ISSN 0729-3135
1989

Leschenault Peninsula
A Study of Land Resources and Planning Considerations

V.P.M. Oma

Resource Management Technical Report 98

Disclaimer

Acknowledgements

The completion of this study was dependant upon the contribution of several people. Phil Bourgault provided technical assistance. Richard Hulajko and Liz Sommerville drafted the Figures. The assistance of officers from the Department of Land Administrations Compilation Branch in compiling and drafting Figure 5 is gratefully acknowledged. Finally Jim Dixon, John Wise and Roger Hartley reviewed the document.

Summary

This land resource survey and land capability assessment was undertaken in order to be able to comment on the tourism development strategy for the proposed Leschenault Coastal Park discussed in the document “Draft Land Use Plans for the Leschenault Coastal Park and the Kemmerton Community Park” (South West Development Authority, 1985).

Leschenault Peninsula is a fragile coastal dune barrier north of Bunbury, Western Australia. Most of the landforms are highly, or potentially highly, unstable and are not capable of sustaining tourism uses other than walking tracks. Minor areas close to Leschenault Inlet are more stable and could be developed for a range of tourism uses including accommodation and day tripper facilities.

However much of the Peninsula is highly degraded and susceptible to wind erosion, while disposal of acid—iron rich liquid effluent from the Laporte (SCM) works in lagoons located within the dunes, has contributed to the visual degradation of the area. A land rehabilitation strategy should be developed and implemented prior to any development of the Peninsula for tourism uses.

Table Of Contents

1. Introduction 1
2. Physical Processes 3
2.1 Climate 3
2.1.1 Rainfall 3
2.1.2 Winds 3
2.1.3 Temperature 5
2.2 Coastal processes 5
2.2.1 Swell and wind waves 5
2.2.2 Littoral drift 5
2.2.3 Wave erosion 6
2.2.4 Tides 6
2.2.5 Storm surge 6
2.2.6 Flooding in the Inlet 7
3. Geology 8
4. Vegetation 10
5. Landforms and Soils of Leschenault Peninsula 11
5.1 The beach 11
5.2 Dunes 11
5.3 Sand plain 13
5.4 Estuarine terraces 13
6. Land Use and Land Degradation 15
6.1 Land use 15
6.2 Land degradation 15
7. Land Capability Analysis 18
7.1 Methodology 20
7.1.1 Land use types and their requirements 20
7.1.2 Land qualities 20
7.2 Capability rating for tourism accommodation 25
8. Land Use Planning Considerations 26
8.1 Tourism accommodation 26
8.2 Recreational use 29
8.3 Land rehabilitation 30
9. References 31

List of Figures

Figure 1. Location map of Leschenault Peninsula. 2
Figure 2. Climatic data for Bunbury, Western Australia. 4
Figure 3. Idealized geological cross section of the study area and the hinterland 9
Figure 4. Leschenault Peninsula: land resources (In the folder on the back cover)
Figure 5. Development of blowouts at Leschenault Peninsula. 17

Tables

Table I. Generalized land capability classes. 19
Table II. Land qualities important for the study area. 22
Table III. Summary table - The mapping units and their land quality values. 24
Table IV. Capability rating for tourism accommodation. 27
Appendix I. Land quality assessment tables. 33
Appendix II. Capability rating table for tourist accommodation. 39

1. Introduction

This resource survey was undertaken as a basis to comment on the proposed Leschenault Coastal Park discussed in the document “Draft Land Use Plans for the Leschenault Coastal Park and the Kemmerton Community Park” (South West Development Authority, November 1985). This document proposed that the Peninsula should be rehabilitated and developed for various tourism uses including day tripper facilities and a range of accommodation types (camping, chalets and a hotel).

Leschenault Peninsula is a coastal barrier separating Leschenault Inlet from the Indian Ocean and occurs north of the Cut at Bunbury (Figure 1). The Peninsula is approximately 11 km long and 0.7 km to 1.5 km wide, and has a total area of approximately 11,000 ha.

The survey is based on interpretation of aerial photographs at a scale of 1:25,000. The map was produced by transferring line work from the aerial photographs onto a Department of Land Administration 1:25,000 base map. Field work was undertaken during 1984/85 and included an assessment of landforms, soils, slope, aspect, vegetation cover and type, and existing land degradation. Previous studies of the geomorphology and vegetation of the Peninsula were also used to determine the mapping units in this study.

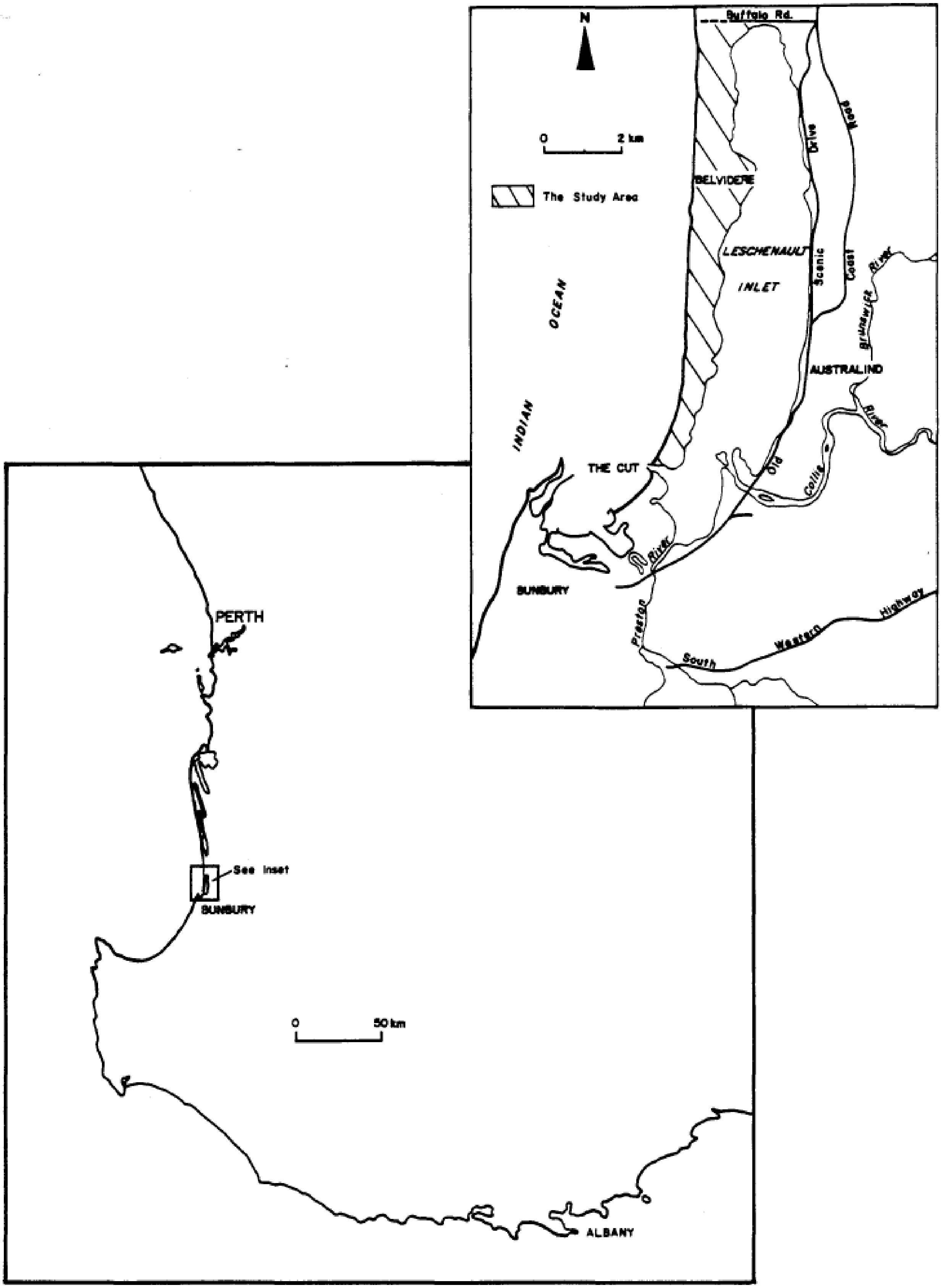


Figure 1. Location Map of Leschenault Peninsula

2. Physical Processes

The climate of the Peninsula, and the coastal processes to which it is subjected, strongly influence the characteristics of the landforms and their susceptibilities to erosion. For this reason, the climate and coastal processes are discussed here in some detail.

