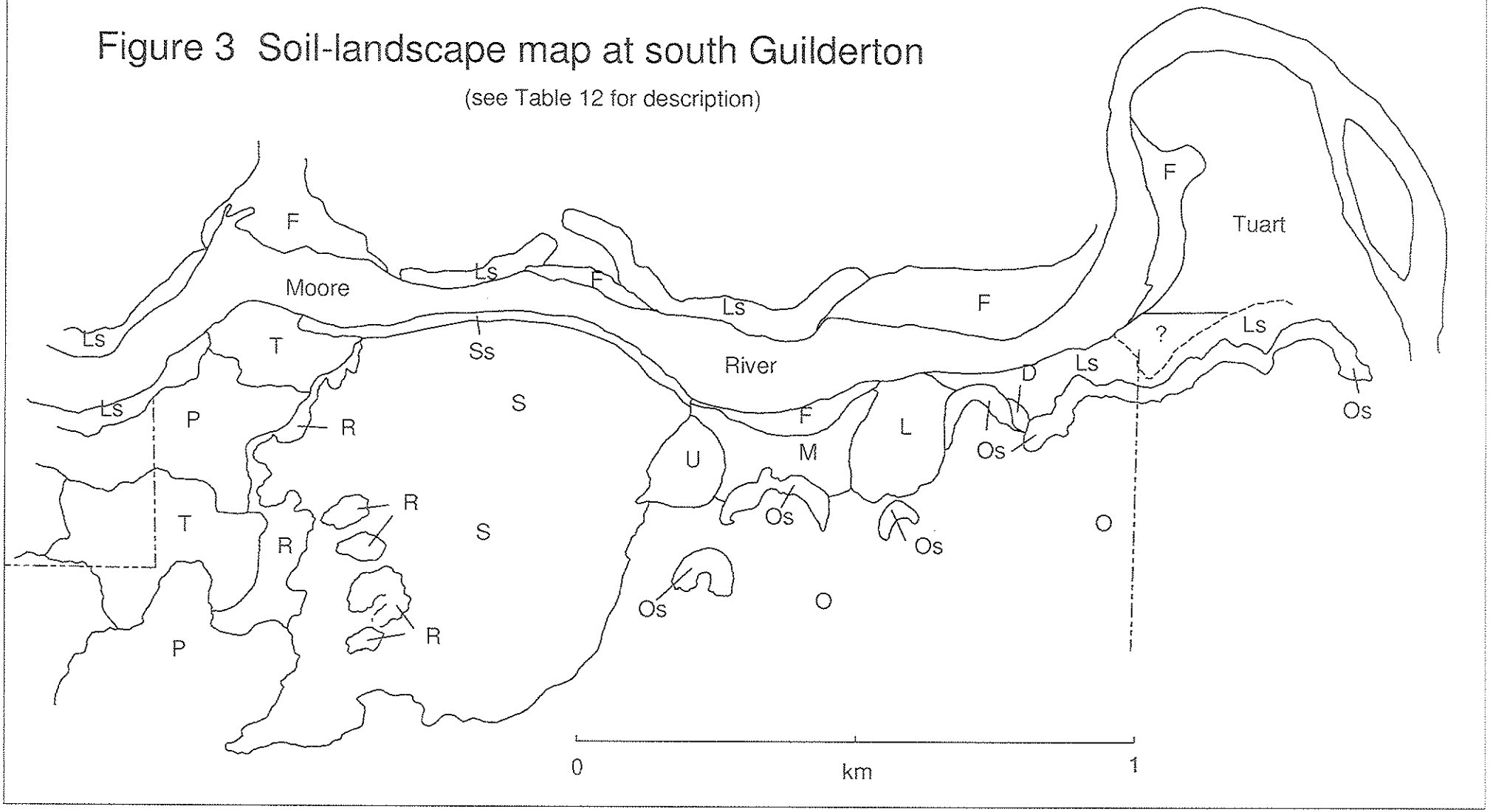
Nutrient export risk is also a significant issue for urban development, even those with deep sewerage. Parks, gardens and storm water drains are the major sources of nutrients and pollutants. The risk of export of phosphorus is low since calcareous deep sand and limestone bind phosphorus reasonably well. However, the risk of nitrogen export is likely to be high since the calcareous sand is rapidly drained and the nitrogen will be flushed with the ground water. Of particular relevance to the impact of the nutrient export is the movement of ground water in the unsaturated layers. The underlying Tamala Limestone and associated yellow clayey sand is capable of shedding water in preference to transmitting it. In this case nutrient rich water may be shed on the boundary between the calcareous sand and the Tamala Limestone. If the limestone slopes towards the Moore River, the contained nutrients will end up in the river.

Table 12 Soil-landscape units in south Guilderton (see Figure 3)

	Map Unit	Soil and lithology	Landform element	Slope	Vegetation
O	Old dunes	Oldest calcareous deep sand dunes	crests, hillslopes and swales with occasional outcropping limestone	gently to moderately inclined	*Melaleuca acerosa* low heath
Os	Old dunes, steep	Oldest calcareous deep sand dunes	hillslopes	moderately to steeply inclined	*Melaleuca acerosa* open low heath
F	River flats	River margin with calcareous and peaty sand	plain	level to very gently inclined	*Melaleuca rhaphiophylla* scrub and areas of sedges
D	Foecunda	Slope with calcareous shallow and deep sand over Tamala limestone	hillslope	gently inclined	*Eucalyptus foecunda* with mixture of associates spp.
L	Limestone	Tamala limestone with calcareous shallow and deep sand	hillslopes	gently inclined	*Melaleuca cardiophylla* and *M. huegelii* heath
Ls	Limestone slopes	Tamala limestone with calcareous shallow sand	hillslopes	gently to moderately inclined, in places steeply inclined	*Melaleuca cardiophylla* and *M. huegelii* low heath, Tuart on steeper slopes
M	Misc slope	Calcareous deep sand	hillslopes	gently inclined	*Melaleuca cardiophylla* heath
S	Sandsheet	Calcareous deep sand	hillslopes, plains and crests	level to gently inclined	mainly bare
Ss	Sandsheet steep	Calcareous deep sand	hillslopes	moderately to steeply inclined	mainly bare
R	Sparse regeneration	Calcareous shallow and deep sand, over Tamala limestone	plains, hillslopes and crests	level to moderately inclined in places	*Spyridium globulosum, Calocephalus brownii* and *Isolepis nodosus* open low shrubland
P	Deflation plain	Calcareous shallow sand, over yellow sand and Tamala limestone	plains, hillslopes and crests	level to gently inclined	*Spyridium globulosum, Allocasuarina lehmanniana* heath with small areas of *Banksia* open low woodland.
T	Small dunes	Dunes left in wake of sand sheet, calcareous deep sand	hillslopes, crests and swales	moderately to steeply inclined	Tuart woodland
U	Undefined rise	An older dune or rise with calcareous deep sand with yellow sand	crest and hillslopes	gently inclined	heath and low heath

Figure 3 Soil-landscape map at south Guilderton

(see Table 12 for description)



Discussion

Regional Variation

The species composition of most of the vegetation is related to that of vegetation in the Wilbinga and Seabird areas. The cluster analysis of the floristic data has demonstrated that the south Guilderton area fits into a pattern of regional variation in floristic composition. South Guilderton is transitional between the Lancelin to Moore River Sector and the Moore River to Quinns Rock Sector.

South Guilderton, however, contains some vegetation which appears to be different from that of most other areas south of Lancelin. These are mainly in the deflation basin with Spyridium globulosum and Allocasuarina lehmanniana common or characteristic species. The main reason for this appears to be that this is the largest mature sand sheet on the west coast south of Lancelin. Other sand sheets are less well developed and have only the very early stages of regeneration on them.

Sites from south of the Swan River and off-shore islands are consistently different from those north of the Swan River. Two sectors not previously proposed by Griffin and Trudgen (1994) are tentatively proposed; Swan River to Mandurah and Mandurah to Busselton. However, the number of sites south of the Swan River is too few to define these sectors and/or to document their characteristic vegetation. A priority should be placed on collecting data to clarity these patterns as they could have significance to planning issues in those areas.

The banks of the Moore River appear to have an association of vegetation types only present in a few places along the west coast. Neither the Swan nor Hill Rivers which truncate the Tamala limestone have the perched calcareous sand dunes adjacent to the river. Also the Moore River is the only place on the west coast with a active mobile sand sheet discharging into a river.

Foreshore protection

The issues related to foreshore protection relate to two aspects; protection of the river and river dependent communities and protection of the visual and aesthetic quality of the river. The latter aspect will not be discussed here.

Several areas adjacent to the river are vulnerable to risks of degradation which could have adverse impacts on the river and vegetation adjacent to it. Any access along the steeper parts of the river will have some adverse impacts. The most obvious are the steeper leeward slopes of the calcareous dunes, even the vegetated ones. Any subdivision of this land which resulted in clearing or the creation of tracks and firebreaks will be a source of soil erosion which will degrade the vegetation adjacent to the river. Weed species ... The area to be included in the foreshore reserve should take this potential into account.

The nutrient export risk is obvious for areas immediately adjacent to the river. However, it is much more difficult to determine the movement of ground water across the undulating surface of the Tamala Limestone.

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Dr Paul van der Moezel accompanied the visit to the proponent's property.

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Appendix 1 Dendrogram of sites

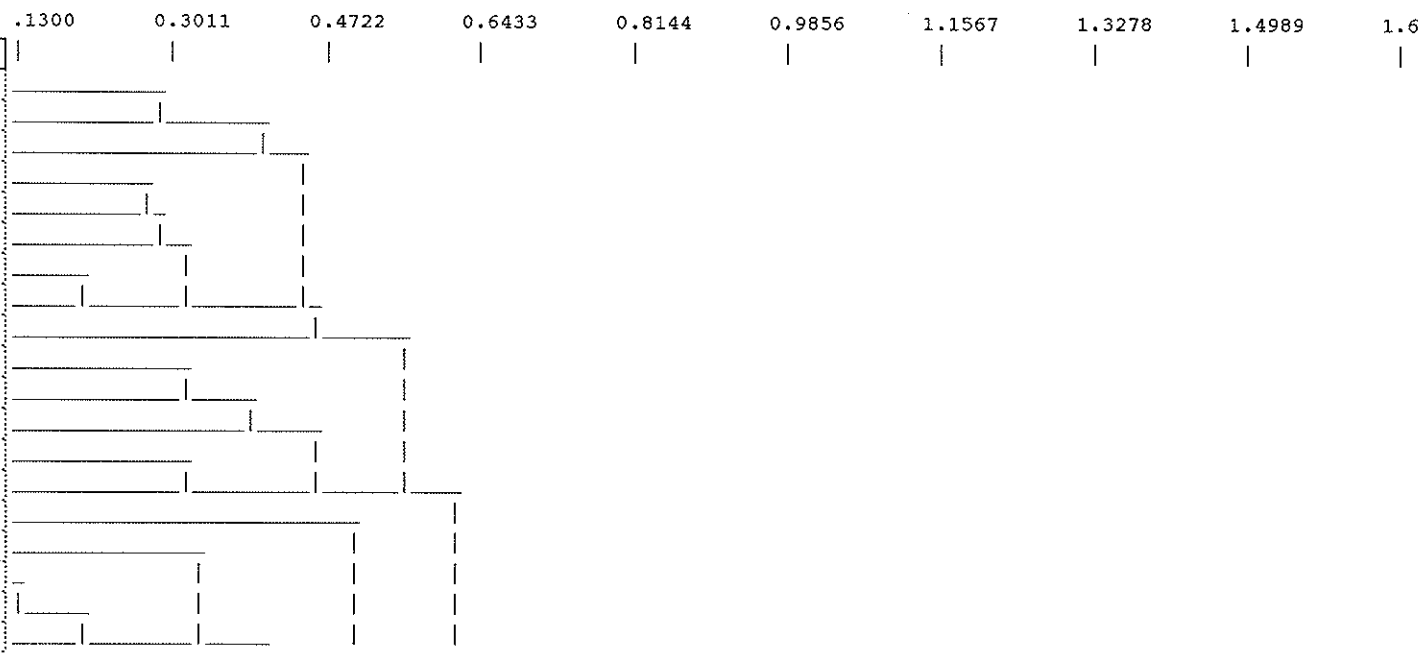
First five columns are the cluster numbers for 4 cluster levels
S- Sector (1 - 4 from Griffin and Trudgen 1994, 5 & 6 tentative sectors).

1 Lancelin to Moore River,
2 Moore River to Quinns Rock,
3 Quinns Rock to Sorrento,
4 Sorrento to Swan River
5 Swan River to Mandurah
6 Mandurah to Dunsborough

gp- group from Griffin & Trudgen (1994)
ft- floristic type of DEP (1996)

Sites on the south side of the Moore River are highlighted.
for01 to **10** are the foreshore area, **guild11** to **16** were on the recreational reserve, Guild01 to 10 were on the property of Frank Roberts to the east.

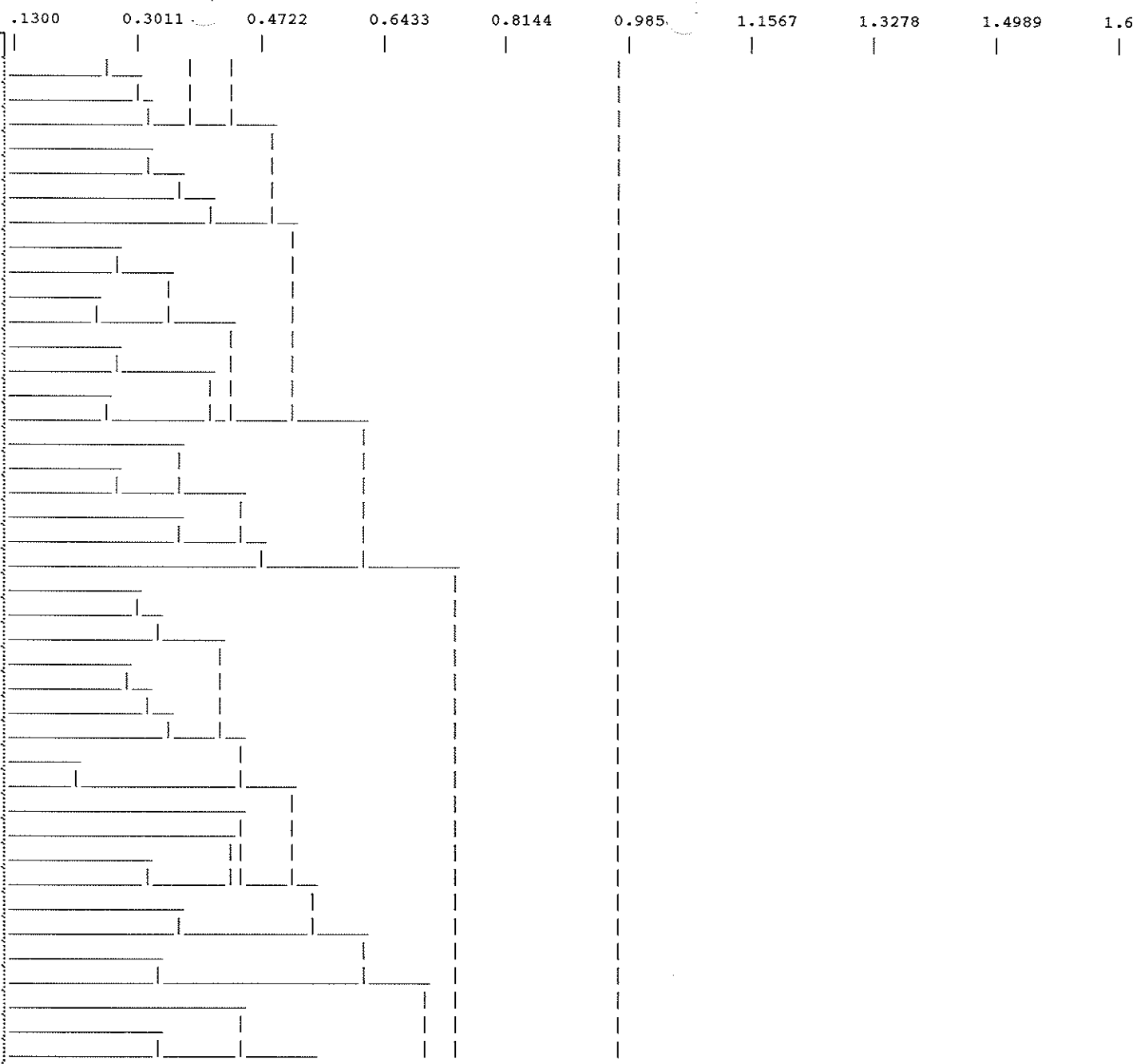
Cluster Level							
7	20	50	100	S	gp	vt	site
1	1	1	1	2	Aa		ALK01
1	1	1	1	3	Aa		BZ40
1	1	1	1	2	Aa		ALK15
1	1	1	1	2	Aa		ALK02
1	1	1	1	2	Aa		ALK06
1	1	1	1	2	Aa		ALK14
1	1	1	1	2	Aa		ALK12
1	1	1	1	2	Aa		ALK13
1	1	1	1	2	Aa		WIB27
1	1	1	1	3	Aa		BZ36
1	1	1	1	2	Aa	29a	WIB11
1	1	1	1	2	Aa		WIB02
1	1	1	1	3	Aa		BZ39
1	1	1	1	1	Aa		LS15
1	1	1	2	2	Aa	29b	WIB01
1	1	1	2	2	Aa	29b	WIB03
1	1	1	2	2	Aa		WIB04
1	1	1	2	2	Aa		WIB07
1	1	1	2	2	Aa		WIB05



