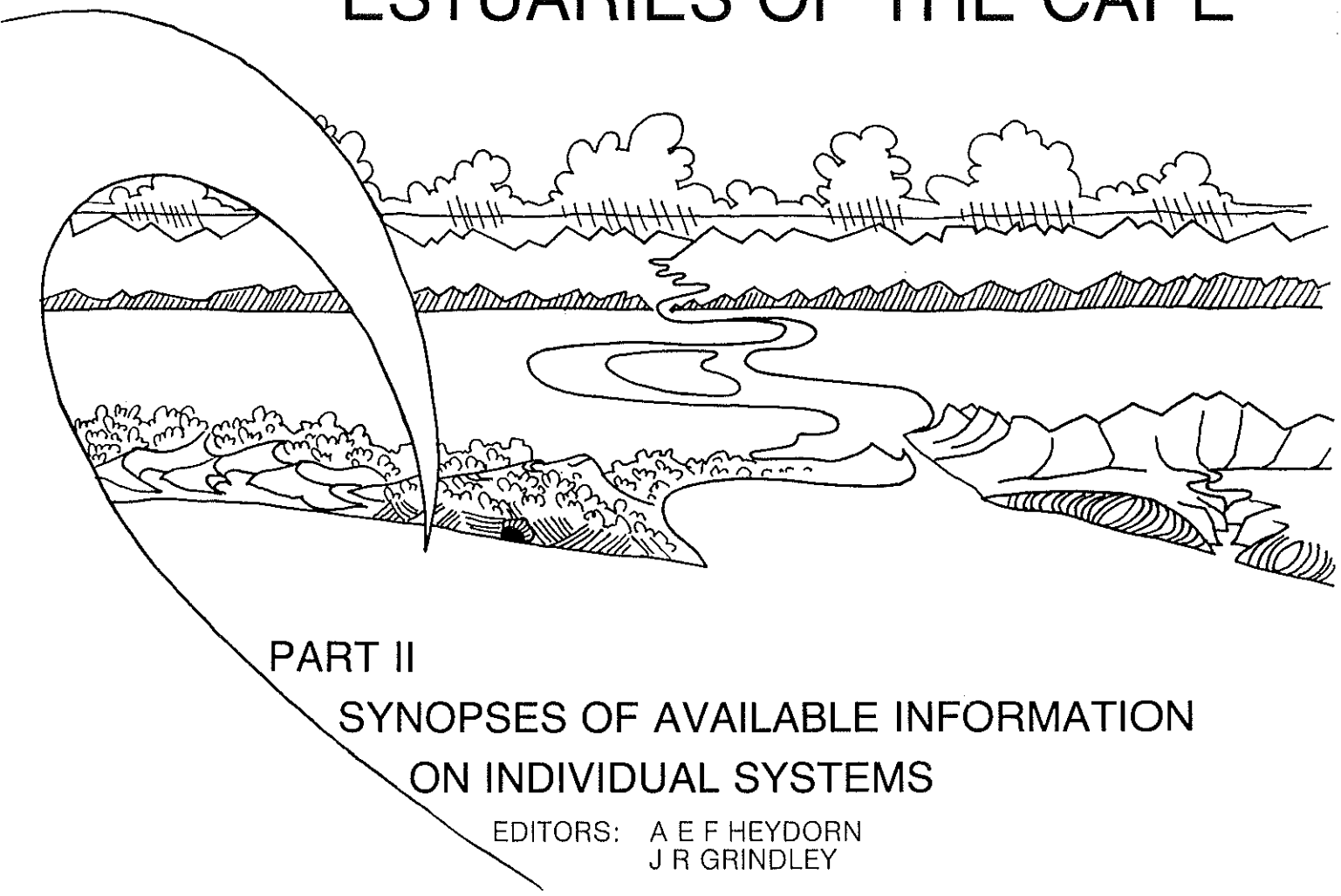
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN
J R GRINDLEY

REPORT NO. 14

SAND (CSW 4)