2.1 Climate

Climatic data was obtained from the Bunbury Meteorological Station. This station (3 km south of the southern boundary of the study area) is located relatively close to the coast and should compare closely with the climate of the Peninsula.

The climate of Leschenault Peninsula is controlled by the eastwards passage of anticyclones and associated troughs. It is characterized as Mediterranean, with hot, dry summers and mild, wet winters (Gentilli, 1971).

2.1.1 Rainfall

The mean annual rainfall of 871 mm falls mainly between May and September, (79% of total rainfall), with a maximum in June (183 mm) (Figure 2). The majority of the winter rainfall is associated with fronts which pass through the study area on average 3-4 times per month. Very little rainfall occurs in summer, but in some years there are heavy falls associated with low pressure troughs originating from the tropics. This rainfall pattern is reflected in the number of rain days (averaging 119 days per year), which vary from 2 days in January to 20 days in July (Figure 2).

2.1.2 Winds

Winds in the study area are determined by the superimposition of local land/sea breezes on the wind pattern associated with the travelling anticyclones. In summer the prevailing winds are generally moderate south-easterly and easterly land breezes in the morning, changing to moderate south-westerly and westerly sea breezes in the afternoon (Figure 2). Winter is characterized by very variable winds in the morning and moderate to strong north-westerly to south-westerly winds in the afternoon. Frontal storms are characteristic of the climate of the study area during winter. On average, 2-4 severe storms occur each winter, with minor storms occurring every two weeks. These storms may lash the Peninsula for several days, bringing heavy rainfall and strong, squally onshore winds. These fronts are generally too far south and too weak to affect the area in summer.

2.1.3 Temperature

The mean daily maximum temperature varies from 8.5°C in July to 27.7°C in February. It very rarely exceeds 35°C, because of the moderating influence of the sea breeze. However, extreme temperatures may persist for several days due to advection of hot, northerly air southwards, associated with low pressure troughs between successive anticyclones. Temperatures below 5°C rarely occur and the area is generally frost-free (Figure 2).

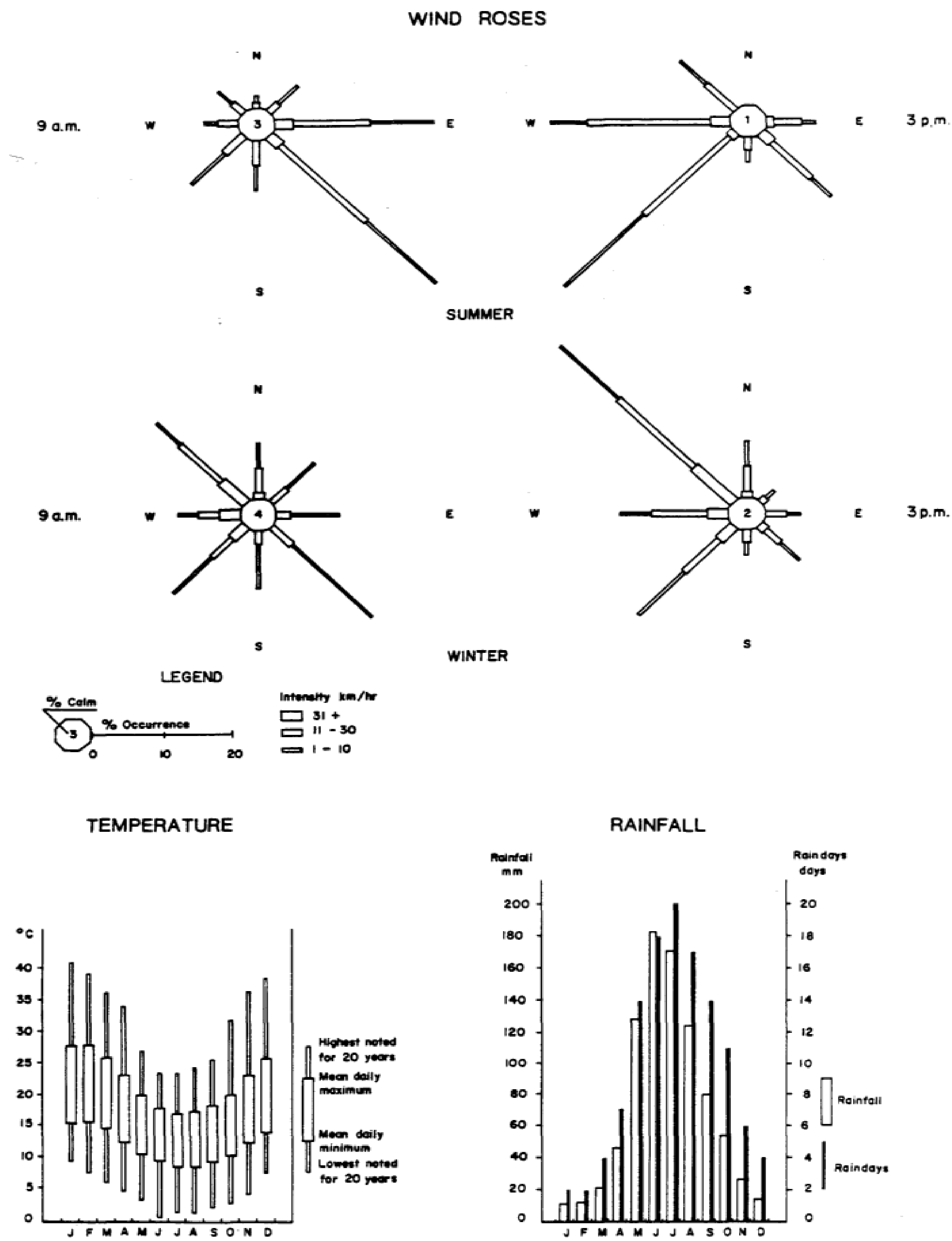


Figure 2. Climatic Data for Bunbury W.A.

2.2 Coastal Processes

The coastal processes operating along the coast in the vicinity of Bunbury and Leschenault Peninsula have been investigated by the (then) Department of Public works as a result of development proposals in the area. The wave climate and the tidal regime are important factors which characterize the wave erosion occurring along the Leschenault coast.

2.2.1 Swell and wind waves

The wave energy reaching the coast at any time is determined by the direction and relative dominance of swell and wind waves.

Swells are long period waves generated in the region of the “roaring forties” and arrive at the coast from the south—west and west. Wind waves are variable, short period waves generated locally by the prevailing winds and may therefore arrive from the south—west, west to north—west. Sea breezes generally reinforce incoming swells, by increasing their amplitude and erosive capacity as they dissipate on the beach, whereas land breezes tend to dampen the swells.

2.2.2 Littoral drift

The swell wave fronts are generally oriented at an angle to the coast and therefore generate along-shore currents in the littoral zone. These littoral currents result in the movement of sand (termed littoral drift) in the near-shore zone. If there is insufficient sand in the near-shore zone, or the drift is interrupted because of barriers such as groynes in the near-shore zone, than erosion of sandy beaches and landforms is likely to occur. In the study area the drift is northwards in winter, but temporarily reverses in summer due to the influence of the north-westerly wind waves. The PWD (1978) calculated that, at Bunbury, some 90,000 m^3 drifts northwards while temporary reversals (due to the influence of north westerly winds waves generated during storms) results in 20,000 m^3 drifting southwards. The nett annual littoral drift at Bunbury, and it is reasonable to assume also for the Leschenault Peninsula (Siragusa, personal communication), is 70,000 m^3 of sand moving northwards. This volume indicates that the littoral currents in the study area are strong and therefore any modification to the littoral currents and littoral drift (by locating groynes and other man-made features in the near-shore zone) is likely to exacerbate the wave erosion problem along the Leschenault coast.

2.2.3 Wave erosion

Department of Marine and Harbours Coastline Movement maps indicate that between 1955 and 1982, the average annual recession rate south of Belvidere was approximately 1 m, but was between 0.5 m and 1 m north of Belvidere. In addition, minor sections of the coast north of Belvidere accreted or remained stable, whereas the whole of the coastline to the south eroded over that time.

An explanation for the higher rate of erosion along the coast south of Belvidere may be that this section of the coast is continuing to adjust to changes in the littoral currents which have occurred as a result of modifications to Bunbury Harbour.

Although coastal recession has been quantitatively assessed only since 1955, it is evident from the geomorphology of the Peninsula that, in a qualitative sense, coastal recession has been the dominant process occurring probably over the last 2000—3000 years. This study has determined a 100 year coastal erosion line (based on the coastal recession which could be expected within 100 years) for land use planning purposes.