Cluster Level								.1300	0.3011	0.4722	0.6433	0.8144	0.985	1.1567	1.3278	1.4989	1.6
7	20	50	100	S	gp	vt	site										
1	1	1	2	2	Aa	29b	WIB09										
1	1	1	2	2	Aa	29b	WIB12										
1	1	1	2	2	Aa		WIB13										
1	1	1	2	2	Aa		WIB23										
1	1	1	2	2	Aa		WIB26										
1	1	1	3	3	Aa		BZ08										
1	1	1	3	2	Aa		WIB18										
1	1	1	3	1	Aa		LS09										
1	1	1	3	1	Aa		PS10										
1	1	1	3	1	Aa		LS05										
1	1	1	3	1	Aa		LS06										
1	1	1	3	2	Aa		WIB16										
1	1	1	3	1	Aa		PS16										
1	1	1	3	1	Aa		MAN07										
1	1	1	3	1	Aa		PS15										
1	1	1	3	2	Aa		WIB20										
1	1	1	4	2			**for01**										
1	1	1	4	1	Aa		PS13										
1	1	1	4	2	Aa	29b	WIB10										
1	1	1	4	2	Aa		WIB15										
1	1	1	4	2	Aa		WIB14										
1	1	1	4	2	Aa		WIB17										
1	1	1	4	1	Aa		MAN08										
1	1	1	4	1	Aa		MAN10										
1	1	1	4	1	Aa		PS14										
1	1	1	4	2	Aa		WIB21										
1	1	1	5	1	Aa		BB33										
1	1	1	5	1	Aa		BB34										
1	1	1	5	1	Aa		BB35										
1	1	1	5	1	Aa		BB36										
1	1	1	5	1	Aa		BB39										
1	1	1	5	1	Aa		LS01										
1	1	1	5	1	Aa		MAN28										
1	1	1	5	1	Aa		MAN05										
1	1	1	6	1	Aa		BB37										
1	1	1	6	1	Aa		MAN18										
1	1	1	6	1	Aa		MAN15										
1	1	1	6	1	Aa		MAN01										
1	1	1	6	1	Aa		MAN14										
1	1	1	6	1	Aa		MAN22										
1	1	1	6	1	Aa		MAN04										

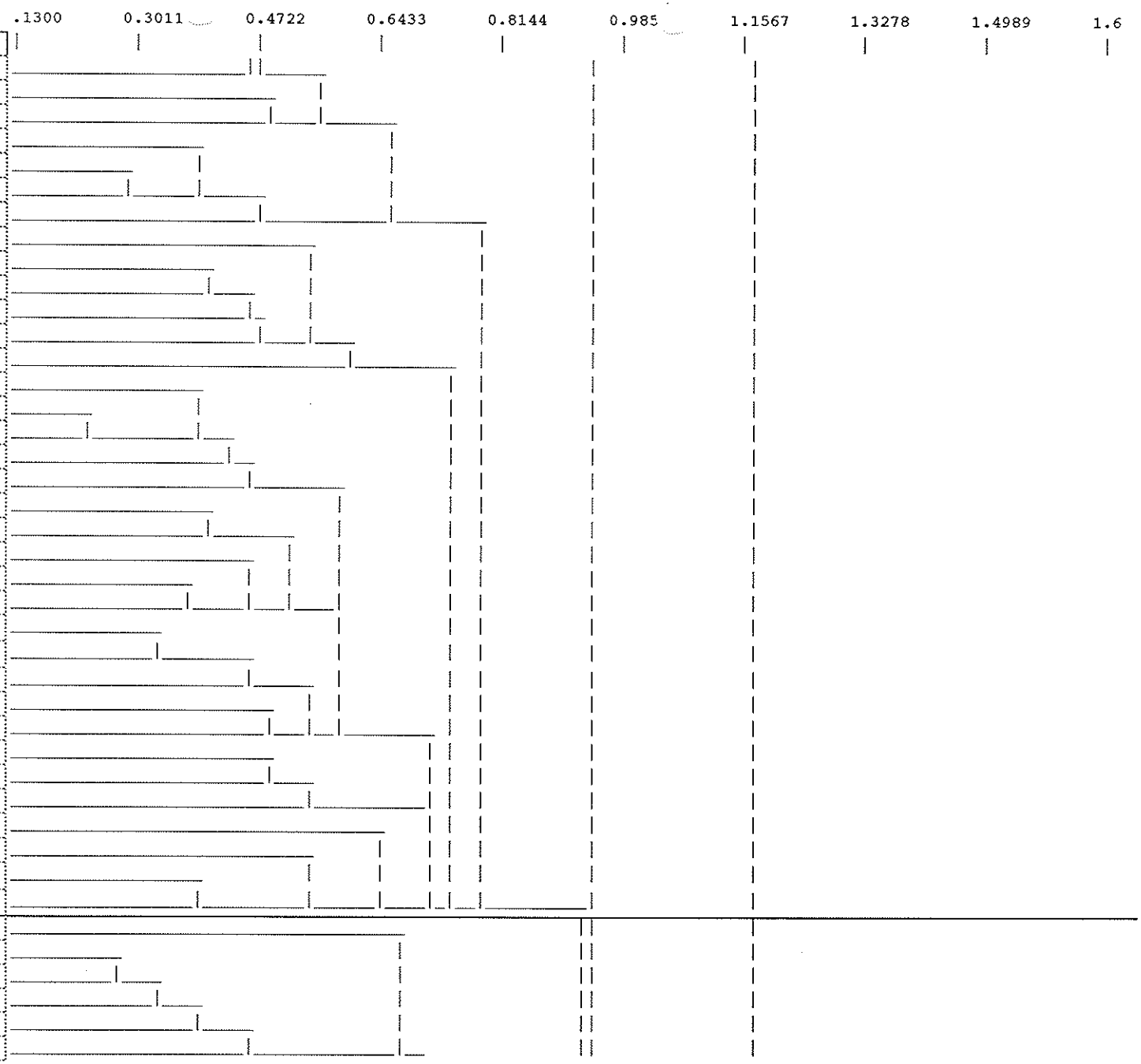
Cluster Level								.1300	0.3011	0.4722	0.6433	0.8144	0.985	1.1567	1.3278	1.4989	1.6
7	20	50	100	S	gp	vt	site										
1	1	1	6	**1**	Aa		MAN25										
1	1	1	6	**1**	Aa		PS17										
1	1	1	6	**1**	Aa		MAN17										
1	1	1	6	**1**	Aa		PS07										
1	1	1	6	**1**	Aa		MAN20										
1	1	1	6	**1**	Aa		MAN16										
1	1	1	6	**1**	Aa		MAN29										
1	1	1	6	**1**	Aa		MAN21										
1	1	1	6	**1**	Aa		LS02										
1	1	1	6	**1**	Aa		PS12										
1	1	1	6	**1**	Aa		MAN12										
1	1	1	6	**1**	Aa		PS01										
1	1	1	6	**1**	Aa		PS04										
1	1	1	6	**1**	Aa		PS03										
1	1	1	6	**1**	Aa		PS02										
1	1	1	6	**1**	Aa		MAN03										
1	1	1	6	**1**	Aa		MAN23										
1	1	1	6	**1**	Aa		MAN24										
1	1	1	6	**1**	Aa		PS08										
1	2	2	7	**1**	Bc		BB38										
1	2	2	7	**1**	Bc		PS11										
1	2	2	7	**3**	Bc		BZ33										
1	2	2	7	**2**	Bc		WIB22										
1	2	2	7	**2**			**for10**										
1	2	2	8	**1**	Bc		MAN09										
1	2	2	8	**1**	Bc		MAN11										
1	2	2	8	**1**	Bc		MAN26										
1	2	2	8	**1**	Bc		MAN13										
1	2	3	9	**1**	Bc		LS10										
1	2	3	9	**1**	Bc		MAN19										
1	2	3	10	**1**	Bc		MAN27										
1	2	3	10	**1**	Bc		PS06										
1	2	4	11	**2**			**for02**										
1	2	4	11	**2**			**for04**										
1	2	4	12	**2**			**for03**										
1	3	5	13	**2**	Ab		ALK03										
1	3	5	13	**3**	Ab		BZ21										
1	3	5	13	**2**	Ab		ALK10										
1	3	5	13	**2**	Aa		ALK04										
1	3	5	13	**4**	Ab		TR08										
1	3	5	13	**3**	Ab		BZ03										

Cluster Level							
7	20	50	100	S	gp	vt	site
1	3	5	13	3	Ab		BZ06
1	3	5	13	3	Ab		BZ04
1	3	5	13	3	Ab		BZ20
1	3	5	13	3	Ab		BZ02
1	3	5	13	2	Ab		WIB25
1	3	5	13	3	Ab		BZ05
1	3	5	13	3	Ab		BZ31
1	3	5	13	2	Ab		ALK05
1	3	5	13	2	Ab		ALK16
1	3	5	13	2	Ab		ALK07
1	3	5	13	2	Ab		ALK09
1	3	5	13	3	Ab		BZ01
1	3	5	13	3	Ab		BZ07
1	3	5	13	3	Ab		BZ32
1	3	5	13	3	Ab		MI26
1	3	5	14	3	Ab		BZ09
1	3	5	14	3	Ab		MI24
1	3	5	14	3	Ab		MI28
1	3	5	14	3	Ab		BZ34
1	3	5	14	3	Ab		MI33
1	3	5	14	3	Ab		BZ35
1	3	6	15	2	Ab		ALK08
1	3	6	15	3	Ab		BZ37
1	3	6	15	3	Ab		BZ27
1	3	6	15	3	Ab		BZ28
1	3	6	15	3	Ab		MI29
1	3	6	15	3	Ab		BZ41
1	3	6	15	3	Ab		MI31
1	3	6	15	3	Ab		MI04
1	3	6	15	3	Ab		MI05
1	3	6	15	3	Aa		BZ10
1	3	6	15	3	Ab		BZ11
1	3	6	15	3	Ab		BZ29
1	3	6	15	3	Ab		BZ30
1	3	6	15	3	Ab		BZ43
1	3	6	15	3	Ab		MI30
1	3	6	16	3	Ab		BZ26
1	3	6	16	2	Ab		WIB24
1	3	6	17	3	Ba	29b	MI01
1	3	6	17	3	Ba	29b	MI02
1	3	6	17	3	Ba	29b	MI06



Cluster Level								.1300	0.3011	0.4722	0.6433	0.8144	0.985	1.1567	1.3278	1.4989	1.6
7	20	50	100	S	gp	vt	site										
1	3	6	17	3	Ab		MI34										
1	3	6	17	6		29b	WHILL-2										
1	3	6	17	3	Ba		MI23										
1	3	6	18	3	Ab	29b	MI07										
1	3	6	18	3	Ab	29b	MI09										
1	3	6	18	3	Ab	29b	MI18										
1	3	7	19	3	Ab		BZ14										
1	3	7	20	4	Ab		TR06										
1	3	7	21	3	Ab		BZ16										
1	3	7	21	3	Ab		BZ18										
1	3	7	21	3	Ab		BZ42										
1	3	7	22	3	Ab		BZ17										
2	4	8	23	2	Ba		ALK11										
2	4	8	23	2	Ba	29b	WIB08										
2	4	9	24	1	Ba		BB18										
2	4	9	25	2			**for05**										
2	4	9	26	3	Ba		BU03										
2	4	9	26	3	Ba	29a	BU04										
2	4	10	27	1	Ba		BB16										
2	4	10	27	1	Ba		BB17										
2	4	10	28	2		29b	Guild06										
2	4	10	28	2			wilb09										
2	4	10	28	2			wilb12										
2	4	10	29	1		29a	SEAB-4										
2	4	10	29	1		29a	SEAB-5										
2	4	10	30	1		29a	SEAB-8										
2	4	10	30	2		29b	tokyu07										
2	4	11	31	3	Eb	29a	BU01										
2	4	11	31	3		29a	BURN-1										
2	4	11	31	3	Eb	29a	BU02										
2	4	11	32	3		29a	BURN-2										
2	4	12	33	5		29a	NAVB-2										
2	4	12	34	5		29a	rich02										
2	5	13	35	1	Bb		BB01										
2	5	13	35	1	Bb		BB06										
2	5	13	35	1	Bb		BB02										
2	5	13	35	1	Bb		BB05										
2	5	13	35	1	Bb		BB07										
2	5	13	35	1	Bb		BB20										
2	5	13	35	1	Bb		BB21										
2	5	13	35	1	Bb		BB11										

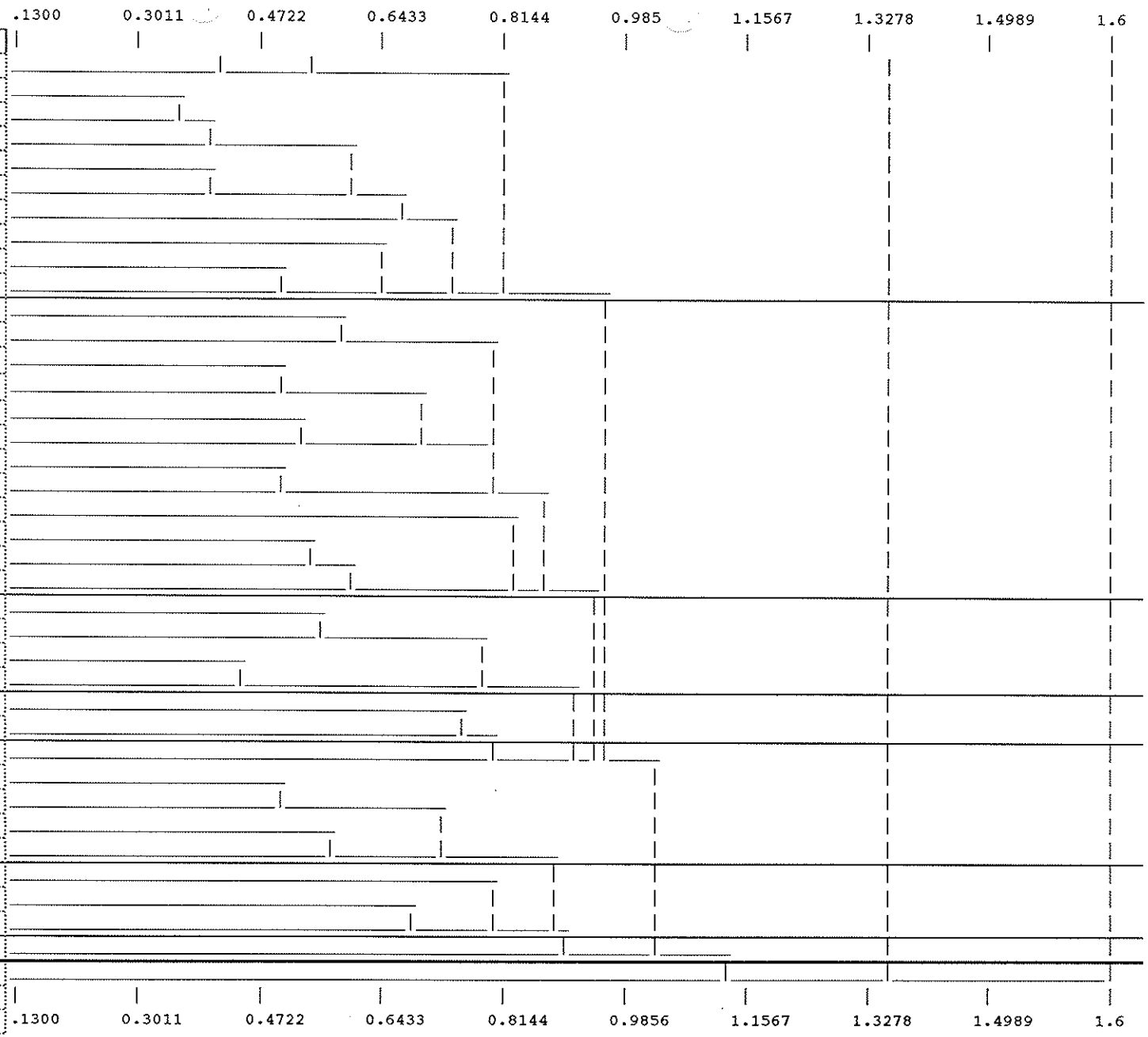
Cluster Level							
7	20	50	100	S	gp	vt	site
2	5	13	35	1	Bb		BB14
2	5	13	35	1	Bb		BB03
2	5	13	35	1	Bb		BB13
2	5	13	36	1	Bb		LP01
2	5	13	36	1	Bb		LP02
2	5	13	36	1	Bb		LP03
2	5	13	36	1	Bb		LP04
2	5	14	37	3	Ab		BZ19
2	5	14	37	5		29b	PB-2
2	5	14	37	5		29b	PB-4
2	5	14	37	5		29b	PB-5
2	5	14	37	5		29b	PB-3
2	5	14	38	3		29a	Pinn02
2	5	15	39	2		29b	Guild01
2	5	15	39	2		29b	NWIL-1
2	5	15	39	2		29b	NWIL-3
2	5	15	39	2			wilb08
2	5	15	39	2		29b	Guild03
2	5	15	40	6		29b	NPRES-1
2	5	15	40	6		29b	WHILL-1
2	5	15	40	2		29b	tokyu04
2	5	15	40	2			wilb01
2	5	15	40	2			wilb03
2	5	15	41	2			**guild11**
2	5	15	41	2			**guild12**
2	5	15	41	2		29b	tokyu06
2	5	15	41	1		29b	SEAB-2
2	5	15	41	1		29b	SEAB-3
2	5	16	42	2		29b	Guild04
2	5	16	42	2			Guild05
2	5	16	42	1		29b	SEAB-7
2	5	17	43	2		29b	Guild02
2	5	17	44	2		29b	Guild10
2	5	17	44	2			**guild13**
2	5	17	44	2			**guild15**
2	6	18	45	1	Ba		BB12
2	6	18	46	1	Ba		BB19
2	6	18	46	1	Ba		BB30
2	6	18	46	1	Ba		BB32
2	6	18	46	1	Ba		BB31
2	6	18	46	1	Ba		BB29