CSIR RESEARCH REPORT 413

Stellenbosch, South Africa
December 1982

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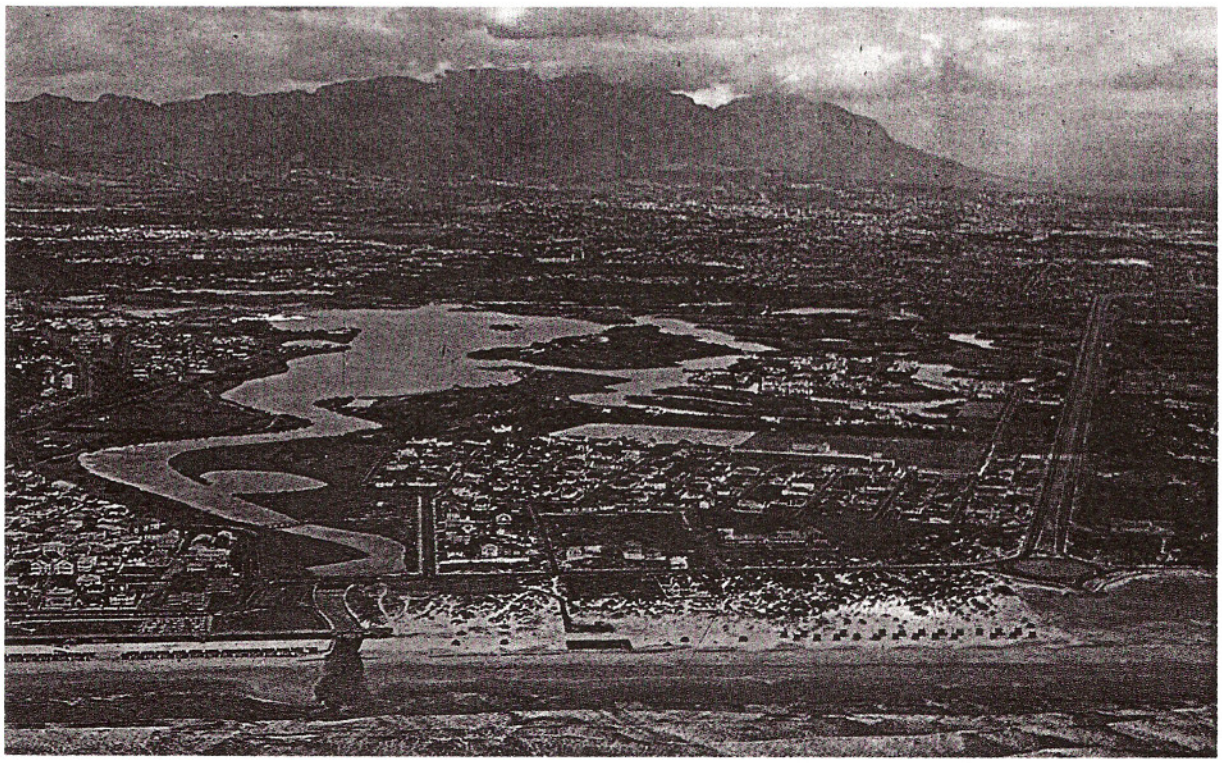

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PREFACE

The Estuarine and Coastal Research Unit (ECRU) was established by the National Research Institute for Oceanology (NRIO) of the CSIR in 1979 with the following aims:

- to contribute information relevant to the development of a cohesive management policy for the South African coastline;
- to compile syntheses of all available knowledge on the 167 estuaries of the Cape between the Kei and the Orange rivers;
- to identify gaps in information, to conduct research to fill these and to stimulate Universities, Museums and other institutions to become involved in this kind of work;
- to contribute to *ad hoc* investigations carried out by NRIO on the impacts of proposed developments in the coastal environment, and especially in estuaries.

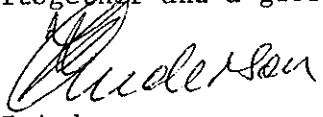
The Unit was established at the request of the Government, and the Department of Environment Affairs contributes substantially to the running costs.

In 1980 the Unit published its first report under the title "The Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley)[+]. As the name of the report implies, it is an overview of the Cape Coast dealing with aspects such as climate, geology, soils, catchments, run-off, vegetation, oceanography, and of course, estuaries. At the specific request of the Government, the report includes preliminary management recommendations.

The present report is one of a series on Cape Estuaries being published under the general title "The Estuaries of the Cape, Part II". In these reports all available information on individual estuaries is summarized and presented in a format similar to that used in a report on Natal estuaries which was published by the Natal Town and Regional Planning Commission in 1978. It was found however, that much information is dated or inadequate and that the compilation of Part II reports is therefore not possible without brief prior surveys by the ECRU. These surveys are usually carried out in collaboration with the Botanical Research Institute and frequently with individual scientists who have special interest in the systems concerned. One of these is Prof JR Grindley of the University of Cape Town who is co-editor of the Part II series.