2.2.4 Tides

Tidal information is available from the Department of Marine and Harbours for the coast at Bunbury and is also applicable to the ocean coast at Leschenault Peninsula. Tidal characteristics within the Inlet are similar to those of the Bunbury coast but the tidal range is reduced. The maximum tides are slightly lower than the levels at the open coast, while minimum tides tend to be significantly lower (Wallace, personal communication). This difference in response compared to ocean tidal levels is due to the greater restriction of tidal flow through the Cut during low tide compared to high tide.

The mean daily high tide within the Inlet varies between 0.3 m and 0.45 m AND, while the mean daily low tide is 0.3 m to 0.4 m below AND.

2.2.5 Storm surge

An assessment of storm surge has been undertaken for the coast at Bunbury (PWD, 1980) and the results are also applicable for the Leschenault Peninsula.

Storm surges on the order of 0.5-1.0 m height may be expected as a result of any normal winter storm. The 100 year storm surge level is predicted to be 1.76 AHD, based both on modeling and from observations of the impact of cyclone Alby. These surges are sufficient to reach high up the beach berm and attack the foredunes and, where foredunes are not established because of continued erosion (south of Belvidere), these surges may attack the base of the parabolic dunes.

2.2.6 Flooding in the Inlet

The Collie and the Preston Rivers discharge into the Inlet at its southern end. Peak flows (generally during winter) result in the whole Inlet being subject to flooding, even though the Cut (through which the rivers discharge to the ocean) is also located at the southern end of the Inlet. The 1:100 year (i.e. extreme) flood level for the whole of the Inlet has been determined as 1.92 m AHD (PWD, 1981), while the 1:10 year flood has been calculated as 1.07 m AND (George, personal communication).

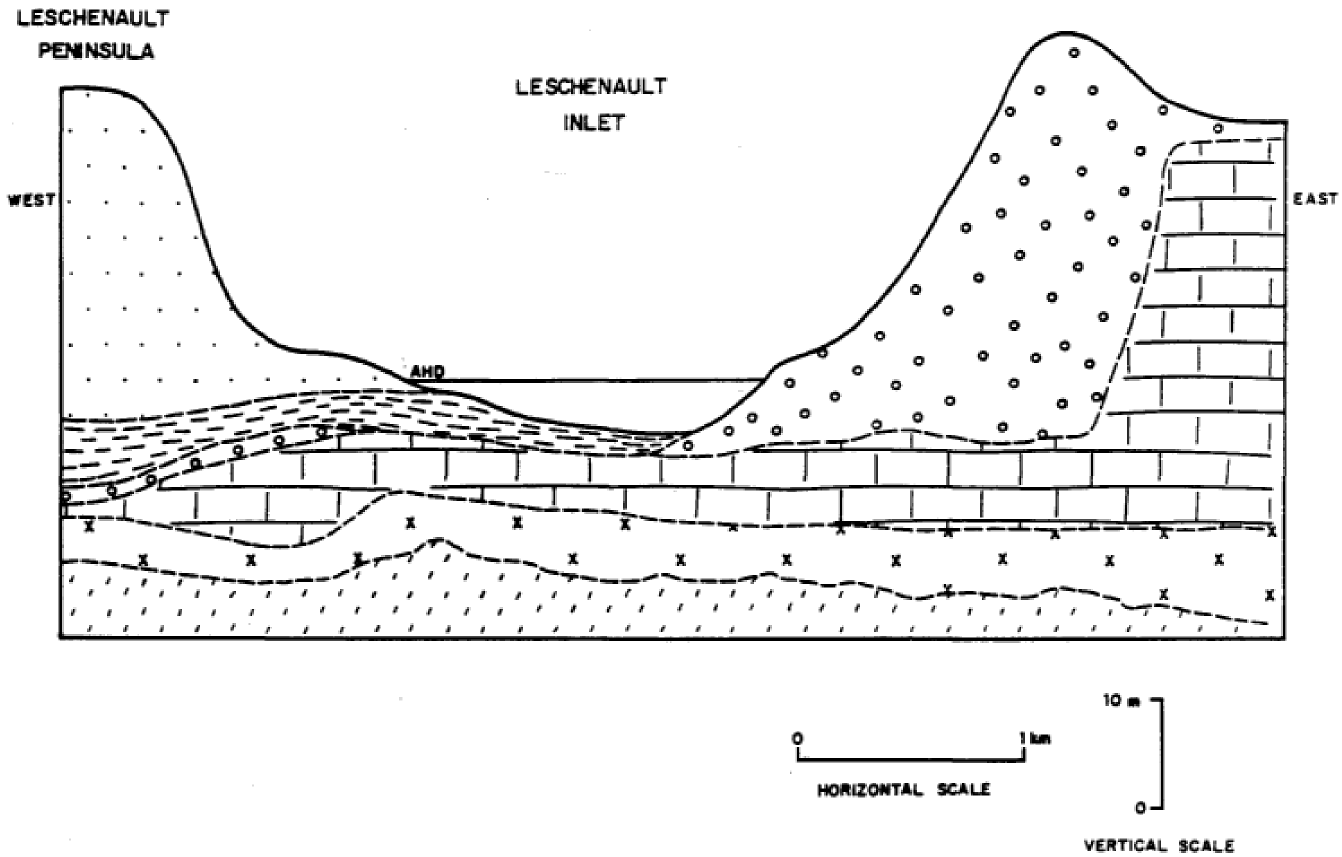
3. Geology

Leschenault Peninsula is a Holocene coastal barrier developed over Pleistocene sediments which in turn, rest on Early Cretaceous sediments of the Warnbro Group (Figure 3) (Semeniuk, 1983).

The Holocene sediments of the Peninsula are of two types. Calcareous dune and shelly beach sands (geologically termed the Safety Bay Sand Formation) occur in a layer up to 40 in thick and form the body of the barrier. These sediments are better known as the geomorphic element, the Quindalup Dune System. Estuarine muddy to sandy, shelly sediments are deposited behind the barrier in a layer up to 6 m thick. These sediments are generally known by their Soil Association term, the Vasse Soil Association (Bettenay, et al., 1960) but Semeniuk (1983) has termed them the Leschenault Formation. The Vasse Soils occur within the Inlet and in fringing tidal flats. These estuarine and lagoonal sediments also occur beneath the barrier which provides evidence that the barrier has prograded over the estuary or coastal lagoon by eastwards migration of the dunes.

The Holocene sediments overly up to 15 m of Pleistocene sediments. The Pleistocene sediments comprise a basal, estuarine unit termed the Australind Formation (Semeniuk, 1983) overlain by the Tamala Limestone (Playford, et al., 1976) of cemented calcareous dune and shelly marine sands. The Pleistocene sediments appear to mirror the Holocene depositional sequence. This provides evidence that a coastal barrier system has been the characteristic geomorphological feature of this area since the Pleistocene. The Tamala Limestone is mantled at depth by a veneer of siliceous sand. The sand is considered by Semeniuk (1983) to be of aeolian origin (which he has named the Eaton Sand), while it is generally considered to be a residual soil formed by subaerial weathering of the limestone, as described by McArthur and Bettenay (1974).

Although McArthur and Bartle (1980) considered that Pleistocene sediments outcrop along the eastern margin of the Peninsula (the Yoongarillup Plain), this has not been substantiated by this study. The Holocene dune and estuarine sediments completely mantle the underlying Pleistocene sequence, except for a minor outcrop of Tamala Limestone along the beach at the northern end of the Peninsula.



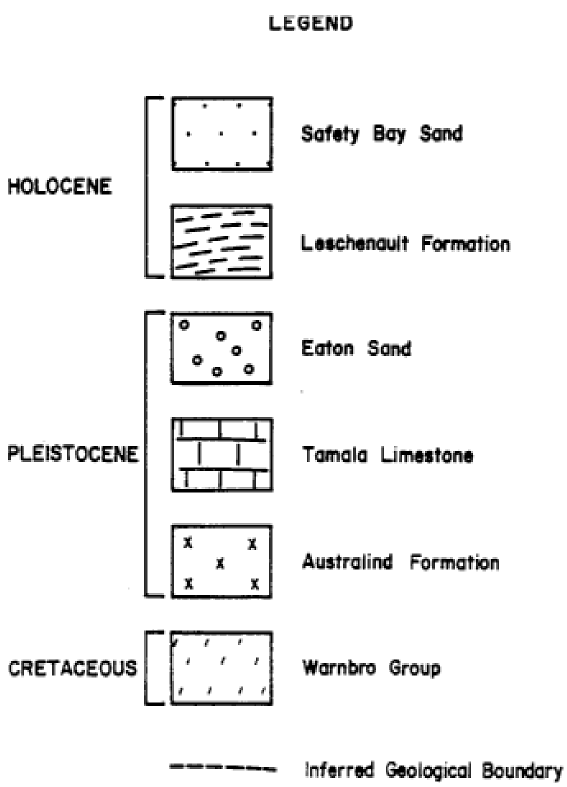


Figure 3.