Cluster Level								.1300	0.3011	0.4722	0.6433	0.8144	0.985	1.1567	1.3278	1.4989	1.6
7	20	50	100	S	gp	vt	site										
2	6	18	47	3	Ba	29b*	MI03										
2	6	18	47	3	Ba		MI08										
2	7	19	48	4		s11	bold05										
2	7	19	48	4		29b	bold11										
2	7	19	48	4		29b	bold08										
2	7	19	48	4		29b	bold10										
2	7	19	49	4	Ac		SW05										
2	7	19	49	4	Ac	29b	SW06										
2	7	19	49	4	Ac	29b	SW07										
2	7	19	49	4	Ac		SW08										
2	7	19	49	4	Ac	29b	SW11										
2	7	19	49	4	Ac		SW09										
2	7	19	50	4	Ac		SW10										
2	7	20	51	4	Ac		TR07										
2	7	20	51	4		29b	TRIG-1										
2	7	21	52	4			m4601										
2	7	21	52	4			m4602										
3	8	22	53	1	C		BB04										
3	8	22	54	1	C		MAN02										
3	8	22	54	2	C		WIB06										
3	8	22	54	1	C		MAN06										
3	8	22	54	1	C		PS05										
3	8	22	55	1	C		PS09										
4	9	23	56	1	D		BB08										
4	9	23	56	3	D		MI15										
4	9	23	56	3	D		MI16										
4	9	23	56	1	D		BB25										
4	9	23	56	1	D		BB26										
4	9	23	57	3	Eb		MI20										
4	9	23	57	3	Eb	29a	MI21										
4	9	24	58	3	D		MI10										
4	9	24	59	3	D		MI19										
4	9	24	60	4	D		TR02										
4	9	25	61	3	Eb		BZ22										
4	9	25	62	1	Eb		LS07										
4	9	25	62	1	Eb		LS14										
4	9	25	62	1	Eb		LS08										
4	10	26	63	3	D		MI13										
4	10	26	63	3	D		MI14										
4	10	26	63	4	D		SW01										
4	10	26	63	4	D		TR01										

Cluster Level								.1300	0.3011	0.4722	0.6433	0.8144	0.985	1.1567	1.3278	1.4989	1.6
7	20	50	100	S	gp	vt	site										
5	11	27	64	1	Ea		BB09										
5	11	27	64	1	Ea		BB15										
5	11	27	64	1	Ea		BB10										
5	11	27	64	1	Ea		BB23										
5	11	27	64	1	Ea		BB24										
5	11	27	64	1	Ea		BB28										
5	11	27	64	1	Ea		BB22										
5	11	27	64	1	Ea		BB27										
5	11	27	65	3	Ea		BZ15										
5	11	27	65	4	Ea		SW02										
5	11	27	65	4	Ea		SW03										
5	11	27	65	4	Ea		TR03										
5	11	27	66	3	Ea		MI11										
5	11	27	66	3	Ea		MI12										
5	11	27	66	4	Ea		SW04										
5	11	27	66	3	Ea		MI22										
5	11	27	66	3	Ea		MI17										
5	11	27	67	2			wilb11										
5	11	28	68	3	Ea		BZ12										
5	11	28	68	3	Ea		BZ38										
5	11	28	68	3	Ea		MI27										
5	11	28	68	2			wilb02										
5	11	28	68	3	Ea		BZ24										
5	11	28	68	3	Ea		BZ25										
5	11	28	68	3	Ea		MI32										
5	11	28	68	2	Ea		WIB19										
5	11	28	68	3	Ea		MI25										
5	11	29	69	3	Ea		BZ13										
5	11	29	70	1	Ea		LS04										
5	11	29	70	1	Ea		LS11										
5	11	29	70	3	Ea		MI35										
5	11	29	70	1	Ea		LS12										
5	11	29	71	3	Eb		BZ23										
5	11	29	71	1	Eb		LS13										
5	11	29	71	1	Aa		LS03										
5	12	30	72	2			**for06**										
5	12	30	72	2			**for09**										
5	12	30	72	2			**for07**										
5	12	31	73	2			**guild14**										
6	13	32	74	6		29a	BMaid02										
6	13	32	74	6		29a	NMaid01										

Cluster Level							
7	20	50	100	S	gp	vt	site
6	13	32	74	6		29a	NMaid03
6	13	33	75	6		30b	LESCH-1
6	13	33	75	6		30b	LESCH-2
6	13	33	75	6		30b	LESCH-5
6	13	33	76	6		30b	LESCH-3
6	13	33	76	6		30b	LESCH-4
6	13	33	77	6		30b*	NMaid04
6	13	34	78	6		30b	PEPB-1
6	13	34	79	6		30b	Possum3
6	13	34	79	6		30b	Possum4
6	14	35	80	4		30a2	bold06
6	14	35	81	5		30a2	WOODP-1
6	14	36	82	2			**for08**
6	14	36	82	2			**guild16**
6	14	36	83	5		30a2	GARDEN-4
6	14	36	83	5		30a2	WOODP-2
6	14	37	84	4		30a2	PEPGRV-1
6	14	37	84	4		30a2	PEPGRV-2
6	14	38	85	5		29a	GARDEN-2
6	14	39	86	4	Eb		TR04
6	14	39	86	4	Eb		TR05
6	14	39	87	4			TRIG-2
6	15	40	88	2			Guild08
6	15	40	88	2			Guild09
6	15	41	89	5		30a2	MHENRY-1
6	15	41	89	5		30a2	MHENRY-2
6	16	42	90	2		30b*	pip01
6	16	43	91	1		30a2	SEAB-1
6	16	44	92	2		30a2	xyan08
6	17	45	93	5		30a1	GARDEN-1
6	17	45	93	5		30a1	GARDEN-3
6	17	46	94	5			rott01
6	17	46	95	5		29a	rott02
6	18	47	96	5			rott03
6	18	48	97	5			rott04
6	18	48	98	5			rott06
6	19	49	99	6		29a	PRES-1
7	20	50	100	2			Guild07



Appendix 2 Species by clusters at 20 cluster level

(Species present in less than 30% of any cluster have been omitted).
(Number prefix to name is 50 cluster number from classification of species.)
(Species are ordered by the dendrogram from classification of species)

	7 cluster -->	1			3	2				4		5		6							7
	20 cluster -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	# sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
	name																				
1	Diplolaena angustifolia			6		7							50		17		33				
1	Banksia prionotes												50								
1	Cassytha aurea var. hirta					5		5		21		17					33				
1	Allocasuarina lehmanniana subsp. lehmanniana		1	19		7			27	7		6	75		8						
2	Catapodium rigida							10							33						
2	Apium annuum					2		10						17	17			50	67		
2	Threlkeldia diffusa					2		14				6							67	100	
2	Sagina maritima							10										25	67		
2	Melilotus indicus							29						8		25				100	
2	Ehrharta longiflora							24	13			3		17	42	25	33			100	
2	Sonchus oleraceus	2				9		38	60			9		42	42	75			33	100	
2	Cerastium glomeratum	2		6		5		33	7					33	42	75		50			
2	Galium murale	2						19						50	42	25		75	33	100	
2	Dianella revoluta	5	3					24	40				50	25	42	50	33				
2	Eucalyptus gomphocephala	3		6					20					33	42	50	67				100
2	Eremophila glabra subsp. West Coast(T.E.H.Aplin 3401)	3	9			5		33	13					8	17			25			
2	Parietaria debilis	3				21	88	33	20			11		75	8		67	100	67	100	
2	Poranthera microphylla	2				16	13	10						25	8		33	50			
2	Clematis linearifolia	3	1	31			88	5	27			6		17	17		33				
2	Thysanotus patersonii	3				7	13	10	7			3		8	17	50		50			
2	Templetonia retusa	5	19	38	17	9		57	33			6		42	33	50					
2	Melaleuca huegelii subsp. huegelii		3	19		2	25	76					25		8						
2	Melaleuca cardiophylla	2	1	19		2	13	48				6					33				
3	Isolepis marginata	5				23	13	24	13			14		25			33		33		
3	Rhagodia baccata subsp. dioica					14		33	13			6			8		100	50	33		
3	Hydrocotyle hispidula					7		19						17			33				
3	Lobelia tenuior					14		10						50		25					
3	Triglochin trichophorum					12		5						17		25		25	33		
3	Danthonia occidentalis					35		24	7												
3	Leptorhynchos scabrus	5				33		10													
3	Leucopogon racemulosus			6		16		14					75		17						
3	Podotheca angustifolia	15	6		17	35	25	14					25		8			25			
4	Vulpia myuros var. hirsuta	34	11		50	12		33	7	14		20	25	8		25				100	
4	Lagurus ovatus	29	4			7		24	80	7		14		33	25			25	33		
4	Anagallis arvensis	42	4		17	2	13	76	60			3	25	42	25	25	33	25			
4	Romulea rosea var. australis	42	9			5		19				3		17	17						
4	Avena barbata	22						10	13			3								100	
4	Acacia saligna	19	5			14									8	25	33				
4	Diplopeltis huegelii var. huegelii		8		33	2			27												
4	Conostylis candicans subsp. candicans	2							47			9									
4	Lolium rigidum					7		10	33			3			8					100	
4	Petrorhagia velutina	3				9		14	60					8		50					

	7 cluster -->	1			3	2				4		5		6							7
	20 cluster -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	# sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
	name																				
4	Briza minor	3																	33		
4	Trifolium campestre	8			17	2										50					
4	Hypochaeris glabra	8			17	12		24	7					8		100			67		
5	Triglochin calcitrapum					21	25	10	27			3			8		33		33		
5	Schoenus grandiflorus	15	5	19	50	42	13	5	47					8	17						
5	Calandrinia corrigioloides	2				35	38	19	27			20		8			33				
5	Thysanotus arenarius	12	3			26		10	33					8	8						
5	Lechenaultia linarioides		4	13		12			33												
5	Danthonia caespitosa	27	53	13	33	7				7		3			8						
5	Poa drummondiana		19	19	33	35	13	19													
5	Scaevola thesioides subsp. thesioides	10	35	19	17	26		19					25								
5	Acacia xanthina	2	23	44		14		5				3			8						
5	Acacia pulchella var. glaberrima		16	6	83	16		10	7			6		8			33				
5	Chamelaucium uncinatum		13	6		42	38	5	13												
5	Brachyscome iberidifolia		9	25	33	44	13	5								50					
7	Schoenus brevisetis	5	16		33	2						3									
7	Leptomeria preissiana	2	1			2				21		17	50		8						
7	Acacia truncata		16		33	12		14				14									
10	Spinifex hirsutus									7	100										
10	Cakile maritima									21	100										
10	Actites megalocarpa										50										
11	Spinifex longifolius						13			36	75	23									
11	Calocephalus brownii									64	25	11									
11	Isolepis nodosa	5				2	13	14		79	25	60							33		
11	Scaevola crassifolia	2	1			7	13	24		64		77	25	8	8			25		100	
11	Tetragonia decumbens							5		36	75	37									
11	Trachyandra divaricata	2		6				14		29	50	20		50	33			75	67		
11	Lepidosperma gladiatum	24	9			9	25	5	20	29		74		42		25	67				
11	Ozothamnus cordatus	27	9			7	25		33			66		8							
11	Pelargonium capitatum	53	3			7		19	87	50	25	51			8		33				
11	Myoporum insulare	8	1	6		5	13	14		7		51			25						
11	Carpobrotus virescens	19	9			26	13	14			50	26		25							
11	Acacia cyclops	5	5			5		14		21		37	50		33	25					
11	Comesperma integerrimum	12		13		7		14				29			50						
13	Fumaria sp. scsp																		33		
13	Cardamine sp. scsp																		33		
13	Gahnia trifida																		33		100
13	Melaleuca lanceolata														8			75	67	100	
13	Callitris preissii subsp. preissii														50			50	33		
13	Solanum nigrum							5							8		33	25	33		
14	Pittosporum phylliraeoides														8		33				
14	Fumaria capreolata								13						33						
14	Asparagus asparagoides								7					8	50						
14	Euphorbia peplus							5	7						33			50	33		
14	Oxalis pes-caprae														17	50					
15	Poa porphyroclados					23		10						17		50				100	
15	Exocarpos sparteus	2			17	2			7			11	25	42							
16	Isolepis cernua					5		5											33		
16	Leucopogon australis					2			7					8	8		33				
19	Drosera erythrorhiza															50					
19	Conyza albida															50					
19	Briza maxima	5						5	27					17	8	50					

	7 cluster -->	1			3	2				4		5		6						7
	20 cluster -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	# sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
	name																				
20	Macrozamia riedlei													8		75	33				
20	Aira caryophyllea					5		10						8	8	75		25			
20	Mesomelaena pseudostygia			6	67											75					
20	Hibbertia hypericoides	2			50											75	33				
20	Ursinia anthemoides				33				13							75					
20	Sowerbaea laxiflora													8		50					
20	Urospermum picroides															50					
20	Podotheca gnaphalioides							5								50					
20	Silene gallica	2						14								50					
20	Xanthorrhoea preissii	2				5										25	33				
22	Thysanotus thyrsoideus				17												33				
22	Crassula exserta																33				
22	Eucalyptus decipiens																33				
22	Eucalyptus argutifolia																33				
23	Caladenia longicauda subsp. calcigena					2		5									33				
25	Acacia sp.													8	8				33		
25	Stellaria media					2		10						42	8					100	
25	Trachymene coerulea					2		5						33				100			
25	Microlaena stipoides	2												42	8	50	33				
25	Caladenia latifolia					7		10	7					58	25	25	67				
25	Calandrinia brevipedata	2				2			27					42	8		33	25		100	
25	Carex preissii					2	13	14						83		25			33	100	
25	Geranium retrorsum								7					58							
25	Oxalis perennans													75			33	25			
25	Dichondra repens													42					33		
25	Hibbertia cuneiformis													83							
25	Agonis flexuosa	2							13					92	8						
25	Zantedeschia aethiopica													42	8			25			
25	Eriochilus dilatatus													33		25					
26	Pterostylis aff. nana	2												33		50					
26	Diplolaena dampieri													42	8			50			
26	Guichenotia ledifolia													17				50			
26	Thysanotus manglesianus													8			33				
29	Pelargonium littorale					5								8			67				
29	Bellardia trixago					2		10						8		25				100	
29	Hydrocotyle callicarpa						50							8						100	
30	Tetragonia tetragonoides					5		5									33				
30	Daviesia divaricata				50	7															
31	Grevillea vestita					2											33				
33	Hakea ruscifolia				17																100
34	Anigozanthos humilis subsp. humilis				33	5															
36	Allocasuarina humilis				67	5										25					
36	Bossiaea eriocarpa			6	67	2															
36	Hakea trifurcata				83	2							25								
36	Petrophile serruriae	2			83	5															
36	Hakea lissocarpha			6	83	7		14													
36	Hakea prostrata	2		6	67	9								8							
36	Jacksonia stricta			6	50	2															
36	Olearia rudis				50	5															
36	Grevillea thelemanniana subsp. preissii			6	67	5		43							8						
36	Dryandra lindleyana	2		6	83	12		29									33				

	7 cluster -->	1			3	2				4		5		6							7
	20 cluster -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	# sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
	name																				
36	Dryandra sessilis var. cygnorum	3		6	83	5		33	13				50		8	75	33				
37	Bromus diandrus	29	5			51	38	67	20	7		43		25	8	25				100	
37	Crassula glomerata	56	15	6		42	13	67		36		37	25		33			25			
37	Acanthocarpus preissii	78	44	25		53	88	67	100			80	50	75	67	25	33	100	33		
37	Hardenbergia comptoniana	56	53	31	17	47	63	76	40	14		83		83	67	25	100				
37	Spyridium globulosum	64	25	63		53	63	43		36		66	100	92	100	100	100	25			
37	Olearia axillaris	69	30			37		43	73	79	25	89	50	33	17	50		25			
37	Rhagodia baccata subsp. baccata	32	22	56	17	63	88	52	13	14		66	25	92	58	25		25		100	
37	Senecio lautus	8	49	13	17	72	50	48	7	50	25	46		42	17			25			
37	Acacia rostellifera	54	11	44		28	88	19	53			31		33	33			25			
37	Calandrinia liniflora					44	50	24	7			11		25							
37	Crassula colorata	3	1	6		40	25	71	7	21		20		17	25			25		100	
37	Daucus glochidiatus	14		31	17	79	88	62	27			31		42	33	100	67	25		100	
37	Trachymene pilosa	12	3		17	70	88	57	20					67	33	100	67	50			
37	Dischisma arenarium	34	4			77	75	48	27	21		43	25	33	25	50					
37	Cassytha racemosa	3	5	19	33	35		52	33	7	25	49	50	33			33				
37	Poa poiformis	78	73	63	50	28		38		7		40	50	25	17			25			
37	Leucopogon parviflorus	42	62	13	17	44		52	20			23	50	58	33			25			
37	Stipa flavescens	69	59	88	33	98	50	86	87	7		17		58	33			100			
37	Lepidosperma angustatum	68	76	44	67	84	13	33	47			3		58	25						
37	Lomandra maritima	92	95	81	67	100	50	43	40			6			17		33				
37	Melaleuca acerosa	98	99	100	100	95	75	57	80			6			25						
37	Loxocarya aspera	90	85	75	100	95	25	71	80						8	50					
37	Conostylis candicans subsp. calcicola	73	89	81	83	84	50	33	60	29		66	75	8	33	25		25			
37	Acacia lasiocarpa var. lasiocarpa	31	82	56	17	74		19	73			6	100		17	50					
37	Phyllanthus calycinus	61	61	19	17	44	38	29	7					67	8		33	50			
37	Heliophila pusilla	29	25	19	17	58		29	40	7		6		8		75					
37	Gompholobium tomentosum	37	39	13	33	47		24	47					8							
37	Cassytha glabella	10	72	13	33	23		5				3									
37	Calothamnus quadrifidus	7	62	19	83	53	13	29	47			3									
37	Cryptandra mutila	5	37	25	17	37		10													
37	Opercularia vaginata	10	49	19	17	42		29	33			6	75	8		50					
37	Hibbertia racemosa	19	39	6	17	40			73			17									
37	Hemiandra pungens	29	63	19		47		10	60	7		49	75	33							
37	Nemcia reticulata	22	53	13	33	35		29	7	7		17	25								
37	Pimelea ferruginea	8	34			19		5				3	25								
41	Spergula sp. scps																			100	
41	Crassula sp.																			100	
41	Siloxerus sp.																			100	
41	Hydrocotyle medicaginoides																			100	
41	Ranunculus pumilio													8						100	
41	Lolium perenne	3										3								100	
42	Alyogyne huegelii var. glossulariaefolius					2											67				
42	Carex appressa																33				
42	Amyema miquelii																33				
42	Geranium solanderi																33				
42	Adriana quadripartita																33				
42	Melaleuca rhaphiophylla			6													33				100
43	Triglochin procerum																				100