These surveys are, however, not adequate to provide complete understanding of the functioning of estuarine systems under the variable conditions prevalent along the South African coastline. The ECRU therefore liaises closely with Universities and other research institutes and encourages them to carry out longer-term research on selected estuarine systems. In this way a far greater range of expertise is involved in the programme and it is hoped that the needs of those responsible for coastal zone management at Local-, Provincial and Central Government levels can be met within a reasonable period of time.

Finally, the attempt has been made to write the Part II reports in language understandable to the layman. However it has been impossible to avoid technical terms altogether and a glossary explaining these is therefore included in each report.



FP Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

[+]CSIR Research Report 380

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SANDVLEI

1. HISTORICAL BACKGROUND

Synonyms and derivations

Zandvlei	*ca.* 1650 (Burman, 1962)
Sandvlei	(1:10 000 Orthomap Sheet 3418 AB 10)
Sandvlei	(1:50 000 Topographical Sheet 3418 AB & AD)
Sandvlei	(1:150 000 S.A. Navy Chart SAN 119)
Zandvlei	Cape Town City Council (CCC) adopted this version in 1981. The CCC prefers Zandvlei to Sandvlei for the vlei at Muizenberg, Lakeside and Marina da Gama (CCC Press Release 1981-01-19). For electoral purposes the Department of Internal Affairs has accepted the spelling Zandvlei.

Historical aspects

Sandvlei features on charts of the Cape Colony as early as *ca.* 1700 (Walker 1922) and appears to have been named by Van Riebeeck in the 1650s (Burman, 1962). At that time Sandvlei appears to