Idealised Geological Cross-Section of the Study Area and the Hinderland (After Semeniuk, 1983).

4. Vegetation

The vegetation of the Peninsula has been mapped by Trudgen (1984). The Peninsula has a flora of mainly coastal and near coastal species and in addition, a suite of species typical of saline mud flats. Of the one hundred and twenty two species found on the Peninsula, forty one do not occur in the nearest coastal National Park (Yalgorup). Of special interest is the occurrence of the White Mangrove (*Avicennia marina*), which together with the stand at Bunbury represents the southern-most occurrence of this species in Western Australia.

Three different vegetation types occur which reflect the geomorphology of the Peninsula.

Vegetation of the fringing estuarine flats varies from Closed Sedgelands

(*Juncus*), Closed Herblands (including *Sarcacornia, Triglochin, Samolus* and

Ruppia), Low Open Health (*Halosarcia*) to Low Woodland of *Melaleuca* species.

Vegetation on areas of sand plain and stable, older Holocene dunes comprise

Tuart (~. *gomphocephala*) Woodland with an understorey dominated by Peppermint

(*Agonis flexuosa*) and a discrete area of *Acacia* Closed Shrub.

The vegetation of the Holocene dunes comprises primary and secondary dune colonizers (*Spinifex hirsutus, Cakile maritima, Olearia axillaris, Scaevola crassifolia*, etc.) on the youngest dunes closest to the coast, and stable Closed Shrubland to Open Forest of *Agonis flexuosa* and *Acacia rostellifera* on the older dunes to the east.

5. Landforms And Soils Of Leschenault Peninsula

The landforms and soils of Leschenault Peninsula have been previously studied by McArthur and Bartle (1980) as part of a regional study of the geomorphology of the Mandurah to Bunbury coastal area.

Leschenault Peninsula contains two geomorphic elements (the Quindalup Dune System and the Vasse Estuarine System) within which 11 soil-landform mapping units have been delineated (Figure 4).

5.1 The Beach

The beach (B) comprises a narrow seaward sloping beach berm and a short, steep, generally cusped, beach face. The siliceous to calcareous sands are medium to coarse grained and stained orange by precipitation of iron leached from the titanium dioxide waste disposal ponds. The beach-surf zone is classified as a medium energy, reflective sandy beach-surf zone according to the model of Wright, et al., (1979).

5.2. Dunes

This survey recognizes four major phases of dune building within the barrier, which supports the findings of McArthur and Bartle (1980), although the landforms have been mapped differently in this study. The present, active phase includes foredunes, blowouts and sandsheets. The three previous phases of parabolic dune formation occurred at different times during the late Holocene (<5000 years ago). These dunes are differentiated by dune structure and also by their degree of soil development, which is a reflection of their relative age and the time they have been subjected to subaerial weathering processes. The parabolic dunes have formed as a result of wave erosion and scarping of the frontal dunes, triggering the formation of blowouts by the action of winds on the bare sand surface. Continued aeolian sand transportation inland resulted in the growth and development of the blowouts which were subsequently stabilized by vegetation to form parabolic dunes.

Foredunes (Qf 1) generally form a single ridge up to 2 in high at the back of the beach. They occur along the coast north of Belvidere, but are generally absent to the south because of continual wave erosion. The foredunes to the north are semi-erosional, being generally wave scarped along their stoss or frontal face and are susceptible to wind erosion. The foredunes are poorly to moderately well vegetated *with Cakile maritima, Spinifex hirsutus* and *longifolius, Ainmophila arenaria* (Marram Grass) and *Arctotheca populifolia*. The sands are deep, white to light grey (1OYRS/2-1OYR7/2) and very pale brown (1OYR8/4) calcareous (and in some areas highly siliceous) sands, which are excessively well drained. The alkaline sands (pH 8-9.5) contain negligible soil development.

Landwards of the foredunes is a complex of nested parabolic dunes of three different ages. The youngest of these dunes (phase 1) occur behind the foredunes and are relatively small, steep-sided parabolic dunes (Qpl) which are vegetated with Closed Heath to Shrubland *of Olearia axillaris, Scaevola crassifolia, Spyridium globulosum and Acacia spp*. Soils are deep, very pale brown (10YR8/3-1OYR8/4) calcareous sands with minimal humus developed at the surface (5—10 cm). The sands are alkaline (pH 8-9.5). These dunes correlate with McArthur and Bartle’s Q2, Q3 and Q4 dunes with minor occurrences of their Q1 dunes.

The second phase comprises remnants of long-walled discrete parabolic dunes (Qp2). These remnants are mostly steep-sided, topographically high ridges and are oriented east-west across the barrier (indicating that the prevailing winds were westerly rather than south-westerly as at present). Their crests are very narrow. Depositional lobes are generally not found and it appears that these have been eroded by the action of tides and wind waves in the Inlet. The ridges are vegetated with coastal heath close to the coast and with *Agonis flexuosa* and (minor) *Eucalyptus gomphocephala* Woodland to the east. To the south of Belvidere, the coastal margin of these dunes is generally wave scarped and devoid of vegetation. These bare surfaces are often strewn with rhizotubules and stones of cemented dune sand which indicates some incipient cementation is occurring at depth in these ridges. Minor soil development (other than incipient cementation) is occurring in these ridges. The surface sands comprises black to dark brown

(1OYR 2/2—1OYR 3/2), humic, calcareous sands with gradual boundaries (at about 30 cm) to the underlying pale (1OYR7/3-1OYR8/3) calcareous sand. The sands are alkaline (pH 8.5—9.5).

The third group (phase 3) comprises small (ribbon to crescent-shaped) remnants of the oldest dunes on the Peninsula (Qp3), which occur along the eastern margin of the barrier, behind the younger dunes. These dunes are topographically low and have gentle slopes. They are generally vegetated with *Agonis flexuosa* Woodland with L *gomphocephala*. Soil development is more pronounced in these dunes than the Qp2 dunes above. Organic staining occurs to approximately 60 cm depth, below which is pale (1OYR8/4-1OYR7/4) calcareous sand. The soils are calcareous throughout and pH varies between 8 and 9.5 at depth. The Qp2 and 0p3 dunes of this study correlate with McArthur and Bartle’s Q1 dunes.

Minor deflation basins (Qd) occur mostly within the nested parabolic dunes (Qp1). These are small hollows which are densely vegetated with Acacia shrublands and comprise deep calcareous sands, with a humic surface horizon and a calcrete layer formed at a variable depth. Deflation basins were also mapped by McArthur and Bartle (1980), and termed unit Qp.

Cutting across all three parabolic dune types are active blowouts. Discrete blowouts (Qb) are evident in the northern part of the area, whereas south of Belvidere coalescing blowouts and sand sheets (Qs) occur which are cannibalizing the vegetated dunes in their path. Some discrete blowouts have developed across the coastal barrier and are depositing sand in the Inlet. Discrete blowouts comprise deep, white to very pale brown calcareous sand and are bare to very poorly vegetated with clumps of Marram Grass, *Olearia axillaris, Acacia spp*. and *Scaevola crassifolia*. The' blowouts have flat to undulating erosional floors (which may be deflated to the level of the winter water table) and steep, eroded walls and depositional lobes. McArthur and Bartle's mobile dunes (Qu) include sandsheets (Qs), blowouts (Qb) and foredunes (Qf1) mapped in this study.

5.3 Sand plain

Areas of flat to very gently undulating sand plain (Qh) occur on the Peninsula. These generally occur along its eastern margin and may represent either deflation basins and plains where they are surrounded by parabolic dunes (such as at Belvidere) or may represent hind dune flats where they occur behind the parabolic dunes. McArthur and Bartle (1980) mapped these areas as upper level flats and terraces of the Pleistocene Yoongarillup Plain, while Semeniuk and Meagher (1981) termed these areas the Woodland Plain, and inferred that they are of (mid) Holocene Age.