	7 cluster -->	1			3	2				4		5		6							7
	20 cluster -->	3	1	2	8	5	6	4	7	9	10	11	12	13	14	15	16	17	18	19	20
	# sites -->	59	79	16	6	43	8	21	15	14	4	35	4	12	12	4	3	4	3	1	1
	name																				
43	Baumea arthrophylla																				100
43	Baumea articulata																				100
43	Baumea juncea																				100
43	Lepidosperma longitudinale																				100
44	Leucopogon sp.																33				
44	Homeria flaccida																33				
44	Banksia grandis																33				
44	Persoonia saccata																33				
44	Hibbertia subvaginata																33				
44	Stypandra glauca													8			33				
44	Carpobrotus edulis							5	7								33				
45	Jacksonia sternbergiana							5									33				
46	Angianthus sp. scps																		33		
46	Halosarcia halocnemoides																		33		
46	Halosarcia indica																		33		
5	Sarcocornia quinqueflora																		33		
46	Samolus repens																		33		100
47	Lolium sp.																		67		
47	Hydrocotyle diantha																		100		
47	Triglochin mucronatum																		67		
47	Plantago exilis																		67		
47	Triglochin minutissimum																		33		
47	Wurmbea dioica																		33		
47	Hypoxis glabella																		33		
47	Drosera stolonifera subsp. stolonifera																		33		
47	Centrolepis polygyna															25			33		

Appendix 3 Main species in Site Clusters

Constant (Most frequently occurring) species in each of the 7 and 20 Cluster Levels (values - % of sites in cluster)

7 Cluster Level

#1

Melaleuca acerosa	98
Lomandra maritima	92
Loxocarya aspera	85
Conostylis candicans subsp. calcicola	82
Poa poiformis	73
Lepidosperma angustatum	69
Stipa flavescens	65
Acacia lasiocarpa var. lasiocarpa	59
Phyllanthus calycinus	56
Acanthocarpus preissii	55
Hardenbergia comptoniana	51

20 Cluster Level

#1

Melaleuca acerosa	99
Lomandra maritima	95
Conostylis candicans subsp. calcicola	89
Loxocarya aspera	85
Acacia lasiocarpa var. lasiocarpa	82
Lepidosperma angustatum	76
Poa poiformis	73
Cassytha glabella	72
Hemiandra pungens	63
Leucopogon parviflorus	62
Calothamnus quadrifidus	62
Phyllanthus calycinus	61
Stipa flavescens	59
Danthonia caespitosa	53
Nemcia reticulata	53
Hardenbergia comptoniana	53

#2

Melaleuca acerosa	100
Stipa flavescens	88
Conostylis candicans subsp. calcicola	81
Lomandra maritima	81
Loxocarya aspera	75
Spyridium globulosum	63
Poa poiformis	63
Acacia lasiocarpa var. lasiocarpa	56
Rhagodia baccata subsp. baccata	56

#3

Melaleuca acerosa	98
Lomandra maritima	92
Loxocarya aspera	90
Acanthocarpus preissii	78
Poa poiformis	78
Conostylis candicans subsp. calcicola	73
Olearia axillaris	69
Stipa flavescens	69
Lepidosperma angustatum	68
Spyridium globulosum	64
Phyllanthus calycinus	61
Hardenbergia comptoniana	56
Crassula glomerata	56
Acacia rostellifera	54
Pelargonium capitatum	53

7 Cluster Level

#2

Stipa flavescens	88
Melaleuca acerosa	81
Loxocarya aspera	80
Lomandra maritima	71
Acanthocarpus preissii	67
Daucus glochidiatus	66
Conostylis candicans subsp. calcicola	64
Dischisma arenarium	61
Trachymene pilosa	59
Lepidosperma angustatum	58
Rhagodia baccata subsp. baccata	54
Hardenbergia comptoniana	54
Acacia lasiocarpa var. lasiocarpa	53
Senecio lautus	52

20 Cluster Level

#4

Stipa flavescens	86
Hardenbergia comptoniana	76
Melaleuca huegelii subsp. huegelii	76
Anagallis arvensis	76
Crassula colorata	71
Loxocarya aspera	71
Acanthocarpus preissii	67
Bromus diandrus	67
Crassula glomerata	67
Daucus glochidiatus	62
Melaleuca acerosa	57
Trachymene pilosa	57
Templetonia retusa	57
Cassytha racemosa	52
Leucopogon parviflorus	52
Rhagodia baccata subsp. baccata	52

#5

Lomandra maritima	100
Stipa flavescens	98
Melaleuca acerosa	95
Loxocarya aspera	95
Conostylis candicans subsp. calcicola	84
Lepidosperma angustatum	84
Daucus glochidiatus	79
Dischisma arenarium	77
Acacia lasiocarpa var. lasiocarpa	74
Senecio lautus	72
Trachymene pilosa	70
Rhagodia baccata subsp. baccata	63
Heliophila pusilla	58
Acanthocarpus preissii	53
Calothamnus quadrifidus	53
Spyridium globulosum	53
Bromus diandrus	51

#6

Rhagodia baccata subsp. baccata	88
Clematis linearifolia	88
Acanthocarpus preissii	88
Trachymene pilosa	88
Parietaria debilis	88
Daucus glochidiatus	88
Acacia rostellifera	88
Melaleuca acerosa	75
Dischisma arenarium	75
Spyridium globulosum	63
Hardenbergia comptoniana	63
Stipa flavescens	50
Conostylis candicans subsp. calcicola	50
Calandrinia liniflora	50
Hydrocotyle callicarpa	50
Lomandra maritima	50
Senecio lautus	50

#7	
Acanthocarpus preissii	100
Pelargonium capitatum	87
Stipa flavescens	87
Loxocarya aspera	80
Melaleuca acerosa	80
Lagurus ovatus	80
Acacia lasiocarpa var. lasiocarpa	73
Olearia axillaris	73
Hibbertia racemosa	73
Conostylis candicans subsp. calcicola	60
Sonchus oleraceus	60
Hemiandra pungens	60
Anagallis arvensis	60
Petrorhagia velutina	60
Acacia rostellifera	53

7 Cluster Level

#3	
Loxocarya aspera	100
Melaleuca acerosa	100
Petrophile serruriae	83
Hakea lissocarpha	83
Hakea trifurcata	83
Dryandra lindleyana	83
Calothamnus quadrifidus	83
Dryandra sessilis var. cygnorum	83
Conostylis candicans subsp. calcicola	83
Acacia pulchella var. glaberrima	83
Lepidosperma angustatum	67
Mesomelaena pseudostygia	67
Lomandra maritima	67
Bossiaea eriocarpa	67
Hakea prostrata	67
Grevillea thelemanniana subsp. preissii	67
Allocasuarina humilis	67
Olearia rudis	50
Vulpia myuros var. hirsuta	50
Daviesia divaricata	50
Schoenus grandiflorus	50
Jacksonia stricta	50
Hibbertia hypericoides	50
Poa poiformis	50

20 Cluster Level

#8	

(same as opposite)

7 Cluster Level

#4	
Olearia axillaris	67
Isolepis nodosa	67
Calocephalus brownii	55

20 Cluster Level

#9	
Olearia axillaris	79
Isolepis nodosa	79
Calocephalus brownii	64
Scaevola crassifolia	64
Senecio lautus	50
Pelargonium capitatum	50

#10	
Cakile maritima	100
Spinifex hirsutus	100
Tetragonia decumbens	75
Spinifex longifolius	75
Actites megalocarpa	50
Carpobrotus virescens	50
Trachyandra divaricata	50

7 Cluster Level

#5

Olearia axillaris	85
Acanthocarpus preissii	76
Hardenbergia comptoniana	74
Scaevola crassifolia	71
Spyridium globulosum	69
Conostylis candicans subsp. calcicola	66
Lepidosperma gladiatum	66
Rhagodia baccata subsp. baccata	61
Ozothamnus cordatus	59
Isolepis nodosa	53
Hemiandra pungens	51

20 Cluster Level

#11

Olearia axillaris	89
Hardenbergia comptoniana	83
Acanthocarpus preissii	80
Scaevola crassifolia	77
Lepidosperma gladiatum	74
Ozothamnus cordatus	66
Conostylis candicans subsp. calcicola	66
Rhagodia baccata subsp. baccata	66
Spyridium globulosum	66
Isolepis nodosa	60
Myoporum insulare	51
Pelargonium capitatum	51

#12

Spyridium globulosum	100
Acacia lasiocarpa var. lasiocarpa	100
Allocasuarina lehmanniana subsp. lehmanniana	75
Conostylis candicans subsp. calcicola	75
Opercularia vaginata	75
Hemiandra pungens	75
Leucopogon racemulosus	75
Acanthocarpus preissii	50
Dianella revoluta	50
Banksia prionotes	50
Leptomeria preissiana	50
Cassytha racemosa	50
Poa poiformis	50
Diplolaena angustifolia	50
Dryandra sessilis var. cygnorum	50
Leucopogon parviflorus	50
Olearia axillaris	50
Acacia cyclops	50

7 Cluster Level

#6

Spyridium globulosum	78
Acanthocarpus preissii	59
Hardenbergia comptoniana	56
Rhagodia baccata subsp. baccata	53
Trachymene pilosa	50

20 Cluster Level

#13

Agonis flexuosa	92
Spyridium globulosum	92
Rhagodia baccata subsp. baccata	92
Hardenbergia comptoniana	83
Carex preissii	83
Hibbertia cuneiformis	83
Acanthocarpus preissii	75
Parietaria debilis	75
Oxalis perennans	75
Phyllanthus calycinus	67
Trachymene pilosa	67
Stipa flavescens	58
Leucopogon parviflorus	58
Caladenia latifolia	58
Lepidosperma angustatum	58
Geranium retrorsum	58
Trachyandra divaricata	50
Galium murale	50
Lobelia tenuior	50

#14	
Spyridium globulosum	100
Hardenbergia comptoniana	67
Acanthocarpus preissii	67
Rhagodia baccata subsp. baccata	58
Callitris preissii subsp. preissii	50
Asparagus asparagoides	50
Comesperma integerrimum	50

#15	
Trachymene pilosa	100
Hypochaeris glabra	100
Spyridium globulosum	100
Daucus glochidiatus	100
Macrozamia riedlei	75
Aira caryophyllea	75
Ursinia anthemoides	75
Sonchus oleraceus	75
Dryandra sessilis var. cygnorum	75
Mesomelaena pseudostygia	75
Hibbertia hypericoides	75
Cerastium glomeratum	75
Heliophila pusilla	75
Silene gallica	50
Petrorhagia velutina	50
Sowerbaea laxiflora	50
Oxalis pes-caprae	50
Dianella revoluta	50
Poa porphyroclados	50
Microlaena stipoides	50
Briza maxima	50
Thysanotus patersonii	50
Drosera erythrorhiza	50
Pterostylis aff. nana	50
Trifolium campestre	50
Eucalyptus gomphocephala	50
Dischisma arenarium	50
Opercularia vaginata	50
Brachyscome iberidifolia	50
Conyza albida	50
Olearia axillaris	50
Podotheca gnaphalioides	50
Urospermum picroides	50
Acacia lasiocarpa var. lasiocarpa	50
Loxocarya aspera	50
Templetonia retusa	50

#16	
Rhagodia baccata subsp. dioica	100
Spyridium globulosum	100
Hardenbergia comptoniana	100
Trachymene pilosa	67
Daucus glochidiatus	67
Eucalyptus gomphocephala	67
Pelargonium littorale	67
Parietaria debilis	67
Caladenia latifolia	67
Lepidosperma gladiatum	67
Alyogyne huegelii var. glossulariaefolius	67

#17	
Acanthocarpus preissii	100
Trachymene coerulea	100
Parietaria debilis	100
Stipa flavescens	100
Galium murale	75
Trachyandra divaricata	75
Melaleuca lanceolata	75
Phyllanthus calycinus	50
Thysanotus patersonii	50
Cerastium glomeratum	50
Euphorbia peplus	50
Callitris preissii subsp. preissii	50
Poranthera microphylla	50
Guichenotia ledifolia	50
Apium annuum	50
Trachymene pilosa	50
Rhagodia baccata subsp. dioica	50
Diplolaena dampieri	50

#18	
Hydrocotyle diantha	100
Hypochaeris glabra	67
Plantago exilis	67
Apium annuum	67
Melaleuca lanceolata	67
Sagina maritima	67
Threlkeldia diffusa	67
Parietaria debilis	67
Trachyandra divaricata	67
Triglochin mucronatum	67
Lolium sp.	67

#19	
Calandrinia brevipedata	100
Crassula sp.	100
Siloxerus sp.	100
Vulpia myuros var. hirsuta	100
Avena barbata	100
Bromus diandrus	100
Ehrharta longiflora	100
Lolium perenne	100
Lolium rigidum	100
Poa porphyroclados	100
Carex preissii	100
Spergula sp. scps	100
Threlkeldia diffusa	100
Rhagodia baccata subsp. baccata	100
Stellaria media	100
Ranunculus pumilio	100
Crassula colorata	100
Melilotus indicus	100
Melaleuca lanceolata	100
Daucus glochidiatus	100
Hydrocotyle callicarpa	100
Hydrocotyle medicaginoides	100
Bellardia trixago	100
Galium murale	100
Scaevola crassifolia	100
Sonchus oleraceus	100
Parietaria debilis	100

7 Cluster Level

#7

Samolus repens	100
Melaleuca rhaphiophylla	100
Eucalyptus gomphocephala	100
Hakea ruscifolia	100
Lepidosperma longitudinale	100
Gahnia trifida	100
Baumea juncea	100
Baumea articulata	100
Baumea arthrophylla	100
Triglochin procerum	100

20 Cluster Level

#20

(same as opposite)

ENTERED ON GIS

Name: Southern Guilderton Environmental Assessment
Date: 11/05/2006
Capture Author: Thomas Leong

Comments:
Polygon
Created to match documented study area with high level of accuracy

Accuracy Levels:

- High = Document contained visual and or described spatial references easily copied, resulting in little or no polygon boundary errors
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- Low = Document contained little or no visual and or described spatial references, resulting in polygon boundary errors

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MOORE RIVER CO. PTY LTD

SOUTH GUILDERTON

ENVIRONMENTAL ASSESSMENT

January 1993

Alan Tingay
& Associates
environmental
scientists

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1. INTRODUCTION

The Moore River Co. Pty Ltd owns a large area of coastal land between the Moore River and southwards to Wilbinga. The north-west portion of this land has been considered for urban development by the Gingin Council in the 1992 Development Strategy and Structure Plan for the Gingin Coastal Region.

In accordance with this regional structure planning the Moore River Co. Pty Ltd plan to develop this portion of their property as urban while in the long term the whole property is being considered for urbanisation.

The purpose of this report is to provide an assessment of environmental opportunities and constraints to urbanisation of the area denoted as future urban on the property south of Moore River.

2. STUDY AREA

The study area is located in the Shire of Gingin and is bounded by the Indian Ocean to the west, the Moore River estuary to the north and pastoral and uncleared land of the same Locations to the east and south (Figure 1).

3. GINGIN COASTAL DEVELOPMENT STUDY

A development strategy and structure plan for the Gingin coastal region was published in June 1992. The preferred strategy for future planning was proposed on the basis of the region's existing characteristics , trends and key issues.

The study site was identified in the structure plan as short term and medium term Urban. Parts of the property to the south are suggested as Regional Open Space to link up with the proposed Wilbinga reserve. To the east the property is undesignated in the structure plan.

The structure plan identifies additional marine facilities which will be required with expansion of the coastal towns. The Department of Marine and Harbours are undertaking research to determine marina sites along the coastline. The structure plan document identified six potential sites from Guilderton to Lancelin with one site at Guilderton South scoring favourably with respect to preliminary favourability rating. This site is within the coastal portion of the study site for this report.