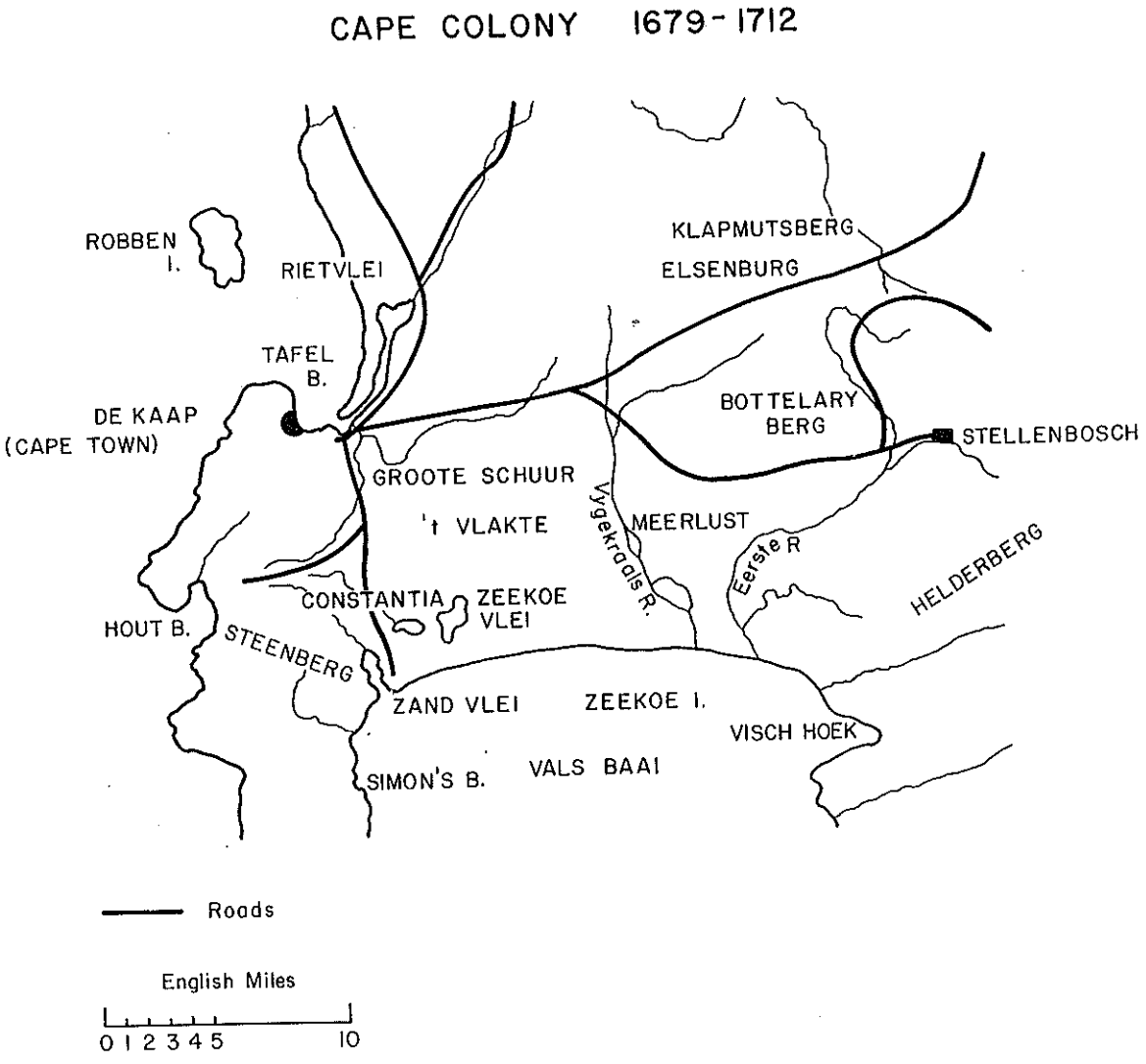


FIG 1: Sandvlei and environs (from Walker, 1922)

have been an inlet adjoining False Bay (Figure 1). The Dutch East India Company established a cattle post on the edge of the vlei in 1673 marking the start of over 300 years of modern human activity in the area. In 1744 the Company established a fortified post to the west of Sandvlei under the command of Sergeant Wynand Willem Muys who gave his name to the seaside resort of Muizenberg (Burman, 1962). Muizenberg village became established as a staging post on the route between Cape Town and Simonstown. Little is known about activity on Sandvlei and in its environs until January 1866 when the water level was greatly lowered by a severe drought (Burman, 1977). Consequently it was considered desirable to drain the vlei completely and to reclaim the land - a process which would also have provided employment during a period of severe economic depression. The vlei was cut off from the sea, the plan being to pump the lake dry. However, the scheme failed because no provision was made to divert the rivers which flow into the vlei in winter. In 1882 the railway reached Muizenberg. The line crosses the north-western portion of Sandvlei on an earth embankment with a bridge allowing passage of water from the Keysers and Westlake rivers to the main body of the vlei. With railway access came the first major recreational use of Sandvlei itself; in June 1884 the first rowing regatta, in which 60 - 70 boats competed was held. Another regatta was held in September 1884 but was not as successful because of the low water level. Consequently plans were made to retain as much water as possible within the vlei (Burman, 1977).

FIG. 2: The railway embankment traversing the northwest part of Sandvlei.

In 1907 the Lakeside Boating Association, later the Imperial Yacht Club, was established and functioned until its disbandment in 1946 as a consequence of the siltation and weed infestation of the vlei (Hocking, 1972). Seasonal falls in water level hampered boating throughout this period. Stephens (1929) stated that Sandvlei would occasionally dry up by the end of summer. Plans for the dredging of Sandvlei were drawn up in 1939 but were postponed for the duration of World War II. Dredging was commenced in 1947 (Cape Town City Engineer's Annual Report, 1947) and by 1961 a total of approximately 1 000 000 cubic yards (760 000 m^3) of spoil had been removed from the vlei to provide 150 acres (60 ha) of open water for boating (Cape Town City Engineer's Annual Reports, 1948 - 1961). At least 81 acres (32 ha) of wetland were obliterated during the dredging operations changing much of the shoreline profile from a gentle gradient to steep, high banks requiring artificial stabilisation. As a result of the dredging, yachting on the vlei was again made possible and the Imperial Yacht Club was re-constituted in 1962 (Hocking, 1972).

In 1969 the Anglo American Corporation proposed the development of Sandvlei as a marina incorporating waterside housing and an ocean yacht harbour. The development, to be known as Marina da Gama, was to have incorporated virtually all of Sandvlei. The eastern component, Eastlake, on the site of a former municipal refuse dump was to be developed first followed by Westlake which was to occupy the wetland area between the railway embankment and Lakeside. Work was started on the southern part of Eastlake in 1970. The canal system was excavated dry i.e. there was no direct connection with the waters of Sandvlei at the time of excavation. Some of the spoil was used to create artificial dunes to shelter the housing development from the prevailing summer southerly wind. Following the global economic recession beginning in 1973 the entire Marina da Gama development was re-evaluated with the result that the ocean harbour project was cancelled as was the construction of Westlake. Thus the existing Marina da Gama occupies the east and north-east shore of Sandvlei and communicates with the main body of the vlei via channels to the north and south of Park Island.