These areas are vegetated with *Eucalyptus gomphocephala* and *Agonis flexuosa* Woodland. Soil development is most pronounced in these areas. Soils comprise dark brown to brown (1OYR3/3-1OYR5/3) siliceous sand to generally 30 cm depth and rarely to 60 cm depth. These sands are highly leached, generally containing less than 2% calcium carbonate (and generally below the limit of detection) although their pH is between 8 and 8.5. Below this leached horizon the sands are generally paler (1OYR8/4-1OYR7/3) and contain 10-20% and up to 30% calcium carbonate. The sands are alkaline (pH 8.5-9.5). An impervious calcrete pan is developed between 60 and 90 cm, below which the pale calcareous sand is only slightly cemented. The pronounced leaching and calcretization indicates that these sandplain soils have been strongly weathered, and originally comprised undifferentiated calcareous dune sand and therefore belong to the Quindalup Dune System.

5.4 Estuarine Terraces

A narrow zone of estuarine sediments occurs fringing the Inlet. Three terraces are recognized within the flats and are differentiated by their relative height above water level, vegetation and underlying sediments.

The lower level terrace (VI) generally comprises black to dark brown, humic surface soils overlying sandy and muddy (often gley) sediments. It is subjected to tidal inundation and is vegetated with a dense cover of halophytic species although bare mud flats also occur. The sediments are highly alkaline and saline.

The mid level terrace (V2) is elevated slightly compared to the lower level terrace. It comprises similar sediments to V1, but also generally contains shelly layers. It is subject to tidal inundation and is densely vegetated with reeds. The upper level terrace (V3) generally comprises shallow (< 30 cm), brown to black, humic, calcareous sands overlying calcreted calcareous sands. It is not generally susceptible to tidal inundation (except for more extreme events i.e. tides between 1 and 1.4 m AHD) but is seasonally waterlogged. It is vegetated with reeds and Melaleuca thickets. The lower and mid level terraces are subject to relatively more frequent floods, but the upper level terrace is only susceptible to extreme floods (i.e. the 1:100 year flood).

The lower and mid level terraces of this study are equivalent to the lower terrace (Ps) of McArthur and Bartle (1980), while the upper level terrace (V3) is equivalent to their upper terrace (Pg).

6. Land Use and Land Degradation

6.1 Land Use

Leschenault Peninsula has been subjected to several different land uses since European settlement.

From at least the turn of the century to approximately the 1970s, cattle were herded from Dardanup to Belvidere and allowed to graze and roam freely across the dunes (Coutis, personal communication). In the l970s and early 1980s, Belvidere became known as a community of alternative lifestylers, but grazing of the land was not continued.

Disposal of SCM Chemicals' (previously Laporte Titanium Limited) acid-iron rich liquid effluent has been occurring on the Peninsula since 1968, but is expected to cease early in 1991, due to the closing down of the existing sulphate plant in October 1990 (Quilty, personnal communication). During this time some 30—40 effluent disposal lagoons were excavated into the eroded dunes south of Belvidere (generally in pre-existing depressions such as erosional floors of the blowouts), although some were located in stable, well vegetated dunes and swales landwards of the unstable blowouts. Service roads for vehicular access and for the routing of the effluent pipelines also account for a substantial amount of clearing in stable, well vegetated areas. The area of stable well vegetated land which was cleared of vegetation for the location of lagoons and access roads is estimated to be about 13 ha.

In recent years the Peninsula has been subjected to uncontrolled use by off-road vehicles because of its proximity to residential centres.

6.2 Land Degradation

There are four possible causes of land degradation on the Peninsula naturally induced disturbance, and disturbance resulting from off-road vehicles, grazing and effluent disposal.

The Peninsula is inherently susceptible to land degradation, and is actively being degraded through the action of erosive winds on fragile, erodible landforms which were initially destabilized by waves eroding the frontal dunes, and perhaps also by naturally occurring wildfires.

The geomorphology of the Peninsula indicates that its historical use for grazing has not been a significant factor in the formation of the blowouts and sandsheets. The dominant landforms of the Peninsula (blowouts through to young parabolic dunes and older parabolic dune remnants) indicate that over recent geologic time, several phases of dune mobilization and restabilization have occurred. In addition the unstable landforms all originate at the back of the beach, which indicates that climatic factors were primarily, responsible for their initiation and subsequent growth. However, grazing may have exacerbated the growth of these landforms in certain areas.

Off-road vehicles generally utilize existing tracks or tend to be active on the beach and within existing eroded areas. An examination of 1941 and 1955 aerial photography demonstrates that there were only a few tracks along the Peninsula at that time and these were generally located close to the Inlet rather than through the unstable dunes near the coast. It is apparent that the use of off-road vehicles has not generally caused the formation of the blowouts, although the very recent formation of some incipient blowouts may be due to inappropriately located tracks.

This report has investigated the role that effluent disposal has played in causing or exacerbating land degradation of the Peninsula. Figure 5 displays the location of the effluent lagoons (and associated areas of disturbance) in relation to the landward limit of the blowouts and sandsheets in 1960 (i.e. before effluent disposal commenced) and in 1983. The Peninsula may be split into three sections based on existing land degradation and its use for effluent disposal. The Peninsula north of Belvidere is least degraded and has not been used for effluent disposal. There are relatively few tracks in this area, while the blowouts tend to be smaller and are discrete entities. The blowouts have generally advanced slightly between 1960 and 1983.

The central and southern sections of the Peninsula have been used for effluent disposal, and land degradation becomes progressively more pronounced to the south.

In the central section of the Peninsula in the vicinity of Belvidere, the blowouts tend to be larger and some have coelesced. Most of the effluent disposal lagoons in this section have been located within stable, well vegetated dunes adjacent to, and inland of, existing blowouts. The blowouts have generally retreated slightly between 1960 and 1983.

The southern section of the Peninsula is highly degraded and comprises mostly blowouts that have coalesced into sand sheets. The majority of the effluent disposal lagoons occur in this area but have been mostly located within pre-existing blowouts and sandsheets. The area of bare sand in blowouts and sandsheets generally increased between 1960 and 1983. This growth of the unstable landforms may be linked with effluent disposal in the southern section, but is not the factor influencing their growth in the northern section.

It appears that effluent disposal has not generally had a significant impact (in terms of area disturbed) on land degradation on the Peninsula. The increase in area of unstable landforms in the southern section is probably due to a combination of naturally induced land degradation (associated with the increased wave erosion occurring along this portion) and effluent disposal. However effluent disposal is the primary cause of clearing and disturbance within the stable, well vegetated landforms.