4. PHYSICAL ENVIRONMENT

4.1 Topography

The property rises steeply away from both the beach and Moore River to a series of high dunes, dune ridges and valleys. Steep slopes occur from the Moore River up to the dune crests (up to 50m AHD) along the shore.

The coastal dunes attain heights of 10m AHD near the coast and up to 30m AHD a short distance inland. In the northern section of the coast there is a large valley behind the dunes which has a low point of less than 5m AHD.

Further inland the property lies between the 10 and 60m AHD levels with several small sandy knolls or chaots rising above the general surface level. A major dune ridge extends inland from the coast near the southern part of the study area and achieves elevations of 50 - 60m AHD.

4.2 Geomorphology

The property lies on the western extent of the Swan Coastal Plain which is an undulating lowland bounded to the east by the Darling and Dandanagan Plateaus and to the west by the Indian Ocean. The property contains two of the main geomorphic features of the Swan Coastal Plain; the Quindalup Dune System and Spearwood Dune System.

The Quindalup Dune System is a Holocene landform which extends along the coast from Geographe Bay to Dongara. Within the Quindalup Dune system there is a variety of aeolian landforms developed by climatic, geomorphic and sedimentology factors as well as coastal processes, distance from strandline and vegetative cover. Large to medium scale geomorphic units which occur within the Quindalup Dune System include parabolic dunes, chaots, shore-parallel ridges, shore-transverse ridges, blowouts, undulating plains, flats and conical hill residuals.

In the study area the Quindalup Dunes extend along the whole coastline in a series of fretted parabolic dunes, chaots, a few small conical hill residuals and a large shore transverse ridge (remnant of a large parabolic dune). The inland Quindalup dunes which extend to the eastern boundary of the study area are part of a large system up to 6km inland starting at the northern end of Wilbinga up to the Moore River. The coastal dunes in places are still active with blowouts and mobile crests moving gradually inland.

The dune system fronting the sandy beach in the northern part of the property does not have any small foredunes. Instead there is a steep rise to the crest of the first dune up to 10m above the sand below. Further south a vegetated foredune has developed with a height of 2m and up to 10m wide. Immediately inland from the narrow low foredune zone the dunes again rise steeply to tall secondary dunes except in places where blowouts have proceeded inland and have broken through the shore-parallel dunes.

The Spearwood Dune System is a series of shore parallel ridges which are older (Pleistocene) than the Quindalup Dune System (Holocene). The Spearwood Dune System

has a similar distribution along the coastline as the Quindalup Dune System but is more extensive laterally from several kilometres inland to sub-marine expressions and coastal islands off-shore. Near the coastline the Spearwood Dunes are mostly overlain by the Quindalup Dunes System.

The Spearwood Dunes in the study area are mainly overprinted by shallow to deep Quindalup dunes. There are no surface expressions of the Spearwood Dunes within 300m of the coast. Further inland the Spearwood Dunes are exposed immediately east of the tall chaotic dune system in the southern and central portions of the property and in the northern section between ridges of parabolic dunes.

The Spearwood Dunes are mainly flat to gently undulating landforms with no major ridge systems on the property.

4.3 Soils

The soils of the study area consist of Safety Bay Sand (Quindalup Dune System) and Tamala Limestone (Spearwood Dune System).

The Safety Bay Sand is composed of pale cream coloured calcareous sands. Soil development is very poor ranging from no development on the youngest dunes and mobile dunes up to 50cm thick on older dunes.

Where the soil profile has been developed the topsoil consists of an organic layer over pale brown soils to 50cm depth. The older dunes may also have weakly cemented subsurface layers which occasionally outcrop on the sides of tall dunes.

The Tamala Limestone soils in the study area belong to the Cottesloe Association which are defined as consisting of exposed limestone which weathers to a siliceous brown sand. Outside the study area the sand can be up to 5m deep over the limestone but within the study area the Tamala Limestone is mainly expressed at the surface as limestone rock with only a shallow sand cover in places.

4.4 Coastal Stability

A typical requirement for the development of land immediately adjacent to the coastline is the setting aside of a Foreshore Reserve. Such reserves are required to provide recreational areas and also to provide a buffer zone between public facilities and private property and the dynamic coastal environment.

The primary physical factor in determining a suitable width for a Foreshore Reserve is the stability of the coastline. Part of the consideration of stability is the ability of the coast to remain stable given variations in physical parameters such as sea level. Characteristics such as long term accretion or erosion, seasonal variation in the sand cycle and the presence of erosion resistant rock formations are important factors that require assessment when considering the width of the Coastal Reserve. To this end the portion of coastline fronting the development area was assessed.

The geomorphology of the subject land is discussed in Section 4.2. A belt of perched dunes of the Quindalup Dune System immediately back the bare beach. These are part of an extensive system of dunes which extend further inland which are up to 20m high and consist mostly of parabolic and remnant dune formations. Dunal "bowls" or depressions and "arms" extend back from the beach generally orientated parallel to the dominant south-westerly wind direction. Some individual dunes extend thousands of metres inland having migrated over elements of the Spearwood Dune system which consists of lithified limestone (Tamala Limestone). Many of the dunes close to the beach are active and currently migrating in a north-easterly direction.

The length of the subject coastline was divided into three sections as an aid for description (Figure 2). These sections are, from south to north; a straight NW/SE orientated beach, some 2000m long, and a slight cusp extending out from the general orientation of the coastline, which has been divided into a southern and a northern section.

The section of straight beach is backed by a belt of cliffed primary dunes 10-15m above sea level. At their base is an ill defined foredune which appears to have infilled the void created by cliffing of the secondary dunes. This feature has also been slightly cliffed in places. Active small blowouts occur regularly within the secondary dunes along this portion of the coast. Neither Tamala Limestone nor beach rock was observed on the beach or within the depressions of the blowouts. It is concluded that this portion of the coast experiences some erosion during winter with seasonal accretion during summer. It appears to be stable or slightly eroding.

The southern portion of the cusp has a better defined foredune feature that extends at its maximum some 20m westwards from the primary dunes. These primary dunes show little cliffing relative to those further south. The foredune feature is cliffed at its beach face and this is most likely the result of erosion associated with storm surge. The foredune area becomes wider and more elevated further north and the cliffing becomes more dramatic. This is associated with a beach that is progressively narrower and steeper.

Limestone was not encountered within the depressions of blowouts in the secondary dunes nor along the beach. It is concluded that this portion of beach is stable and possibly undergoing some accretion. Cyclic erosion and accretion appears to be confined to the primary dune.

The northern portion of the cusp contains a similarly structured primary dune, however, this gradually decreases in extent to the north. Associated with this decrease is an increase in the incidence of cliffing in the secondary dunes. Approximately 700m from the mouth of Moore River the primary dune is absent and severe cliffing of the secondary dunes occurs. This portion of beach is oriented such that it would be fully exposed to northerly winds and seas during storm events. The presence of the Moore River would also complicate coastal dynamics with flows possibly causing cliffing of the secondary dune close to the river mouth.

No limestone was recorded along this section of coast, however, Tamala Limestone was observed in the cut through the secondary dune created by the Moore River. This is the only evidence to suggest that limestone may be at the base of the perched secondary dunes along the coast within the study area. The northern portion of the cusp to the Moore

River appears to be stable to regressing. Erosion is more pronounced immediately south of Moore River.

It is concluded that this section of coast should have in the order of a 100m Coastal Reserve as recommended in Department of Planning and Urban Development guidelines for development along stable coastlines. This may need to be wider in places where a long term pattern of erosion occurs such at near the Moore River mouth. The absence of Tamala Limestone along the coast means that there is little opportunity for reduction of the width of this Reserve.

4.5 Hydrology

The information for this section is based on a report by Rockwater Pty Ltd for the Heavy Industry Site Study for Wilbinga and Breton Bay.

Groundwater aquifers occur from the surface to several thousand metres depth in limestone and sandstone formations separated by impermeable layers of shale, siltstone and marl.

The shallow aquifer, the Tamala Limestone, consists of limestone and residual sand up to 60m depth. Further south at Yanchep and Two Rocks there is evidence of caverns and solution holes in the zone of water table fluctuation.

The study area represents the extreme north-west corner of the Gnangara groundwater mound. The groundwater generally slopes downward to the west to sea level near the coast but would also have some outlet to the north into the Moore River. Groundwater flow is estimated to be about 2400m^3/d per kilometre of coastline.

Recharge of the groundwater occurs through rainfall infiltration through the porous soil. Annual recharge over the site is estimated to be about 30% of rainfall. Water table levels fluctuate only a small amount during the year, about 10 to 30cm.

A freshwater/saltwater interface occurs at the coast where seawater underlies the fresh groundwater. At Two Rocks the saltwater wedge extends 500m inland to an eventual depth of 27m below sea level.

The deeper Leederville Formation extends to 200 and 700m below sea level and contains fresh groundwater which is recharged in the vicinity of the Gingin Scarp. A thick 100 to 200m impermeable strata prevents groundwater flow between the Tamala Limestone aquifer and the Leederville Formation.

5. BIOLOGICAL ENVIRONMENT

5.1 Vegetation

The vegetation of coastal areas between Perth and Lancelin is strongly determined by the Quindalup and Spearwood Dune soil types as well as geomorphic features and proximity to the coast.

An attempt to standardise vegetation descriptions in coastal environments north of Perth was proposed for the Yanchep area (Alan Tingay & Associates, 1992). This classification system forms the basis of the descriptions and mapping for this report.

The most basic unit for describing vegetation is the Association which is a recognisable unit of component species with particular dominants after which the association is named. The Yanchep classification system groups associations which are floristically similar into Types which can be further grouped into Alliances.

The vegetation of the study area was surveyed and described according to the above system. The main vegetation associations, types and alliances occurring in the study area are listed below. A vegetation map of the area is shown in Figure 2.

Alliance A - Young Quindalup Dune Heath.
Type A1 - Strand Vegetation
Associations - Aa *Ammophila arenaria* Grassland (Marram).
OaSI *Olearia axillaris* Open Shrubland over *Spinifex longifolius* Grassland.

Type A2 - Olearia axillaris on Q4 Sand.
Associations - OaSc *Olearia axillaris/Scaevola crassifolia* Shrubland.

Type A3 - *Acacia rostellifera/Spyridium globulosum* on Q3 sand.
Associations - AleSg *Allocasuarina lehmanniana/Spyridium globulosum* Scrub.

Alliance B - Old Quindalup Dune Heath
Type B1 - *Melaleuca acerosa/Acacia lasiocarpa* on Q2 Dunes.
Associations -

MaA1	*Melaleuca acerosa/Acacia lasiocarpa* Low Open Heath
MaA1Cu	*Melaleuca acerosa/Acacia lasiocarpa/ Chamelaucium uncinatum* Low Open Heath
MaCu	*Melaleuca acerosa/Chamelaucium uncinatum* Low Open Heath
MaCq	*Melaleuca acerosa/Calothamnus quadrifidus* Closed Heath
MaOa	*Melaleuca acerosa/Olearia axillaris* Shrubland
AleMa	*Allocasuarina lehmanniana/Melaleuca acerosa* Shrubland
ArMa	*Acacia rostellifera/Melaleuca acerosa* Closed Heath
Ar	*Acacia rostellifera* Closed Heath
SgMa	*Spyridium glodulosum/Melaleuca acerosa* Shrubland

Alliance C - Limestone Heath Types
Type C1 - *Dryandra sessilis* on Limestone Outcrops
Associations - Ds *Dryandra sessilis* Heath to Closed Heath

Type C3 - *Melaleuca huegelii* on Limestone Outcrops
Associations - Mh *Melaleuca huegelii* Low Open Heath
DsMh *Dryandra sessilis/Melaleuca huegelii* Open Heath
AtMh *Acacia truncata/Melaleuca huegelii* Heath
Mc *Melaleuca cardiophylla* Closed Scrub

Alliance D - Sand Over Limestone Vegetation
Type D1 - *Banksia attenuata* Vegetation
Assocations - Ba *Banksia attenuata* Low Woodland
BaBp *Banksia attenuata/B.prionotes* Low Woodland

Type D3 - *Eucalyptus gomphocephala* (Tuart) Vegetation
Association - EgAle *Eucalyptus gomphocephala* Woodland over *Allocasucrina lehmanniana* Shrubland

The first vegetation encountered along the coast, the strand vegetation is quite limited in extent in the study area. Where low foredunes have developed these are covered mainly in Marram Grass (*Ammophila arenaria*). Between these foredunes and the large secondary dunes a narrow section of *Olearia axillaris* Shrubland with some *Spinifex longifolius* occurs. Where there is no foredune the vegetation at the base of the first secondary dune consists mainly of *Cakile maritima.*

The seaward face and crests of the first tall secondary dune typically contain an *Olearia axillaris/Scaevola crassifolia* (OaSc) Shrubland. A narrow zone of this vegetation association occurs along the length of the coastal dunes.

Immediately inland from this OaSc vegetation these is a variety of vegetation associations belonging to the *Melaleuca acerosa/Acacia lasiocarpa* (MaA1) Type which occur typically on more stable Quindalup dunes with the beginnings of a soil profile. In the coastal areas other shrubs which can dominate with the vegetation type include *Acacia rostellifera, Olearia axillaris* and *Spyridium globulosum.* Rarely does the vegetation achieve any substantial height, being mostly a heath formation less than 2m tall.

Towards the northern portion of the study area, south of the Moore River the MaA1 Type vegetation also commonly contains an abundance of *Chamelaucium uncinatum* (Geraldton Wax). Near the top of the southern bank of the Moore River *Allocasuarina lehmanniana* occurs in large dense Scrub formations. *Allocasuarina lehmanniana/Melaleuca acerosa* Shrublands are found in the large valley east of the coastal dunes in the north-west part of the property.

The inland Quindalup dunes are dominated by MaA1 Low Open Heaths with *Calothamnus quadrifidus* and *Chamelaucium uncinatum* co-dominant in many areas.

Dryandra sessilis and *Melaleuca huegelii* vegetation Types occur where limestone soils outcrop in the inland areas. The *Melaleuca huegelii* type, often with *Acacia truncata*, occupies a more westerly distribution than the *Dryandra sessilis* Heaths.

One stand of *Melaleuca cardiophylla* Closed Scrub occurs on shallow sand over limestone near the top of the Moore River southern bank west of the sand blowout.

Where the Spearwood sand covers the limestone, *Banksia attenuata* Low Woodlands predominate. These areas are located in isolated patches of the inland area. *Banksia prionotes* is also found amongst the *B. attenuata* Woodlands in places.

Eucalyptus gomphocephala (Tuart) Woodlands with trees up to 20m tall occur in the study area mainly in one woodland west of the large sand blowout. The understorey of the Tuart Woodland consists mainly of an *Allocasuarina lehmanniana* Shrubland.

5.1.1 Vegetation Quality

The condition of the vegetation was assessed with an emphasis on the degree of disturbance and extent of weed invasion. The following condition scale was used for the assessment:

U Undisturbed - No obvious signs of damage caused by the activities of man.

SD Slightly Disturbed - Some slight signs of damage caused by the activities of man. eg. presence of non-aggressive weeds, vehicle tracks.

D Disturbed - Signs of damage caused by the activities of man including some impact on the vegetation structure such as caused by grazing, fire, logging. Non-aggressive weeds mainly, possibly with some more aggressive ones.

OD Obvious Disturbance - Obvious impacts of man such as grazing, partial clearing, frequent fires. Vegetation structure slightly altered but able to regenerate. More aggressive weeds such as Veldtgrass probably present.

SeD Severely Disturbed - Severely impacted by grazing, fire or clearing with little scope of regeneration to normal structure. Usually with a number of weed species including aggressive species.

D Degraded - Areas that are completely or almost completely without native species in the structure of the vegetation. Includes areas that are parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs.

The condition of the native vegetation in the study area ranged from Degraded areas cleared for pasture to Undisturbed. The areas of vegetation in best condition were coastal sections west of the main fence line and track. These areas contain few weeds and very few tracks. Vegetation parallel with the southern Moore River riverbanks is also good with just Slightly Disturbed condition from a higher density of tracks and greater number of non-invasive weed species.

The inland areas have largely been cleared for agriculture while islands of remnant native vegetation range from disturbed to Severely Disturbed due to the effects of grazing and prevalence of invasive weeds.

5.1.2 Conservation Values of Vegetation and Implications for Planning

The study area has a wide range of vegetation associations and types. Most of these types are common on Quindalup and Spearwood Dune Systems on the Swan Coastal Plain. While the broad types may be common, specific associations may be uncommon or poorly represented in conservation reserves. The vegetation of the Quindalup Dune System is poorly conserved between Mandurah and Lancelin except for a narrow band of the youngest Quindalup Dune types which occur within the Foreshore Reserve areas. The Spearwood Dune vegetation is better conserved in Yanchep and Neerabup National Parks for example.

Investigations in 1991 for potential sites for the Heavy Industry Site north of Perth identified the Wilbinga area to the south of the study area as containing vegetation with very high conservation values. Recent discussions between relevant Government agencies have resulted in the likelihood of retaining the Wilbinga property as a nature reserve. Wilbinga contains nearly all of the vegetation associations and types that occur within the study area.

Particular vegetation associations which have been identified elsewhere as having a high priority for conservation and which also occur in the study area include the stand of *Melaleuca cardiophylla* Scrub which is close to its southern limit of distribution and is poorly represented in conservation reserves. There is only one small stand of this association along the northern boundary close to Moore River.