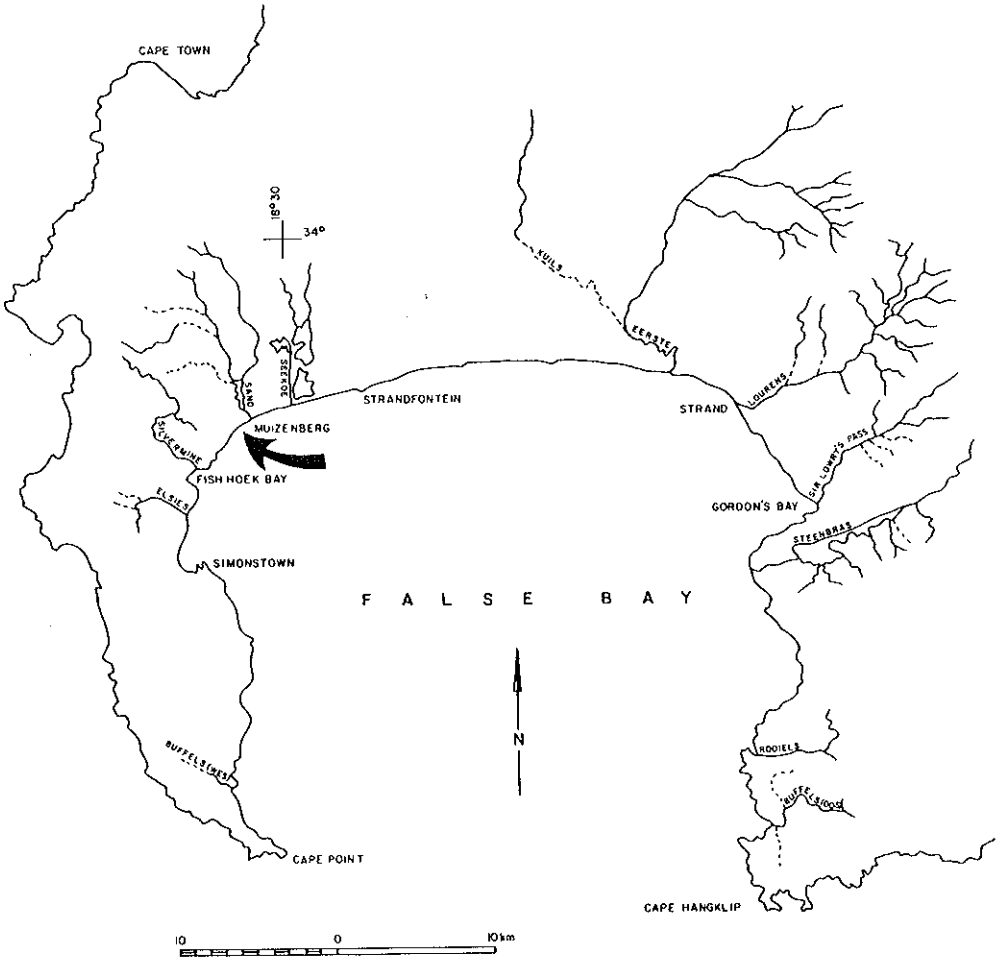
Archaeology

No sites of archaeological interest have been recorded in the immediate vicinity of Sandvlei (G Avery, Archaeology Department, South African Museum, Cape Town, pers. comm.).

2. LOCATION

34°05'S; 18°28'E.

Sandvlei mouth lies approximately 700 metres east of Muizenberg station on the north-western shore of False Bay. Co-ordinates of the mouth: 34°06'24"S; 18°28'42"E.



2.1 Accessibility

The shoreline of Sandvlei except for parts of Marina da Gama (residential) is reserved as public open space for at least 50 - 100 metres from the water's edge. Road access from Main Road, Muizenberg - Lakeside and from Prince George Drive is shown in Figure 3. Access to Wildwood Bird Sanctuary is controlled by the Parks and Forests Department of the Cape Town City Council (CCC). Permits are obtainable from the CCC on written application. The key to the main gate of Wildwood is kept at the CCC Marina da Gama nursery.

2.2 Local authorities

The Sandvlei water body and its entire shoreline are controlled by the CCC. Forty two percent of the catchment is also under CCC control while the remaining 58 percent is controlled by the Divisional Council of the Cape (CDC) and various State Departments including Defence, Forestry and Prisons.

3. ABIOTIC CHARACTERISTICS

3.1 River catchment

3.1.1 Catchment area

The total catchment area is 8 500 ha of which 3 587 ha are controlled by the CCC and 4 913 ha by the CDC and various State Departments. Begg (1976, 1981) consistently errs in giving the Sandvlei catchment as 800 ha.