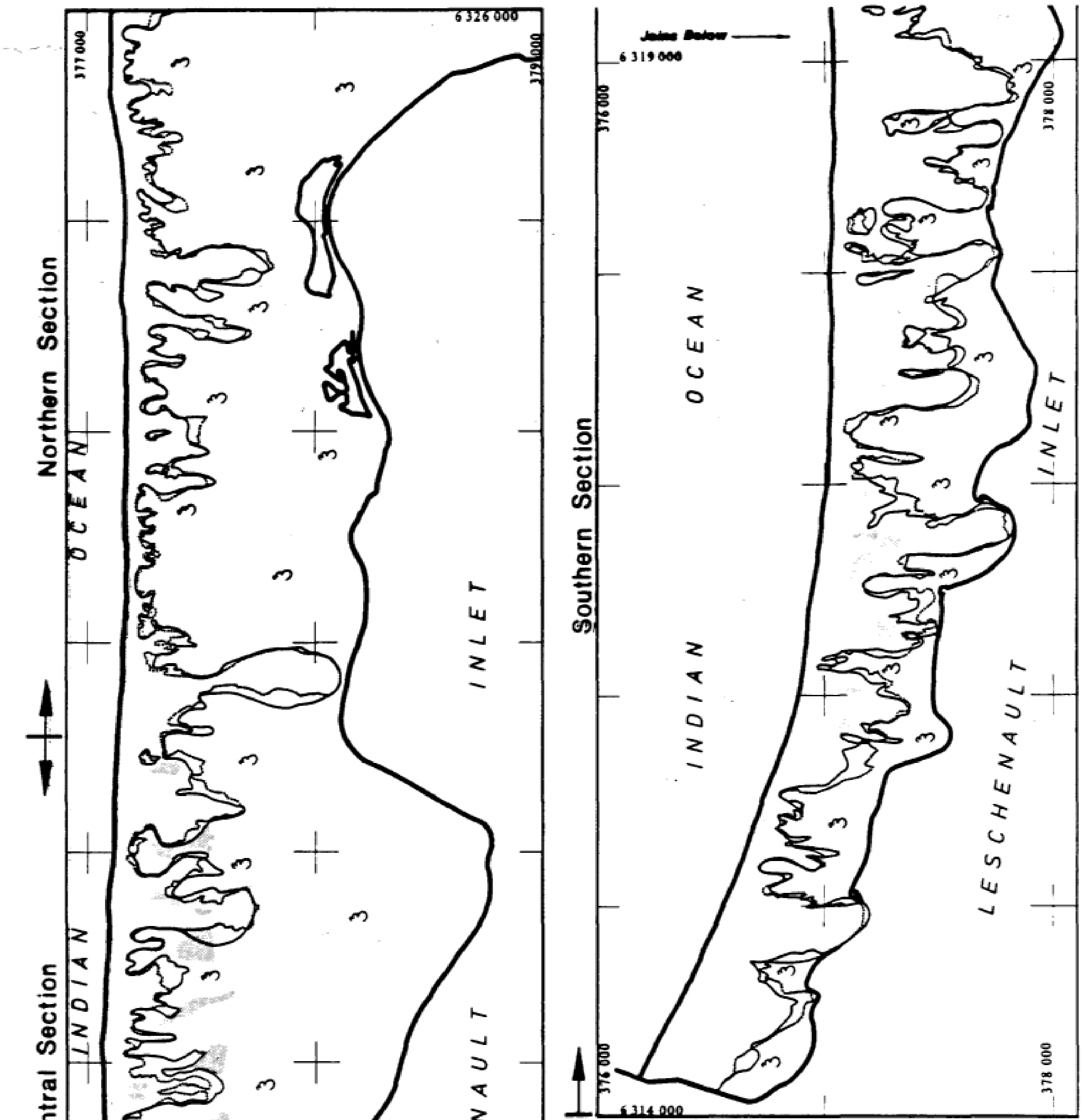


Figure 5

DEVELOPMENT OF BLOWOUTS AT LESCHENAULT PENINSULA
SCALE: 1:25 000
Grid Interval: 1 000m

Waterline as at 17th Mar 1983
Landward margin of Blowouts as at 26th Oct 1960
Landward margin of Blowouts as at 17th Mar 1983
Effluent Lagoons and associated disturbed areas
Vegetation

-13-

7. Land Capability Analysis

Land Capability is defined as the ability of land to sustain a specified land use without resulting in significant (onsite and offsite) degradation of the land resources. Land capability analysis is an important tool for land use planning where changes in land use, or intensification of land uses are proposed.

Land capability analysis considers both the impact of development on the land resources and the physical limitations (hazards) to development imposed by the land resources. A five class system is used by the Department of Agriculture, which indicates the relative degree of hazards and limitations to development (Table I).

Table I. Generalized land capability classes

Land Class	Degree of limitation	General description
I	None to very slight	Areas with a very high capability for the proposed activity or use. Very few physical limitations to the specified use are present or else they are easily overcome. Risk of land degradation under the proposed use is negligible.
II	Slight	Areas with a high capability for the proposed activity or use. Some physical limitations to the use occur, affecting either its productive use or the hazard of land degradation. These limitations can however, be overcome through careful planning.
III	Moderate	Areas with a fair capability for the proposed activity or use. Moderate physical limitations to the land use occur, which will significantly affect its productive use or result in a moderate risk of land degradation unless careful planning and conservation measures are undertaken.
IV	High	Areas with a low capability for the proposed activity or use. There is a high degree of physical limitations which are either not easily overcome by standard development techniques or which result in a high risk of land degradation without extensive conservation requirements.
V	Severe	Areas with a very poor capability for the proposed activity or use. The severity of physical limitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

7.1 Methodology

The methodology for determining the capability rating of each mapping unit generally followed Wells and King (1989) and involved:
(1) determining the types of land use under consideration and their physical requirements,
(2) determining the land qualities which affect those uses,
(3) qualitatively evaluating the capability of the mapping units in terms of the limitations imposed by the land qualities.

7.1.1 Land use types and their requirements

Possible uses for the Peninsula include low key, passive recreation (bush walking, picnic facilities, etc.) and tourist accommodation ranging from camping, chalet developments to resort hotels. The passive uses have few land use requirements. Walking tracks, access roads and parking areas desirably should require little maintenance and should therefore not be developed on steeply sloping dunes which are susceptible to wind and water erosion or in areas subject to tidal inundation, flooding, or wave erosion. Buildings should not be threatened by sand inundation and wind or wave erosion or flooding and tidal inundation. Relatively flat areas with deep, well drained soils are most favoured for construction of buildings and the provision of services such as reticulated power and water. If onsite septic effluent disposal systems are to be installed, then the soils should be capable of absorbing and purifying the waste without risk of contaminating the superficial aquifer (if the water is to be harvested) and, most importantly, without risk of nutrients or microbes entering Leschenault Inlet. The alternative to on—site disposal, is to provide an on—site package treatment plant. The major requirements are deep, well drained sands which are easy to excavate, and an area of land for disposal of the treated effluent which is sufficiently distant from the Inlet to prevent pollution of the Inlet.

7.1.2 Land qualities

A land quality is an attribute of the mapping unit (usually described in qualitative terms) which acts in a distinct manner on the capability of the land to sustain the proposed land use, in this case tourism accommodation (chalets to more intensive developments).

The land qualities which may pose limitations to development are ease of excavation; foundation soundness; waterlogging hazard and tidal inundation risk; flood risk; wind and water erosion hazard; wave erosion risk; soil absorption ability and groundwater pollution hazard (which is determined by the land qualities microbial purification ability and nutrient retention ability).

Each land quality is generally determined by a number of separate factors termed land characteristics. For example in the study area the land quality “ease of excavation” is determined by four land characteristics. The soil depth in relation to the required depth of excavation is an obvious factor. The presence of rock or clay significantly increases the cost of excavation because of the need to use specialized equipment. A shallow water table greatly increases the difficulty of excavation. The slope of the land also limits the use of machinery on the site. The land qualities and relevant land characteristics for the study area are listed in table II below. Land quality assessment tables have been developed for the study area and were used to determine the “value” of each land quality according to the most limiting land characteristic. These tables are included as appendix I. Table III lists each of the mapping units in terms of its land quality values.

Table II. Land qualities important for the study area

Land Qualities	**Land Characteristics**
Foundation soundness	Slope Soil texture Nature of the underlying material
Ease of excavation	Soil depth Nature of the underlying material Depth to the seasonal high water table Slope
Waterlogging hazard	Soil texture Depth to the seasonal high water table Depth to an impermeable layer Vegetation type
Flood risk	Landform type Height in relation to flood levels
Tidal inundation risk	Vegetation type Height in relation to tidal range
Water erosion hazard	Slope
Wave erosion risk	Position in relation to the 100 year Coastal erosion line
Wind erosion hazard	Aspect/exposure to onshore winds Landform type Vegetation type Vegetation structure
Soil absorption ability	Soil permeability Depth to an impermeable layer or seasonal high water table
Microbial purification ability	Soil texture Soil colour Depth to an impermeable layer or seasonal high water table
Nutrient retention ability	Soil texture Soil colour Phosphorus retention index Reactive iron
Groundwater pollution hazard	Microbial purification ability Nutrient retention ability

Table III. Summary table - The mapping units and their land quality values

Mapping Units	bt	x	l	ti	f	e	v	w	a	nr	p	s^{x}
B	VH**	VL	H	VH		VL	VH	VH	VL	VL	VL	H
Qfl	M	H	VL			L	VH	VH	H	VL	VL	H
Qb	M	M	VL			L	VH*	VH	H	VL	H	H
Qs	M	M	VL			L	VH*	VH	H	VL	H	H
Qpi	M	L	VL			L	VH*	VH	H	VL	H	H
Qp2	L	L	VL			M	VH*	H	H	VL	H	H
Qp3	H	H	VL			L		M	H	VL	H	H
Qd	VH	H	L			VL		M	M	L	VL	H
Qh	VH	H	L			VL		L	M	L	VL	H
VL	M	VL	VH	VH	VH	VL		VL	VL	L	VL	H
V2	M	L	H	VH	VH	VL		VL	VL	L	VL	H
V3	VH	M	M	H	H	VL		VL	M	L	VL	H

x Should be determined: (1) if an onsite groundwater resource is to be utilized for water supply purposes, and/or (2) to assess the potential for nutrients and microbes to enter the Inlet from a source located within approximately 100 m of the Inlet.