The area of Tuart Woodland west of the sand sheet is an isolated pocket of Tuarts which is unusual so close to the coast north of Perth.

Vegetation types dominated by *Allocasuarina lehmanniana* are very unusual on the Swan Coastal Plain, being found in only one reserve, the Trigg Bushland Reserve.

5.2 Flora

A survey of native flora was conducted in early November for this environmental assessment. Prior to the survey, a request was made to the Department of Conservation and Land Management for information on any known Rare plant populations on or near the property and a list of potential Priority species which could occur.

No populations of rare plant species are known to occur on the property. Eleven Priority species were listed by C.A.L.M as occurring in the general district but not necessarily on the property. These are as follows:

Species	Priority Code
Chamelaucium conostigmum ms	3
Chorizema varium	1
Dryandra sclerophylla	2
Eucalyptus argutifolia	R(rare)
Eucalyptus foecunda	4
Leucopogon oliganthus	3
Olax scalariformis	3
Pericalymma floridum	2
Stylidium sp. Yalgorup	3
Tetratheca pilifera	3
Verticordia paludosa	1

A total of 117 native species were recorded from the flora survey (Appendix 1). The most represented families include Cyperaceae (5 species), Poaceae (4) and Haemodoraceae (4) for the Monocotyledons and the Proteaceae (12), Asteraceae (10) and Papilionaceae (9) for the Dicotyledons. There is a complete absence of orchid species from the list due to the timing of the survey when most orchid, and other ephemeral species, would have died back to their underground components.

The species list probably represents about 90% of the total native species present in the study area.

None of the species recorded are Declared Rare Flora or Priority Flora (C.A.L.M November, 1992).

However, three species are worthy of mention due to their poor representation in reserves or uncommon distribution. These species are as follows:

- *Allocasuarina lehmanniana*

  This species occurs on Quindalup Dunes and shallow sand over limestone and is uncommon on the Swan Coastal Plain occurring in only one reserve (Trigg Bushland Reserve). It also occurs south of Yanchep and at Wilbinga. In the study area this species occurs in large stands in the northern section.

- *Billardiera erubescens*

  This species is known from the south coast up to Wongan Hills but mainly on inland sites. It has only been recorded in the Perth coastal area near Two Rocks. At both Two Rocks and the study site this species occurs infrequently on exposed limestone vegetation (*Melaleuca huegelii* Type) close to the coast in the northern section.

- *Thomasia triphylla*

  Restricted to coastal limestone between Breton Bay and Augusta. It is near its northerly extent in the study area, where it occurs on exposed limestone (*Melaleuca huegelii* Type) close to the coast in the central portion.

5.2.1 Planning Considerations Relating to Significant Flora

While no Declared Rare Flora species were recorded and hence no statutory obligations apply, unusual species could be considered in subdivision planning. In particular the significant stands of *Allocasuarina lehmanniana* could be protected as much as possible within open space along the top of the Moore River southern riverbank. In addition a feature could be made of some or all of the Tuart grove which also has an understorey of *A. lehmanniana*.

5.3 Fauna

The information for this section is based on a report by Ninox Wildlife Consulting for the Wilbinga and Breton Bay areas. In that report, five broad habitat categories were identified. Of these habitats, the woodland communities of *Banksia* and *Eucalyptus* contained the most fauna species, especially birds. The strand communities contained the least number while the different types of sand and limestone heath communities were intermediate. Pasture and cleared areas support mainly bird species.

No rare fauna species were recorded from Wilbinga or Breton Bay. Significant habitats identified at Breton Bay were the *Acacia rostellifera* Thickets, *Melaleuca acerosa* Heath and *Melaleuca cardiophylla* Thickets. Only the *Melaleuca acerosa* Heath occurs abundantly in the study area. There are also no rocky shorelines in the study site for use by seabirds such as Cormorants.

The value of the study area as a wildlife corridor is limited due to the large amount of clearing in inland areas. The most significant feature would be the area of undisturbed coastal vegetation which could link coastal fauna habitats from Wilbinga to Moore River.

6. ENVIRONMENTAL ASSESSMENT

The physical and biological environment of the study area is typical of coastal landforms between Perth and Lancelin.

The site contains a large area of Quindalup Dunes perched over the underlying Spearwood Dune System as well as areas where the Spearwood Dune sands and limestone occur at the surface.

The native vegetation which is characteristic of these coastal soils has been cleared and fragmented to a large extent for the requirements of providing grazing land.

As a result, the site does not have a high overall conservation value. However, there are a number of features of particular interest which warrant consideration in the development of subdivision plans for the property. These features are as follows:

- *Allocasuarina lehmanniana* - dominated vegetation types which occur along the northern boundary.
- Tuart Woodland west of the sand sheet in the north-west section.
- Other restricted vegetation associations - *Melaleuca cardiophylla* Scrub.

These features should be considered for protection by retaining them as much as possible within Public Open Space or perhaps within a reserve along the southern bank of the Moore River which could be of variable width to incorporate important areas. Such a reserve would have the additional benefit of increasing the protection of the Moore River from possible pollution from residential development.

A suggested river bank reserve is shown in Figure 2 which includes the significant stands of *Allocasuarina lehmanniana*, the Tuart Woodland and the small *Melaleuca cardiophylla* Scrub.

The assessment of the coastline revealed a more or less stable coast with variable areas of slight erosion and accretion. There is no outcropping rock along the coast or within 300m of the coast. It is recommended therefore that a Foreshore Reserve width of 100m, as nominated in the Draft Coastal Planning Policy of the Department of Planning and Urban Development, be accepted. The actual surveyed boundary could vary according to topographical constraints such as alignment on the eastern side of major dune systems.

7. REFERENCES

Mappin Marjoram (1992). Development Strategy and Structure Plan for the Gingin Coastal Region. Prepared for the Gingin Shire Council.

SOUTH GUILDERTON NATIVE FLORA LIST

MONOCOTYLEDONAE

POACEAE	Poa drummondiana
	Spinifex hirsutus
	Spinifex longifolius
	Stipa flavescens
CYPERACEAE	Isolepis nodosa
	Lepidosperma angustatum
	Lepidosperma gladiatum
	Mesomelaena pseudostygia
	Schoenus grandiflorus
RESTIONACEAE	Loxocarya flexuosa
DASYPOGONACEAE	Acanthocarpus preissii
	Lomandra maritima
PHORMIACEAE	Dianella divaricata
ANTHERICACEAE	Thysanotus sparteus
	Tricoryne elatior
HAEMODORACEAE	Anigozanthos humilis
	Anigozanthos manglesii
	Conostylis candicans
	Haemodorum spicatum
IRIDACEAE	Patersonia occidentalis

DICOTYLEDONAE

CASUARINACEAE	Allocasuarina humilis
	Allocasuarina lehmanniana
PROTEACEAE	Banksia attenuata
	Banksia menziesii
	Banksia prionotes
	Conospermum stoechadis
	Dryandra nivea
	Dryandra sessilis
	Grevillea ~~thelemanniana~~ preissii
	Hakea costata
	Hakea trifurcata
	Hakea lissocarpha

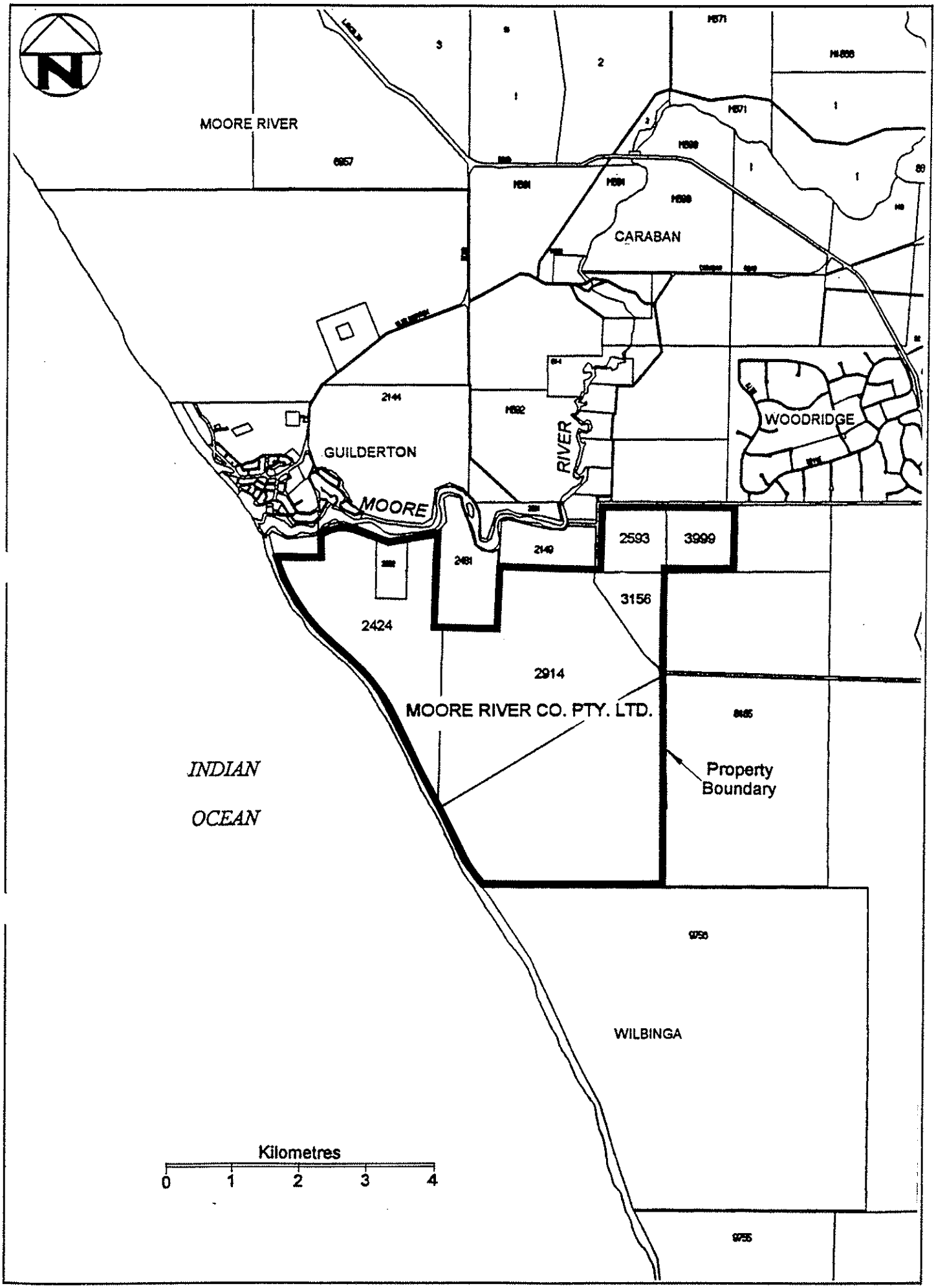
PROTEACEAE (continued)	Hakea prostrata
	Petrophile serruriae
SANTALACEAE	Leptomeria preissiana
	Santalum acuminatum
LORANTHACEAE	Nuytsia floribunda
CHENOPODIACEAE	Rhagodia baccata
	Threlkeldia diffusa
AMARANTHACEAE	Ptilotus polystachyus
GYROSTEMONACEAE	Tersonia cyathiflora
AIZOACEAE	Carpobrotus virescens
PORTULACACEAE	Calandrinia liniflora
LAURACEAE	Cassytha racemosa Cassytha flava
PITTOSPORACEAE	Billardiera erubescens
MIMOSACEAE	Acacia cochlearis
	Acacia cyclops Ac. xanthina
	Acacia lasiocarpa
	Acacia pulchella
	Acacia rostellifera
	Acacia saligna
	Acacia truncata
PAPILIONACEAE	Daviesia divaricata
	Daviesia triflora
	Gompholobium tomentosum Gomph. aristat.
	Hardenbergia comptoniana
	Jacksonia stricta
	Kennedia prostrata
	Nemcia capitata
	Nemcia reticulata
	Templetonia retusa
ZYGOPHYLLACEAE	Zygophyllum fruticulosum Zyg. simile
RUTACEAE	Diplolaena ~~drummondii~~ angusti
APOCYNACEAE	Alyxia buxifolia
POLYGALACEAE	Comesperma confertum
	Comesperma intergerrimum

EUPHORBIACEAE	Phyllanthus calycinus
STACKHOUSIACEAE	Stackhousia pubescens Tripterococcus brunonsis
RHAMNACEAE	Cryptandra mutilla Spyridium globulosum Trymalium ledifolium
STERCULIACEAE	Thomasia triphylla
DILLENIACEAE	Hibbertia racemosa Hibbertia cuneiformis Hibbertia hypericoides
VIOLACEAE	Hybanthus calycinus
THYMELEACEAE	Pimelea ferruginea Pimelea sp.
MYRTACEAE	Calothamnus quadrifidus Chamelaucium uncinatum Eucalyptus gomophocephala Melaleuca acerosa Melaleuca cardiophylla Melaleuca huegelii
APIACEAE	Trachymene pilosa
EPACRIDACEAE	Acrotriche cordata Leucopogon insularis Leucopogon parviflorus Lysinema ciliatum
LAMIACEAE	Hemiandra pungens
SOLANACEAE	Anthocercis ilicifolium Anthocercis littorea
MYOPORACEAE	Eremophila glabra Myoporum insulare
RUBIACEAE	Opercularia vaginata
LOBELIACEAE	Isotoma hypocrateriformis Lobelia tenuior

GOODENIACEAE	Lechenaultia floribunda
	Lechenaultia liniarioides
	Scaevola crassifolia
	Scaevola nitida
	Scaevola paludosa
	Scaevola thesioides
STYLIDIACEAE	Stylidium brunonianum
	Stylidium junceum
LOGANIACEAE	Logania vaginalis
ASTERACEAE	Calocephalus brownii
	Helichrysum cordatum
	Helipterum cotula
	Olearia axillaris
	Olearia rudis
	Podotheca angustifolium
	Senecio lautus
	Senecio quadridentatus
	Senecio -
	Waitzia acuminata

Lepto. scabrum

DILLENIACEAE



ALAN TINGAY & ASSOCIATES

REGIONAL LOCATION OF SOUTH GUILDERTON PROPERTY

FIGURE 1

MOORE
RIVER PTY LTD

Coal Areas Claimed

RIVER

MOORE

metres

0 500

VEGETATION TYPES
- ASSOCIATIONS

Study Area Boundary

A2 *Olearia axillaris* Vegetation on Q4 Sand

A3 -Ale *Allocasuarina lehmanniana* Scrub

B1 *Melaleuca acerosa/Acacia lasiocarpa* Vegetation on old Quindalup Dunes

-AleMa *Allocasuarina lehmanniana/ Melaleuca acerosa* Shrubland

-MaOa *Melaleuca acerosa/Olearia axillaris* Shrubland

C1 *Dryandra sessilis* on Limestone Outcrops

C3 *Melaleuca huegelii* Vegetation on limestone Outcrops

-Mc *Melaleuca cardiophylla* Closed Scrub

D1 *Banksia attenuata* Vegetation

D3 *Eucalyptus gomphocephala* (Tuart) Vegetation

Sand

Cleared or Degraded Vegetation

Proposed Areas for Reservation

INDIAN OCEAN

FIGURE 2
VEGETATION MAP OF SOUTH GUILDERTON PROPERTY SHOWING PROPOSED AREAS FOR RESERVATION

ALAN TINGAY & ASSOCIATES

ENTERED ON GIS

Name: North West Corridor Structure Plan – Yanchep Structure Plan
Date: 12/05/2006
Capture Author: Thomas Leong

Comments:
Polygon
Created to match documented study area with high level of accuracy

Accuracy Levels:

- High = Document contained visual and or described spatial references easily copied, resulting in little or no polygon boundary errors
- Acceptable = Document contained visual and or described spatial references with complex boundaries, resulting in minor boundary errors
- Low = Document contained little or no visual and or described spatial references, resulting in polygon boundary errors

Attributes
Report Info – Captured without problems
Custodial/Contact – Captured without problems
Content – Captured without problems

JANUARY 1993

S3 Attachment G

NORTH WEST CORRIDOR

STRUCTURE PLAN

DEPARTMENT OF
PLANNING AND URBAN DEVELOPMENT

PARTMENT OF CONSERVATION AND LAND MANAGEMENT

HEAD OFFICE
HACKETT DRIVE CRAWLEY
WESTERN AUSTRALIA
Phone (09) 386 8811
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STATE OPERATIONS HEADQUARTERS
50 HAYMAN ROAD COMO
WESTERN AUSTRALIA
Phone (09) 334 0333
Facsimile (09) 334 0466

Please address all correspondence to Executive Director, P.O. Box 104, COMO W.A. 6152

CONFIDENTIAL

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Your Ref:
Our Ref:
Enquiries: Mr L Mutter
Phone: 405 0728

CALM

FAXED 18/3/94 . 12.40

Chief Executive Officer
Department of Environmental Protection
Westralia Square
141 St George's Terrace
PERTH WA 6000

DEPARTMENT OF ENVIRONMENTAL PROTECTION
22 MAR 1994
File No 1 1/P/94 07 Initials GHI
File No 2 _____ Initials _____

Attention: Mr G Middle

REZONING OF SWAN LOCATIONS 2082, 2424 AND 2914 - SHIRE OF GINGIN, SOUTH OF MOORE RIVER MOUTH (SOUTH GUILDERTON)

A review of the nature conservation values of these properties which I referred to in my letter of 10 March 1994 has been completed. The review is confined to the vegetation of the area.

Vegetation Types

The area subject to the rezoning proposal is largely situated on the Quindalup Dune System with a small area of Spearwood Dune System in the south and west.