Lengths of rivers and tributaries entering Sandvlei

River	Length (km)	Managing authority
Little Princess Vlei Stream	1,05	CCC
Westlake Stream	4,70	0,1 km CCC: 4,60 km CDC & others
Westlake Stream tributaries	1,10	CDC & others
Keysers River	7,50	3,95 km CCC: 3,55 km CDC & others
Keysers River tributaries	2,20	CDC & others
Langvlei Canal	3,95	CCC
Sand River Canal/Diep River	12,60	5,8 km CCC: 6,8 km CDC & others
Total length of all rivers entering Sandvlei:	33,10	

These streams drain a basin bounded by Wynberg Hill, Cecilia Ridge (Table Mountain), Constantiaberg, Silvermine Plateau, Muizenberg Mountain and a less obvious watershed running roughly N - S approximately 1 km east of Sandvlei (Figure 5). The main systems in terms of length are the Keysers River and the Sand River Canal/Diep River. The Keysers River runs parallel to the railway embankment on its west side and enters the Westlake portion of Sandvlei through an extensive reed bed. The Westlake Stream also enters this reed bed at its western extremity. The combined waters of the Keysers River and Westlake Stream enter the main basin of Sandvlei via the single bridge in the railway embankment. The confluence of the Sand River and Langvlei Canal lies approximately 1 km north of Sandvlei. These combined canalised streams enter the vlei on the east side of Wildwood Island.

Geomorphology

The eastern half of the catchment forms part of the Cape Flats and is a recent marine coastal plain. The western half slopes upwards to the west, the watershed being located on a resistant mountain scarp.

Geology

The original Malmesbury System shales and quartzites in the western Cape were intruded by Cape Granite and the resulting formation was overlaid by Table Mountain Sandstone. Subsequently

FIG. 3: Sandvlei Estuary

Drawn from Aerial Photograph No. 272/4 JOB 391 (1981)