* The portions of these units to the west of the coastal erosion line have a very high wave erosion risk. To the east of this line, the units are not subjected to this risk.

t

b – foundation soundness	v – wave erosion risk
x – ease of excavation	w – wind erosion risk
i – waterlogging hazard	a – soil absorption ability
ti – tidal inundation risk	nr – nutrient retention ability
f – flood risk	p – microbial purification ability
e – water erosion hazard	s – groundwater pollution hazard

**VH - Very high, H - High, M - Moderate, L - Low, VL - Very low.

7.2 Capability Rating for Tourism Accommodation

The capability rating table for tourism accommodation used in this study is presented in appendix II. This table assigns a weighting to the values for each land quality according to whether the land quality imposes a greater or lesser limitation for tourism accommodation. The table is used by inserting the value of each land quality in Table III into its appropriate place in the capability rating table and determining the most limiting land quality for each mapping unit. The capability rating and limitations to development of each mapping unit for tourist accommodation is displayed in table IV.

The dunal and estuarine landforms of Leschenault Peninsula generally have a very low to low capability to sustain tourism accommodation. However there are minor areas of the Peninsula comprising sandplain (Qh) and the oldest parabolic dunes (Qp3), which have a moderate capability to sustain this use.

8. Land Use Planning Considerations

The following comments arise from the capability analysis for tourist accommodation and a consideration of the land uses proposed for the Peninsula in the document "Draft Land Use Plans for the Leschenault Coastal Park and the Kemerton Community Park" (South West Development Authority, 1985).

8.1 Tourist Accommodation

The capability analysis has demonstrated that most of the landforms of the Peninsula are not capable of supporting tourist accommodation use (Classes IV and V), generally either because of susceptibility to erosion, or due to problems with septic effluent disposal and possible pollution of the Inlet.

There are relatively minor areas of the Peninsula which have a moderate capability (Class III) for tourist accommodation use. These are areas of sandplain (Qh), deflation basins (Qd) and the older parabolic dunes (Qp3). However, neither of these landforms are considered suitable for development where the adjacent landforms are highly mobile or unstable (i.e. Qb, Qs, Qfl). In addition, deflation basins and the Qp3 dunes are limited in area and are generally partly surrounded by highly (or potentially) unstable landforms through which access and fire protection may be difficult. It is recommended that, although moderately capable of supporting the use, deflation basins and the Qp3 dunes are probably not suitable for this use because of problems with providing access, adequate fire management (without resulting in wind erosion) and the potential for blowouts and sand sheets to inundate these areas in the longer term.

Areas of sandplain (Qh) are more readily accessible than Qp3 dunes but vary markedly in size. There are several areas of sandplain (see land resource map, Figure 4), which are sufficiently large to permit more intensive use. Belvidere is the largest area of sandplain on the Peninsula and is suited for a resort hotel or chalet development. Other areas may be suited to less intensive chalet or camping use. The major limitation to development is the need to adequately provide for septic effluent disposal without resulting in pollution of the Inlet. Where this may be a problem, it may be necessary to provide at least a 100 m development set back from the Inlet and/or install package treatment systems and dispose of the treated waste over land sufficiently far from the Inlet. The smallest sandplain areas are probably not suitable for tourist accommodation use, but because they are generally flat, sheltered from winds and provide pleasant views across the Inlet, these areas could be used for recreational facilities such as picnic areas, playgrounds and car parks.

Table IV. Capability rating for tourism accommodation

Soil/ Landform Mapping Unit		Limitations For Tourism Accommodation	Capability Rating
B	Beach	Very low capability due to very high tidal inundation, wave erosion risk and wind erosion hazard.	V
Qf1	Foredune	Very low capability due to a very high wind erosion hazard and wave erosion risk.	V
Qb	Blowout	Very low capability due to a very high wind erosion hazard.	V*
Qs	Sand sheet	Very low capability due to a very high wind erosion hazard.	V*
Qp^1	Nested parabolic dunes	Very low capability due to a very high wind erosion hazard if the covering vegetation is disturbed.	V*
Qp^2	Long-walled parabolic dunes	Low capability due to a high wind erosion hazard if the covering vegetation is disturbed.	IV*
Qp^3	Subdued parabolic dunes	Moderate capability with a possible limitation imposed by groundwater contamination.	III+
Qd	Deflation basin	Moderate capability with a possible limitation imposed by wind erosion hazard.	III
Qh	Sandplain	Moderate capability with a possible limitation imposed by groundwater contamination.	III+
V1	Low level terrace	Very low capability due to very high risks of tidal inundation, flooding and nutrient enrichment of the Inlet.	V
V2	Mid level terrace	Very low capability due to very high risks of tidal inundation, flooding and nutrient enrichment of the Inlet.	V
V3	Upper level terrace	Low capability due to high risk of nutrient enrichment of the Inlet and flooding..	IV

* The portion of these units occurring to the west of the coastal erosion line also have a very high wave erosion risk and therefore attract a very low capability rating (V).

+ The portion of the sandplain and Qp3 units occurring close to the Inlet (within approximately 100 m) have a high potential for nutrients to leach into the Inlet and therefore attract very low capability ratings (V).

8.2 Recreational Use

There will be pressure to "open up" the Peninsula for a range of recreational uses when it is no longer required for effluent disposal by SCM Chemicals. These uses include off-road vehicles (ORV), beach fishing, swimming and boating in the Inlet and passive uses such as bush walking and ocean swimming. The section of the Peninsula south of Belvidere should not be made readily accessible to the public, because of the widespread occurrence of highly degraded dunes, through which vehicular access would be difficult and costly to maintain. However an area of severely degraded dunes could be formally set aside for off—road vehicular use, although access would need to be carefully controlled to prevent access beyond its boundaries.

Access to the beach for swimming, fishing and ORV use is an important local issue. Vehicular access to the beach should generally be discouraged because of the cost of maintaining a trafficable surface, while the whole of the Peninsula would be rendered accessible from the beach.

However it may be acceptable to provide vehicular access to the beach at the northern end of the Peninsula (by providing access from Buffalo Road). At this location the beach and foredunes are underlain by shallow limestone and roads and car parks should be less susceptible to wave erosion than the beach to the south. In addition, providing access at the northern end should minimize the number of vehicles utilizing the beach along the whole length of the Peninsula. Access to the beach near Buffalo Road would be costly to construct and maintain because of the location within the nested parabolic dunes and blowouts. It is recommended that 2WD access terminating in a parking area should be located in the deflation basin landwards of the Qp1 dunes, and only 4WD access should be provided (if at all) to the beach.

Deflation basins (Qd) could be developed for car parks and picnic areas although access to these areas through Qp1 and Qp2 dunes may be difficult and costly to maintain.

The provision of swimming beaches and boat jetties along the western side of the Inlet should not be encouraged. The Inlet is generally very shallow and not suitable for swimming, while disturbance to the fringing vegetation may cause erosion of the estuarine flats due to tidal movements and wind waves lapping the surface.

Bush walking is a suitable recreational activity along the Inlet and through the dunes. As there are already an excessive number of tracks through the dunes, it is recommended that these should be rationalized and the majority closed to vehicular and pedestrian traffic and rehabilitated. A few tracks should be formalized and properly constructed to minimize the potential for wind and water erosion to occur. Board-and-chain pedestrian walking tracks should be considered or footpaths constructed where access through steeply sloping dunes cannot be avoided.

8.3 Land Rehabilitation

A land rehabilitation strategy should be developed for the Peninsula (see Figure 5) taking into account the severity and causes of land degradation within each section. While all three sections have been subjected to wind and wave erosion, erosion is least in the northern section and is most severe in the southern section. The northern section has not been subjected to clearing and earthworks for effluent disposal, while this has commonly occurred in the central and southern sections.

Rehabilitation in the northern section should concentrate on maintaining the existing landforms, by stabilizing the blowouts and recreating a well-vegetated foredune where it has been removed.

Rehabilitation in the central section should concentrate initially on rehabilitating the effluent disposal lagoons and associated areas of disturbance; recreating a well vegetated foredune where it has been removed (or- revegetating the frontal dune where a foredune is not present because of continual wave erosion); and stabilizing those blowouts which are particularly unstable. The revegetation strategy should maintain the existing form and scale of the landforms.

Rehabilitation of the lagoons and adjacent degraded areas in ‘the southern section is being undertaken by the Department of Resources Development. Rehabilitation of the area is costly and is only likely to be successful with a long—term commitment to land management. The most cost—effective method of rehabilitating the southern section is for the degraded dunes to be extensively reshaped to permit mechanized planting and seeding. However the resulting undulating plain created by reshaping is in stark contrast to the pre—existing landforms in this area (parabolic dune ridges and swales). It is unlikely that the pre-existing diverse vegetation communities could be re—established on such a uniform, windswept surface. It is recommended that existing ridges are maintained as far as practicable and reshaping is concentrated within the lower lying swales and deflated areas.