A range of vegetation types characteristic of the Quindalup Dune System are present with most of the vegetation in very good condition with little evidence of significant weed invasion. This contrasts with the general condition of vegetation on the Swan Coastal Plain.

Tingay and Associates (1993) list three unusual vegetation types in their environmental assessment of the proposal, i.e. *Allocasuarina lehmaniana* dominated scrub, Tuart woodland west of the sand sheet and *Melaleuca cardiophylla* scrub. The *Allocasuarina* and the *Melaleuca* types are rare on the coastal plain, while the Tuart is unusual in occurring on the Quindalup dunes and having suffered little weed invasion.

Significant Flora Species

Keighery (1992 - Significant species of flora of the coastal belt of the Swan Coastal Plain, Unpublished Report) lists 33 species that are restricted to Quindalup dunes or Tamala limestone. At least six of these species of conservation significance occur in the area subject to the rezoning proposal (the six species are: *Rhagodia baccata* ssp. *dioica*, *Petrolphile serruraie*, *Nemcia reticularam* (coastal form), *Trymallium albicans*, *Diplolaena angustifolia* and *Hemiandra pungens* (dune form)).

It is possible that the Declared Rare Flora species *Chorizema varium* may also occur in the vicinity of the limestone area south of the Moore River mouth.

Another species reported by Tingay and Associates as *Billardiera erubescens* is likely to be an undescribed species allied to *Billardiera ringens*. There is only one known population of this undescribed species.

74035

Nature Conservation Value

The area subject to the rezoning proposal is considered to be of high nature conservation value because of the very good condition of the vegetation, the presence of rare and unusual vegetation types, the presence of at least six flora species of conservation significance, the finding of the *Billardiera* species and the possibility of Declared Rare Flora *Chorizema varium* being present.

Reservation Status of Nature Conservation Value

Quindalup vegetation types are very poorly reserved between Lancelin and Mandurah and neither the Declared Rare Flora *Chorizema varium*, which may occur on the subject area, nor the undescribed *Billardiera* species are known to occur on any reserve. *Hemiandra pungens* (dune form) is not known to occur on any conservation reserve.

I trust the above information will assist with your consideration of the appeal(s) against the level of assessment assigned by the Environmental Protection Authority to the rezoning proposal.

Syd Shea
EXECUTIVE DIRECTOR

18 March 1994

SHERM LETTERSNEPA-1

FRIENDS OF MOORE RIVER ESTUARY & BUSHLAND
26 WALEBING WAY, GUILDERTON 6041

MEDIA RELEASE MEDIA RELEASE MEDIA RELEASE

SYSTEM SIX UPDATE - GUILDERTON REGIONAL PARK

On Wednesday, 2nd August, Conservation Council spokesperson, Associate Professor Phil Jennings will launch a proposal for the Guilderton Regional Park with the Friends of the Moore River Estuary and Bushland.

"Moore River forms the northern boundary of the System Six area: as the least contaminated river system within that region it deserves special consideration, however it is currently at grave risk from a major development. This situation must be challenged," said Phil Jennings.

"It is urgent that the Government protect this river estuary and bushland south of the river, which is in pre-settlement condition - a rare treasure," Phil Jennings said. The System Six Update, for which submissions are currently being accepted, is the perfect opportunity to assess the conservation value of this unique area.

Friends of the Moore River Estuary and Bushland was formed to develop this proposal for a Regional Park, which will include land adjacent to the ocean and the river held by the Moore River Pty. Ltd., some private blocks, and some crown reserve land, totalling 4,400 hectares.

Spokesperson for the group, Steve Hall, said that "the intention is to create a substantial green buffer zone to halt urban sprawl heading north. Guilderton Regional Park would adjoin the proposed Wilbinga National Park, which in turn links up with the existing Yanchep National Park."

It would ensure that Perth did not gradually spread right to the Moore River limit of the System Six area, which according to DPUD "offers the last and only opportunity for the creation of a coastal metropolitan regional park which would be representative of the coastal landforms and natural vegetation which has all but been eliminated in the remainder of the region."

Phil Jennings comments: "Ever since 1983, various governments and oppositions have made policies about protecting river systems and controlling urban sprawl - let them make good their promises to the people of this state.

"Many natural features of the area give it great significance as a conservation area, for example the Quindalup Dune System, which is well vegetated in this location, but poorly represented in conservation reserves, and also, the tuart woodland which is the furthest north the species is found.

He concluded that "Guilderton Regional Park is a place of outstanding natural heritage which must be protected. Action is needed now to secure the area for conservation. The Regional Park should be established to protect and manage the area so that it can be enjoyed for generations to come."

ENDS - EMBARGOED UNTIL DELIVERY, WED. 2 AUGUST, 2.30 P.M.

VENUE - Conservation Council office
79 Stirling Street
Perth

(conference room, 3rd floor)

Contacts: Phil Jennings - 360 2274
Steve Hall - 321 7033
Jo Vallentine - 272 4252

FRIENDS OF MOORE RIVER ESTUARY AND BUSHLAND

C/- 26 Walebing Way Guilderton 6041

August 2, 1995

AN OPEN LETTER TO ALL MEMBERS OF THE STATE PARLIAMENT OF WESTERN AUSTRALIA

For some months, a group of concerned citizens has been preparing a proposal for a regional park on the southern side of the Moore River. This has been undertaken, in part, as a submission to the *System 6 Update Programme*. The scope and boundaries of the System 6 Update "will include the whole of the Swan Coastal Plain south of the Moore River" (page 3, System 6 Update, Information Kit). The other reason we have prepared this now is that the Gingin Shire currently has a proposal before the Minister for Planning (Town Planning Scheme Number 8, Amendment 22). The shire's proposal is the first step towards a major development by the Moore River Company on what is probably the most sensitive part of this site.

According to the State Government's Department of Planning and Urban Development this area "offers the last and only opportunity for the creation of a coastal metropolitan regional park which would be representative of the coastal landforms and natural vegetation which has all but been eliminated in the remainder of the region" (DPUD, Yanchep Structure Plan 1993).

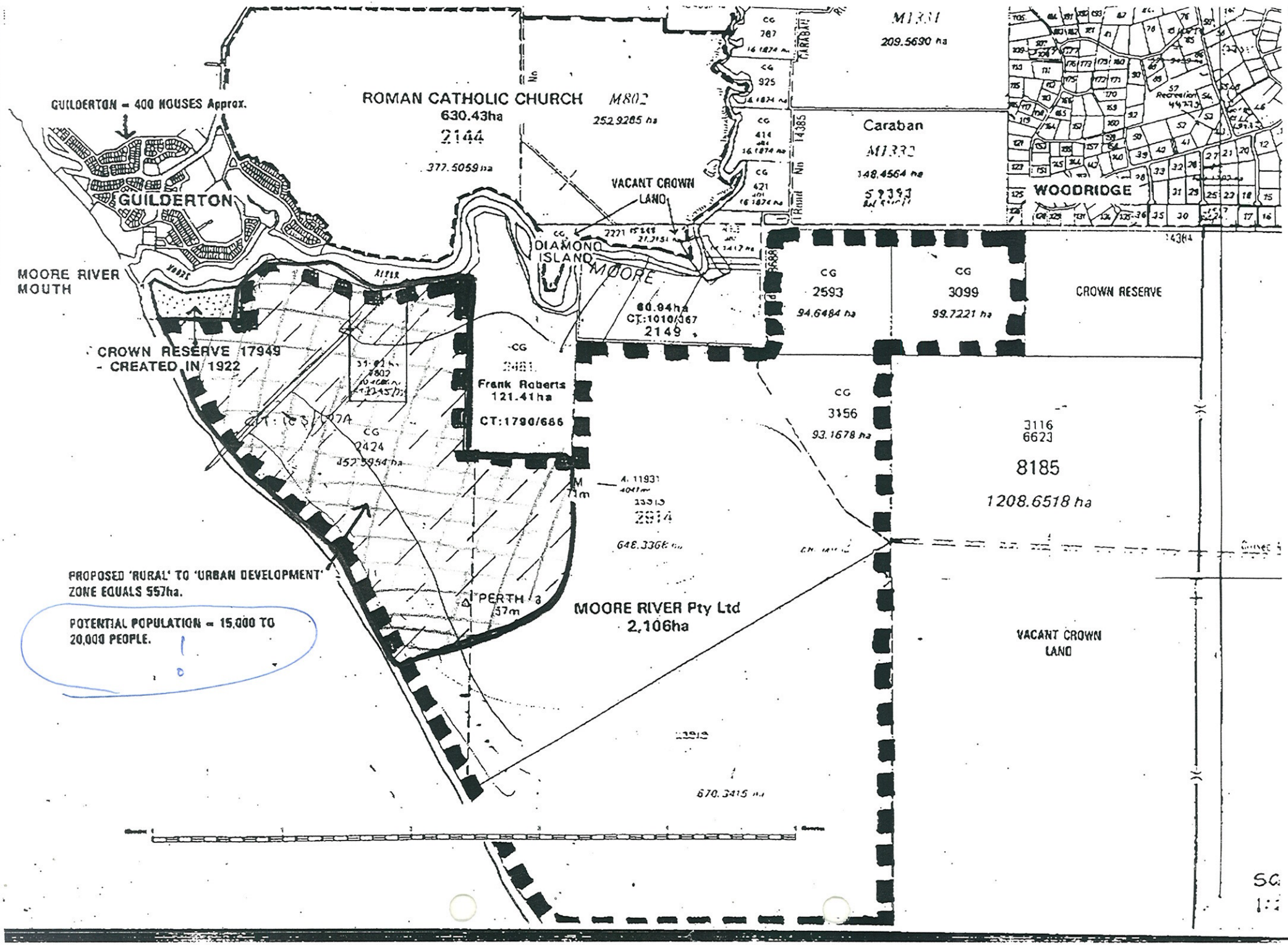
Political parties across the board have policies concerning coastal protection, river management and containing urban sprawl. It would be extremely shortsighted to let this opportunity go the way of others in the System 6 region. The area under discussion is a rare example of pre-colonial conditions combining coastal heathland, Quindalup dunes, the northernmost stand of Tuart trees and an ever-changing estuary. It warrants protection for the future generations of the people of Perth. Decisive action needs to be taken to protect this area, the attached proposal contains the blueprint and reasons for that protection. We believe that adoption of this proposal by the government would be warmly welcomed the many, many, people from all over Western Australia who have enjoyed the beauties of the Moore river area.

Please examine this proposal carefully, and, if you have any questions or would like to assist our efforts, we would be glad to hear from you.

With best wishes.

Yours sincerely

Stephen Hall	(096) 22 2908
Jo Vallentine	272 4252
Elizabeth Eaton	387 3466
Debbie Onus	577 1005



Attachment E
53

SOUTH GUILDERTON :

A Statement of Environmental Significance of Quindalup Dunes

for

Guilderton Community Association

by

E.A. Griffin

Consultant Botanist

402 Berwick St.,

St. James, 6102

Introduction

The proposal for urban development of privately owned land south of the Moore River at Guilderton has drawn criticism from some in the local community, conservation groups and others. A basic criticism relates to the perceived values of the remnant vegetation on the land. This statement provides an assessment of the values in a regional context.

Limitations

I have not visited the site. The reports and photos provided were evaluated in the context of the most recent literature available (Griffin 1993). The assessment is confined to the values of the Quindalup Dunes.

A. Geomorphology

On the west coast of W.A. the Holocene Quindalup Dunes geomorphic unit comprise beach ridge plains, foredunes and a series of parabolic dunes which have been blown away from the coast and passed over the earlier (generally) Pleistocene Spearwood dunes. The dunes right on the coast (loosely called foredunes) are probably no more than a few hundred years old and include a few currently active blowouts. The parabolic dunes range in age from about 0 to 6,000 years old. Semeniuk et. al. (1989) who divided the west coast into sectors based on different combinations of landforms, recognised one between Lancelin and Whitfords.

The South Guilderton site fits the model for this Sector. It does, however, contain one combination of landforms unique in this sector. This is the mobile sandsheet and its trailing deflation basin.

Blowouts and mobile sandsheets are not of themselves rare in this sector but there are aspects of this one which are. The South Guilderton sandsheet is of medium size and mature with its well developed trailing deflation basin. It differs substantially from ones at Manakoora and Mindarie. These are both quite young being connected with the coast. Manakoora, the youngest, has no trailing deflation basin and Mindarie only a poorly developed one. The sandsheet just north of Ledge Point has a well developed basin. It differs from South Guilderton in several regards. It is younger being in a relatively fast moving phase, the vegetation on its deflation basin is mostly very young and none of it is mature. Perhaps more importantly the geomorphic type over which they are travelling is different. The Ledge Point sandsheet is travelling over a narrow plain of weakly cemented lime sand deposited in the Holocene (cf Griffin 1993). South Guilderton is passing over the gently undulating Pleistocene Spearwood Dunes with their (in this area) shallow yellow quartz sand over kankar (limestone). The nearest sandsheets travelling over the Pleistocene limestone with a well developed deflation basin are considerably to the north in the Wannagarran Nature Reserve and Nambung National Park. These are both in the Lancelin to Dongara Sector of Seminiuk et al (1989).

McArthur and Bartle (1980) also commented that this sandsheet was unusual believing that it was the only one which did not originate from on the coast. They believed that this might have been initiated by human disturbance and/or fire. I strongly disagree with this interpretation and see direct evidence in the aerial photographs of it originating from the coast. They misinterpreted part of its deflation basin as a dune feature much older than is possible if the current sandsheet had passed over it. This feature is actually the skeletal residue (weakly cemented limesand) of an old Holocene dune over which this sandsheet has passed and stripped away the loose sand.

The exposed weakly cemented Holocene dunes is another feature unique to the South Guilderton sandsheet in this sector. No other sandsheet exposes this material. It is present in the wake of some sandsheets just north of Lancelin but rarely so north of Grey.

Finally it is unique on the West Coast being the only sandsheet which is discharging into a water body. It is this which probably maintains its west east orientation rather than south west - north east which would be expected for one on this part of the coast.

It is concluded that the South Guilderton sandsheet is a landform unique in the Lancelin to Whitfords Sector. This does not mean it is odd, just that it is the only one remaining which is typical of the processes which formed the now stabilised Quindalup dunes in this area.

B. Vegetation and Flora

The vegetation of the Quindalup Dunes in the Lancelin to Whitfords Sector is mostly low heath with patches of scrub and occasional trees. Griffin (1993) demonstrated that the floristic composition varies and can be broadly divided into five types: incipient foredunes, foredunes, young inland deflation plains, young inland dunes and older inland dunes or plains. The composition of each of these was demonstrated to vary regionally. Griffin (1993) was also able to define Sectors of the central west coast based on this regional variation in composition. Lancelin was supported as a basic division between Sectors, however, it was also considered that further divisions within the Lancelin to Whitfords Sector would be possible with further documentation.

Three landform/vegetation units are now considered:
1. foredunes and incipient foredunes,
2. young deflation plain, and
3. older dunes and plains.

1. Foredunes and Incipient Foredunes

Griffin (1993) demonstrated that there was little variation in composition of these units which could be related to regional factors. The composition of these are, therefore, likely to be quite similar to most other coastal dunes in this sector.

2. Young Deflation Plain

It follows directly from the arguments on geomorphology above that the vegetation growing on the deflation basin developed in the wake of the South Guilderton sandsheet will be unique in this Sector. This follows for even the oldest (most westerly) portion of the deflation plain which is significantly younger than the other deflated surface. (Tingay (1993) map this in their *Melaleuca acerosa/Acacia lasiocarpa* Type with vegetation on much older dunes and plains.)

To substantiate this floristic difference conclusively a detailed site based floristic survey will be required. However, what is available in the way of supporting evidence is the occurrence of *Allocasuarina lehmanniana* thickets. The only other examples of vegetation dominated by this species are in the deflation basin of the Ledge Point sandsheet and a few very small patches such as at Swanbourne. The Ledge Point stands are growing on the Holocene limestone and quite likely to have a different composition to that of the stands at South Guilderton.

The occurrence of stands of Tuart (other than the occasional plant) within the Quindalup dunes is unusual. Its presence in areas immediately after the passage of a mobile sandsheet is rare anywhere let alone in this sector. As its understorey is reputedly in excellent condition with little weed invasion, these stands are even more important.

Because the sector has a significant influence on the composition (Griffin 1993) it can be argued that the floristic composition of vegetation on the young deflation plain is likely to be unique to this Sector.

3. Older Dunes and Plains

The composition of the older dunes and plains is again sector dependant, but more so than for the younger landscapes. Within the Lancelin to Whitfords sector there is considerable areas of near natural vegetation on these older landforms, albeit almost entirely in private ownership. On this basis it would be easy to conclude that those stands at South Guilderton are not unique. However, it should be kept in mind that Griffin (1993) concluded there is significant undocumented regional variation within this sector.

In this context it is reasonable to expect that locations such as Wilbinga and Seabird have vegetation on these landforms which is similar to South Guilderton. Just how similar and South Guilderton significance could only be clarified by detailed regional site based comparisons.

Tingay (1993) presents some information but not enough to assess this. There are, however, a few points which can be made from their report. They note that the *Melaleuca acerosa/Acacia lasiocarpa* Type dominates. However, in the north and inland of South Guilderton "... Low Open Heaths with *Calothamnus quadrifidus* and *Chamelaucium uncinatum* co-dominate in many areas." They also go on to assert that "Wilbinga contains nearly all of the vegetation associations and types that occur within the study area (South Guilderton)." In relation to just one important species (*C. uncinatum*) this is not the case. There are only one or two plants of *C. uncinatum* at Wilbinga (i.e. locations 9755, 9756 & 9757). This is a species more typical of older Holocene dunes in the Seabird area.