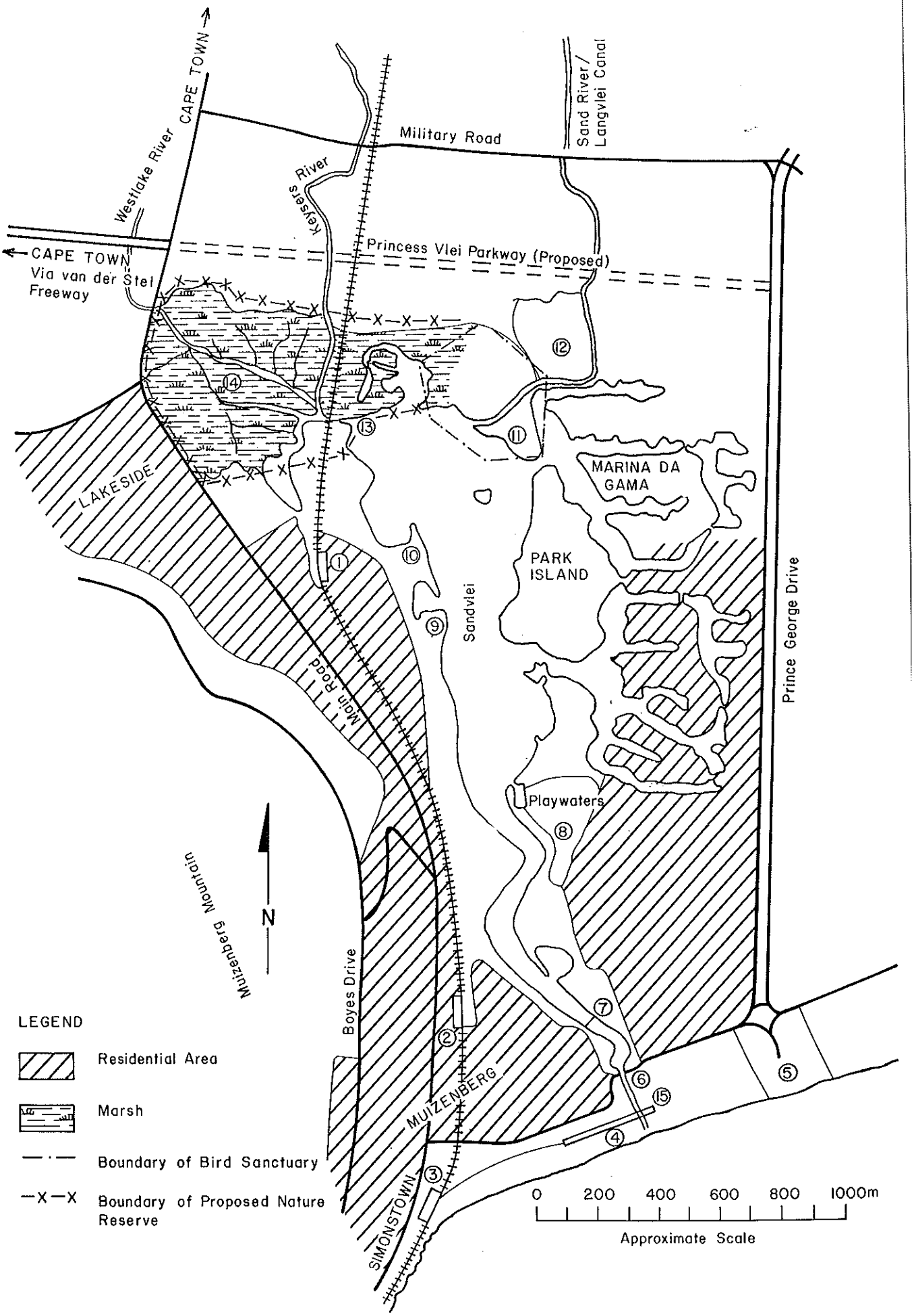


FIG. 3: SANDVLEI ESTUARY

1. Lakeside Station (SATS)
2. False Bay Station (SATS)
3. Muizenberg Station (SATS)
4. The Promenade
5. Sunrise beach
6. Royal Road bridge
7. Thesen's footbridge
8. Playwaters (Sandvlei caravan park)
9. Imperial Yacht Club
10. Sea Scouts Headquarters and SA Navy League Headquarters
11. Wildwood Bird Sanctuary
12. CCC Marina da Gama nursery
13. Bridge allowing passage of water from the Keysers and Westlake Rivers into Sandvlei proper
14. Westlake reed-marsh
15. Radial well