9. References

Bettenay, E., McArthur, W.M. and Hingston, F.J. (1960). The Soil Associations of part of the Swan Coastal Plain, Western Australia. Soils and Land Use Series, 35, Division of Soils, CSIRO.

Bureau of Meteorology. Selected climatic data.

Department of Marine and Harbours. Coastline Movements: Robert Point (Mandurah) to Bunbury Breakwater. Leschenault 067-23—1 to 067-26-i.

Gentilli, J. (1971). Climates of Australia and New Zealand. World Survey of Climatology, 13. Elsevier.

McArthur, W.M. and Bettenay, E. (1974). The development and distribution of the soils of the Swan Coastal Plain, Western Australia. CSIRO, Soil Pub. 16.

McArthur, W.M. and Bartle, G.A. (1980). Soils and land use planning in the Mandurah-Bunbury Coastal Zone, Western Australia. CSIRO, Land Res. Manage. Ser. 6.

Playford, P.E., Cockbain, A.E. and Low, G.H. (1976). Geology of the Perth Basin, Western Australia. West. Australia Geol. Survey Bull. 124.

Public Works Department (1978). Bunbury Outer Harbour Siltation Investigations. Report 78/3.

Public Works Department (1980). Prediction of Extreme High Ocean Water level events for operation of the Bunbury Storm surge Barrier. Report 80/1

Public Works Department (1981). Leschenault Estuary, Collie River and Preston River Regional Flood Study. Engineering Division, Public Works Department.

Semeniuk, V. (1983). The Quaternary stratigraphy and geological history of the Australind-Leschenault Inlet Area. J. Roy. Soc. WA., 66(3), pp. 71—83.

Semeniuk, V. and Meagher, T.D. (1981). The geomorphology and surface processes of the Australind-Leschenault Inlet coastal area. J. Roy. Soc. W.A., 64(2), pp. 33—51.

South West Development Authority, (1985). Draft Land Use Plans for the Leschenault Coastal Park and the Kemerton Community Park. 172 pp.

Trudgen, M.E. (1984). The Leschenault Peninsula. A flora and vegetation survey with an analysis of its conservation value and appropriate uses. Department of Conservation and Environment, Bull. 157. Western Australia. 39 pp.

Wells, M.R. and King, P.D. (1989): Land Capability Assessment Methodology for rural-residential development and associated agricultural land uses. Land Resources Series, 1, Western Australian Department of Agriculture. 58pp.

Wright, L.D., Chappell, J., Thom, B.G., Bradshaw, M.P. and Coweil, P. 1979. Morphodynamics of reflective and dissipative beach and inshore systems. South eastern Australia. Mar. Geol., 32, pp. 105-140.

Appendix I. Land Quality Assessment Tables

Assessment table for "foundation soundness, b"

Land Characteristic	Very high	High	Moderate	Low	Very low
Slope, %	0-5	5-8	8-15	15-30	>30
Soil texture	Sand	Humic sand		Deep clays or peat	
Nature of the underlying material	Rock Sand		Interbedded clays, sands, peat		

Assessment table for "ease of excavation, x"

Land Characteristic	Very high	High	Moderate	Low	Very low
Soil depth, m	>2	1-2	0.5-1	0.5-0	
Nature of the underlying material	Sand	Limestone			
Depth to water table, m	>2	1-2	0.5-1	0.5-0	Permanently under water
Slope, %	<5	5-8	8-15	>15	

Assessment table for "waterlogging hazard. i"

Land Characteristic	Very high	High	Moderate	Low	Very low
Soil texture	Calcareous mud, clay				
Depth to watertable, m	Permanently under water	<0.5	0.5-1	1-2	>2
Depth to impermeable layer, m			<0.5	0.5-1	>1
Vegetation type	Reeds, rushes	Melaleuca sp.			

Assessment table for "tidal inundation risk, ti"

Land characteristic	Very high	High	Moderate	Low	Very low
Vegetation type	Mud flats, reeds, rushes	Melaleuca sp.			
Height in relation to tidal range	Within mean daily (i.e. <0.5m AHD)	Within the range of high tides (i.e. 0.5-1.7m AHD)			

Assessment table for "flood risk. f"

Land characteristic	Very high	High	Moderate	Very low
Landform type	Low to mid terrace	Upper level terrace		
Height in relation to flood levels	Within the range of 1:10 year (i.e. <1m AHD)	With the range of more extreme floods (i.e. 1:100 year flood 1-1.9m AHD)		Higher than extreme flood levels (1.e. >1.9m AHD)

Assessment table for "water erosion hazard, e"

Land characteristic	Very high	High	Moderate	Low	Very low
Slope, %			>15	5-15	<5

Assessment table for "wave erosion risk, v"

Land characteristic	Very high	High	Moderate	Low	Very low
Position in relation to wave erosion line	West of the line				East of the line

Assessment table for “wind erosion hazard, w”

Land characteristic	Very high	High	Moderate	Low	Very low
Aspect	W-S	NW		E	
Landform type		Dune crest		Dune slope	Plain
Vegetation structure	Bare-Herbland	Heathland	Shrubland	Woodland	Forest
Vegetation type	Bare primary dune colonizers	Secondary dune colonizers	Coastal shrub species	Agonis flexuosa dominant	Agonis Flexuosa and E. gomphocephala dominant

Assessment table for "microbial purification ability, p"

The assessment table was provided by the E.P.A. and considers soil texture and colour (reflecting the clay content), land slope and soil depth.

Soil texture	Slope, %	Colour	Depth, m	Rating
Sands		Pale, leached or calcareous	>5, <5	H VL
		Coloured (Yellow, red, brown)	>2.5 <2.5	H VL
Loams and heavier textured soils	<8		>2.1 <2.1	H VL
	8-15		>2.1 <2.1	M VL
	15-30		>2.1 <2.1	L VL
	>30		<2.1	VL

Assessment table for "nutrient retention ability, nr"

This table was provided by the E.P.A. and considers the phosphorus retention index (PRI) and reactive iron levels of the soil (where available) or the soil texture and colour (i.e. reflecting the clay content of the soils).

Very low: Soils with a PRI of < 2 or reactive iron < 200 ~.zg/g (usually pale, leached sandy soils).

Low: Soils with a PRI of 2—30 or reactive iron of 200-1,500 ~g/g (usually loamy or coloured sands).

Moderate: Soils with a PRI > 30 or reactive iron > 1,500 ~.Lg/g (usually barns and heavier textured soils).

Assessment table for “soil absorption ability, a”

Land characteristic	High	Moderate	Low	Very low
Soil permeability	Very rapid-rapid	Moderate to moderately rapid	Moderately slow	Slow
Depth to impermeable layer, cm	Deep (>100)	Moderately deep (50-100)	Shallow (25-50)	Very shallow <25

Assessment table for “groundwater pollution hazard”

This table was provided by the EPA and considers the combination of microbial purification ability and nutrient retention ability.

Low: Soils with a high microbial purification ability and moderate nutrient retention ability.

Moderate: Soils with a low to moderate microbial purification ability and low to moderate nutrient retention ability.

High: Soils with a very low microbial purification ability and/or very low nutrient retention ability.

Appendix II. Capability Rating Table for Tourist Accommodation

Land Quality	Land Quality values				
Ease of excavation, x	VH **t**	H	M-L	VL	
Foundation soundness, b	VH	H	M-L	VL	
Waterlogging hazard, i	VL	L	M	H-VH	
Water erosion hazard, e	VL	L	M	H	VH
Wind erosion hazard, w	VL	L	M	H	VH
Wave erosion risk, v	N				VH
Tidal inundation risk, ti	N			H	VH
Flood risk, f				H	VH
Soil absorption ability, a	H		M	L	VL
Groundwater pollution hazard, s*	N		L	M	H
Overall capability rating class	I	II	III	IV	V

t

N	Nil hazard/risk	M	Moderate rating
VL	Very low rating	H	High rating
L	Low rating	VH	Very high rating

* Note that groundwater pollution hazard need only be assessed: (1) if an onsite source of groundwater is to be utilized for water supply purposes; and/or (2) to determine the potential for nutrients and microbes to enter the Inlet from a source located within approximately 100 m of the Inlet.

The land qualities nutrient retention ability and microbial purification ability are not listed in the capability rating table because they are used to determine the land quality groundwater pollution hazard.