C. Conservation Significance

It is demonstrated here, both on geomorphology and vegetation grounds, that there are areas of the South Guilderton property which are of high conservation significance. The most important portion is the mobile sandsheet and the deflation basin trailing it back to the foredunes. This is clearly unique in the Lancelin to Whitfords sector. It is possible that it is unique in all Quindalup Dunes.

Tingay (1993) recognised that some of the individual vegetation types within the deflation basin (e.g. Tuart and *Allocasuarina lehmanniana*) were of significance enough to retain them "... as much as possible within Public Open Space or perhaps a reserve along the southern bank of the Moore River ...". Unfortunately they failed to recognise the full significance of either the individual vegetation types or more importantly the whole land unit.

The reserve proposed by Tingay (1993) is very small with its largest lobe little more than 300 m wide. The Quindalup Dunes are fragile and the steep slopes along the river particularly so. These areas are also particularly vulnerable to weed invasion. The intensity of the development proposed will provide great pressure on such a small narrow area. Areas such as the Tuart woodlands will quickly revert to a grass and weed understorey rather than its relatively weed free shrub layer.

The other vegetation of the Quindalup Dunes at South Guilderton are not so significant. The foredunes are widely distributed and well represented in coastal reserves.

While the older inland dunes are also widely distributed, however, there are few reserves in this sector which conserve it. Tingay (1993) claim that the Wilbinga area is soon to be dedicated as a nature reserve. The Department of Planning and Urban Development has included Wilbinga in an area designated as Open Space. However, there have been no public statements to this regard since the time of the previous Labor government. In any case it was noted above that, on the evidence available, the composition of the vegetation at Wilbinga is not entirely equivalent to that of South Guilderton.

D. Conclusions

1. The whole of the mobile sandsheet and its trailing dune are of high conservation value and should be included in a Regional Park or even Nature Reserve.

2. The significance of the vegetation on the older dunes and plains should be assessed in a regional context by detailed site based floristic comparison before decisions to proceed with the proposed development are finalised.

References

Griffin, E.A. (1993) *Flora of the Quindalup Dunes between the Swan and Irwin Rivers*. Unpublished Report to Coastal Planning Branch, Department of Planning and Urban Development and the Heritage Council of W.A. 172pp.

McArthur, W.M. and Bartle, G.A. (1980) Landforms and Soils as an Aid to Urban Planning in the Perth Metropolitan Northwest Corridor, Western Australia. Land Resource Management Series No. 5, CSIRO, Melbourne. 14pp.

Semeniuk, V., Cresswell, I.D. and Wurm, P.A.S. (1989) The Quindalup Dunes: the regional system, physical framework and vegetation habitats. *J. Roy. Soc. West. Aust.* **71**:34-47.

Tingay, A. and Associates (1993) 'South Guilderton Environmental Assessment', unpublished report for Moore River Co. Pty. Ltd., Perth.

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.1.4 DRAINAGE

The Moore River comprises the main overland drainage route, with low summer flows being maintained by groundwater base flow. The river runs southward along much of the study area and turns westward to reach the ocean near Guilderton. The river is prevented from interchanging with the ocean for most of the year because of the sandbar which forms across its mouth. However, periodic floodings allow sufficient interchange of ocean and river water so as to preserve the biological stability of the Moore River Estuary *(Rippingale, R.J., 1988)*.

2.1.5 VEGETATION

The Quindalup vegetation complex covers up to five kilometres inland and includes salt and lime tolerant species. Near the coast, low shrubland species are sparse in places and relatively fragile. Once destroyed, erosion and soil mobility are more likely to occur *(Gozzard 1985, p.6)*. Common species include Acacias, Rottnest Island pine and Rottnest Island ti-tree. The latter is most prolific in swamp areas near Guilderton where there is a continual supply of groundwater. East of the Quindalup vegetation, the Coastal Region contains low open forest and woodland of Banksia and Eucalyptus. Many limestone outcrops sustain coastal heath species, Banksia, Sheoak and prickly bark.

It is widely believed that Plytophthora cinnamomi (Jarrah dieback) is present throughout the area of the Structure Plan and careful consideration must be made to minimize its spread.

2.1.6 SPECIAL SITES

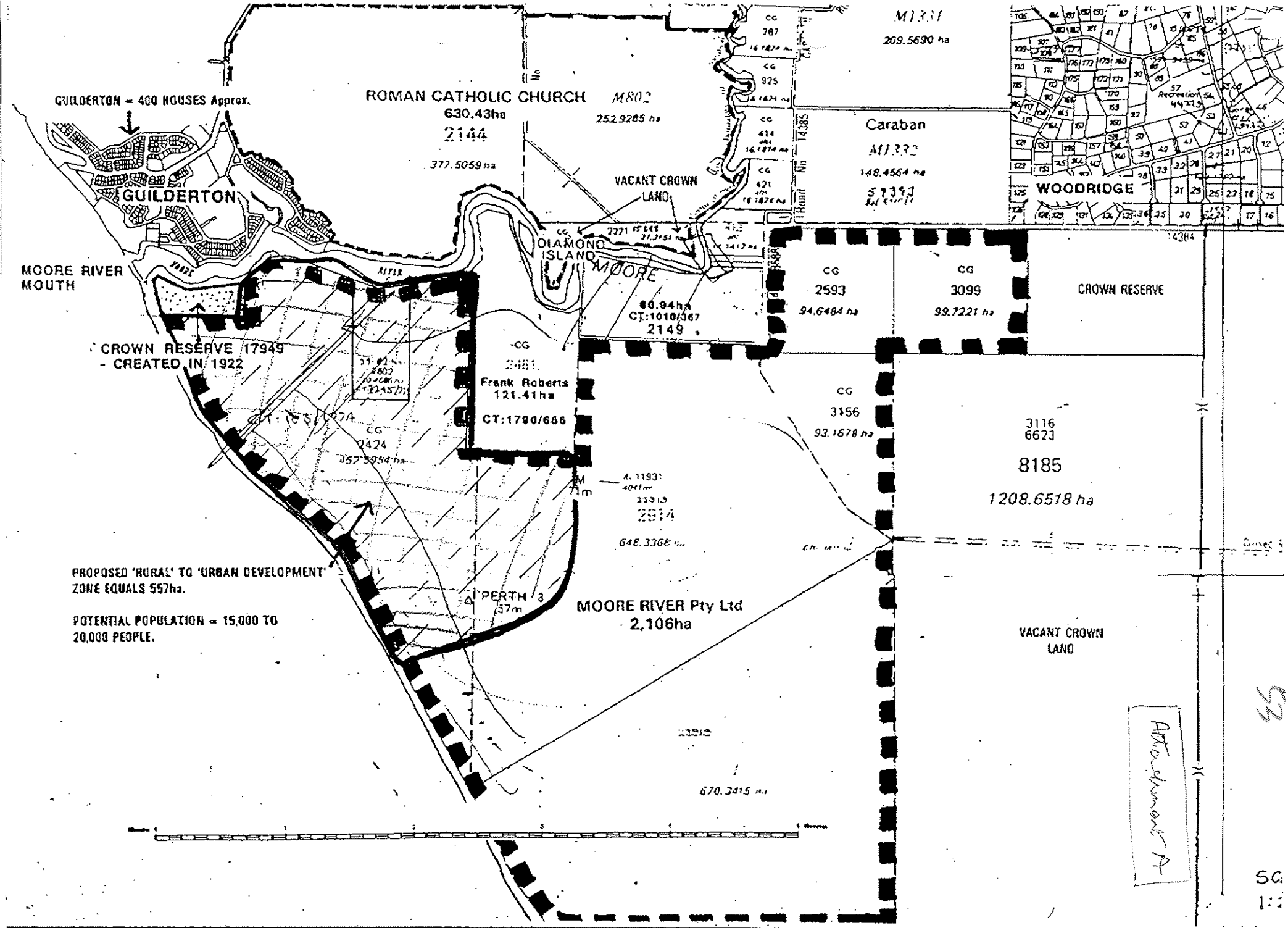
These Tuarts are on the property of Mr J Dewar and also interspersed with rare species west of the "Little Desert".

Two areas in the Coastal Region are of particular environmental significance. The first is a stretch of Tuart forest which covers some three square kilometres, along the Moore River near Guilderton. The greater supply of water along the river supports this area of exceptionally tall woodland which is believed to be the most northern significant community of Tuarts in Western Australia. The extent of this forest is displayed on the of Physical Opportunities & Constraints map, displayed later in this report.

The second area of environmental significance is the Moore River estuary itself, which forms a relatively enclosed ecosystem, vulnerable to the effects of nutrient build up and excessive recreational use *(Rippingale R.J., 1988)*.

2.1.7 WATER RESOURCES

The Coastal Region was included in a report on the geology and hydrogeology of the superficial formations between Lancelin and Guilderton *(Moncrieff and Tuckson 1989)*. Though there are no surface wetlands other than the Moore River, the area has significant reserves of good quality underground water.



53 Attachment C

WARWICK, W.A., 6024
4th February 1994

Dr Oleh Kay
Suite 6 "Guild House"
56 Kishorn Road (South)
Mount Pleasant, W.A., 6153

Dear Sir,

This is a short letter-report in response to your request on the implications of the proposed development at Guilderton as recently advertised by the Shire of Gin Gin. This letter report is organised as follows:

1. Natural environment of the "peninsula" at Guilderton,
2. Significance of the area,
3. Potential impacts of development,
4. Conclusion, and
5. References.

1. Natural environment of the "peninsula" at Guilderton

The area to the south of Guliderton that is proposed for development is a "peninsula" of land that separates the estuary of the Moore River from the Indian Ocean. The Moore River is an unusual estuary within the System Six area in that it is barred by a Holocene dune belt that forms a medium relief barrier to the river. Thus the river has been deflected northwards from its course for a short distance. The mouth of the river is sealed (barred) by low relief sand deposits that (alternatively and periodically) build up to the level of a berm or low beach ridge, and then are breached by river floods. The northward migrating barrier dune over the Holocene has stabilised and become vegetated. Because of its isolation, the dune vegetation is in good condition. The estuary leeward of the barrier is small and narrow, and comprises shallow water flats and a channel. As such it is an atypical estuary in this region between Moore River and Bunbury.

2. Significance of the area

There are two features about this area that make it regionally significant. These are:

a) the type of estuary represented by the Moore River system is unusual for the System Six area. In the System Six area there are only 4 estuaries, viz., the Swan, the Peel-Harvey, the Leschenault, and the Moore River. The first four are large, the last is relatively small. The Swan River Estuary is an inundated, meandering system that traverses Bassendean Dunes and Spearwood Dunes (there is no Holocene dune barrier); thus the estuary is a system of channels, bays, coves, and broad waters that reflect this inundated meandering pattern. The Peel-Harvey Estuary is a complex, compound barred type centered on the junction of three landforms; the main barrier is a limestone barrier. The Leschenault Estuary is a long narrow lagoon behind a high-relief barrier dune ridge. The Moore River estuary stands alone as a small, simple low-relief dune-barred system that has a beach/mouth bar at the junction with the sea.

b) the Quindalup Dunes comprising this system are of a coastal barrier type. However, they are unusal in this area regionally in that they are barring an estuary, and that their disposition in relationship to the estaury is dynamic along-shore [in contrast, the high-relief barrier of the Leschenault system is fixed in relationship to along-shore, but active in a retrograde situation]. The Quindalup Dunes here are also well vegetated, and in good condition. In the light of this, it is obvious that the Quindalup Dunes here present a good example of a once-off environment that is regionally unique (cf Semeniuk Cresswell & Wurm 1988)

3. Potential impacts of development

The potential impacts of the proposed development are manifold. Some are impacts are on unique environments, some will be on coastal procceses, some will involve water quality. The potential impacts of the proposed development are discussed as follows:

a) loss of dune system and vegetation,
b) groundwater rise and coastal erosion,
c) coastal setback,
d) water quality,
e) effect of marina.

a) The loss of dune system and its vegetation will be a major loss scientifically to this region. There are no other similar types of Quindalup Dune to estuary situations as represented at Guilderton. Other Quindalup Dune systems in this region, as described in the literature (see references), are cuspate forelands and dunes perched on limestone cliffs. This type of dune to estuary situation is not represented elsewhere. Also, such a system has yet to be explored in terms of its geological and geomorphic history, and it will provide a scientific heritage different from cuspate forelands and other coastal dunes in the region because of its location. As a corallary, the vegetation on this "peninsula" also assumes regional significance, not necesarily because of rare and endangered flora, but rather because of its relatively undisturbed nature and its location or a finger of land surrounded by marine and estuarine waters.

b) Development of the "peninsula" will likely result in groundwater perturbations insofar as the dune vegetation will be removed and the hydrologic balance will be disturbed. Where there is a rise in water table due to de-vegetation, there will be a rise in water table, which will result in coastal erosion. Although the beach in this area appears to have been long-term stable, the probability is that the proposed coastal development will initiate coastal erosion. Any extaction can result in the invasion of a saltwater wedge. This aspect of the development critically needs study.

c) There are two aspects in regards to coastal setback that need discussion: firstly, even if the coast was stable, the setback allowed in this development is insufficient in that it does not allow for unusual storm events; secondly, as discussed in (b) above, it is anticipated that the coastal will erode if the proposed development proceeds, and therefore a much wider setback must be allocated.

d) Urbanisation that is not deep sewered in a situation so close to the coast will contaminate the estuarine and marine waters with nutrient seepage, with implication on the fauna there. Even if the sites were deep-sewered, the use of fertilisers on lawns and gardens will also result in nutrient enrichment. Simply put, urbanisation too close to natural water bodies will result in enrichment of nutrients in those water bodies (e.g., the recent problems of nutrient enrichment in the Swan River estuary).

e) A marina in this setting, as proposed may have impacts on coastal sediment drift. In local areas, south of this site, dependent on oceanographic and geomorphic setting, the gross annual sediment transport can vary from as little as 5000 cubic metres to as much as 100,000 cubic metres. The transport rates in this area are unknown indetail, but it would be advisable to be cautious with regard to permtting marina development without prior investigation of regional to local sediment transport budgets.

4. Conclusion

In the light of the problems and caveats presented above, I would strongly urge that this proposed development be subject to public and scientific scrutiny via a review process. In this regard, if you wish, you may append this letter to your submission to the Environmental Protection Authority. This letter-report is necessarily brief due to time contraints with this re-zoning process, but I can provide more detail or discussions if required at a later date.

5. Selected References

Semeniuk V 1985 The age structure of a Holocene barrier dune system and its implication for sealevel history reconstructions in southwestern Australia. Marine Geology, 67: 197-212

Semeniuk V & Searle DJ 1986 The Whitfords Cusp - geomorphology, stratigraphy and age structure. JRSoc WA 68: 29-36.

Semeniuk V Searle DJ & Woods PJ 1988 Sedimentology/stratigraphy of a cuspate foreland, SW Australia. J.Coastal Res 4: 551-564.

Semeniuk V Cresswell ID & Wurm 1989 Quindalup Dunes: the regional system, physical framework and vegetation habitats. J R Soc WA 71: 23-47

Semeniuk CA & Semeniuk V 1990 Coastal landforms and peripheral wetlands of the Peel-Harvey Estuarine System. JRSoc WA 73: 9-21

Yours sincerely

Dr Vic Semeniuk

small, simple [illegible] beach/mouth bar at the junction with the sea.

Attachment D.

Moore River Pty Ltd

Land rezoned urban development

Scale: 1 km

500 metre buffer

1000 metre buffer

1500 metre buffer

Examples of buffers around the Moore River

Prepared for Guilderton Community Association Inc.
Prepared by Biospherics Pty Ltd

Copy for B. Keighery

MEMO TO: DR RAY STEEDMAN
FROM: GARRY MIDDLE
SUBJECT: GUILDERTON
DATE: Wednesday, 24 January 1996

Some notes for your talk:

1. The original proposal was referred to the EPA on 28 Jan 1994 as a proposed Amendment to the Shire of Gingin's Town Planning Scheme (Attachment 1). Level of assessment was set at Informal Review with Public Advice. Many appeals were received.
2. The significant environmental issues associated with this proposal are:
   - water quality in the Moore River Estuary - management of stormwater and disposal of effluent;
   - adequate river and ocean foreshore protection;
   - protection of other significant vegetation on the site.
3. Some of the site has been used for grazing and is either partly or totally cleared of native vegetation (Attachment 2).
4. As part of the referral the proponent, through a consultant, made some additional commitments which went part of the way in addressing the environmental issues (Attachment 3).
5. The proposal generated many appeals and Ministerials (three volumes for files!).
6. The regional importance of the vegetation is the most significant environmental issue. CALM provided advice on this matter in a letter dated 18 March 1994 (Attachment 4).
7. The CALM advice was incorporated into the EPA advice given on 6 September 1994 (Attachment 5).
8. The EPA advice commented that areas of significant vegetation identified by CALM could be incorporated into enlarged foreshore reserves (river and ocean), and that this should happen through detailed design of the development (refer also to proponent commitments).
9. At the time of writing this I am unable to trace were the proposal is at in the planning system.
10. The Friends of Moore River Estuary and Bushland are promoting the idea of a Guilderton Regional Park (Attachment 6).
11. The area has also been nominated for inclusion in the System Six update. A preliminary survey of some of the land has been carried out and early indications are that the area of vegetation likely to be of regional significance could be larger than first thought. This is only a preliminary assessment.

I hope this is helpful for you.

Gary Middle