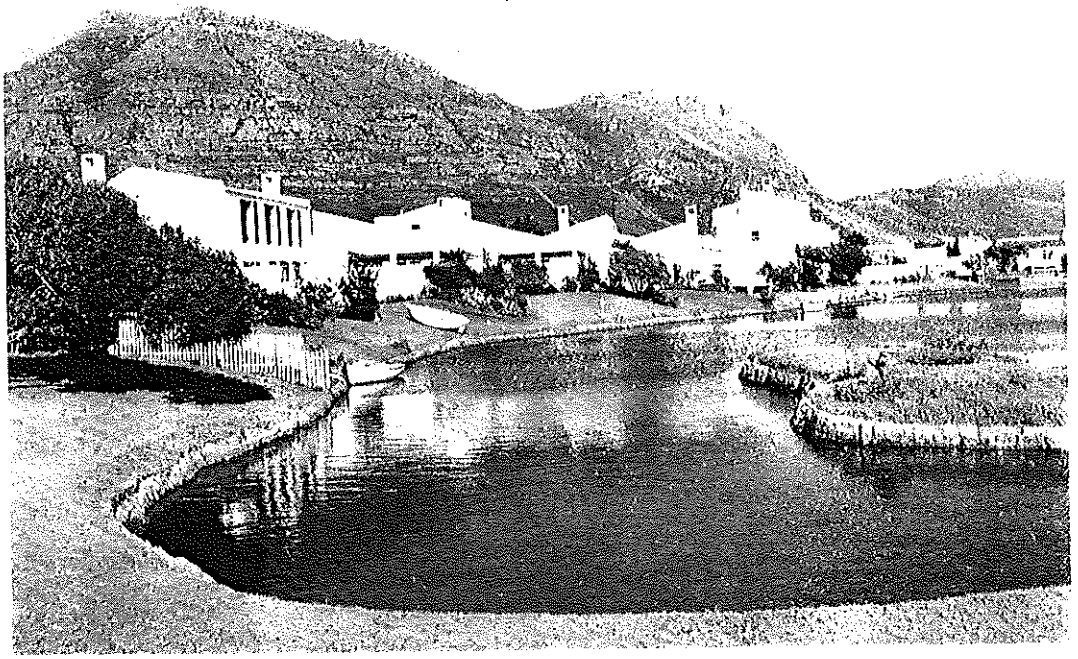
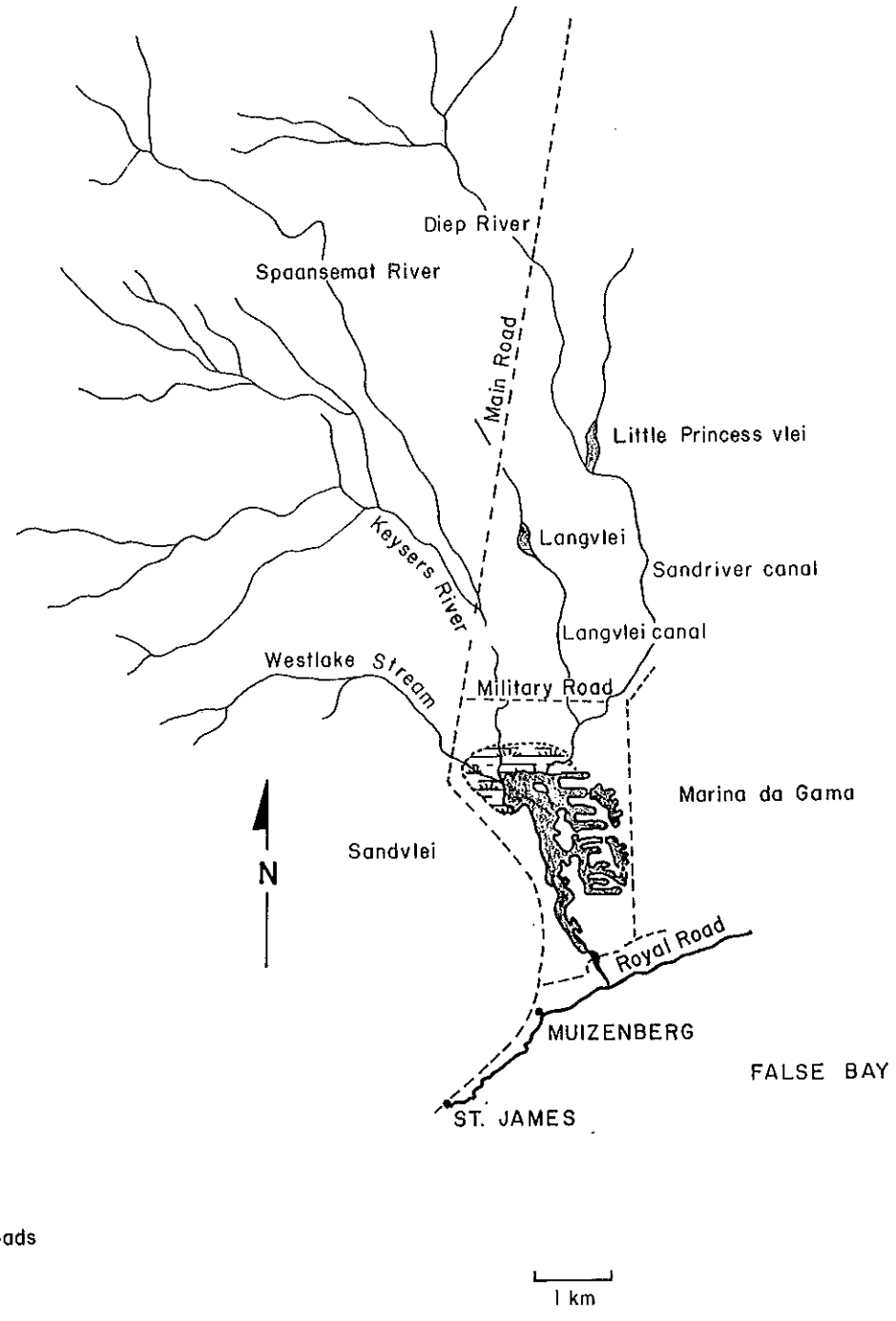


FIG. 4: Marina da Gama: waterside housing on canals with artificially stabilized banks.

FIG. 5: The catchment area of Sandvlei. (from Begg, 1976.)



the sandstone was eroded to expose the underlying granite and Malmesbury System rocks (Haughton, 1969). The soils to the east of Sandvlei consist of fine-grained quartzitic sands mixed with marine shell fragments. To the west of the vlei the soils contain alluvium washed down from the catchment.

The rivers and watercourses draining into Sandvlei rise in the mountains to the north and west and on the sandy flats to the north. The sandstones of the Table Mountain Series impart a particular character to both the vegetation and the dissolved solids in the waters which drain from the mountainside. The water is soft, peat-stained (dark brown) and slightly acid. The Table Mountain Series consists of hard (quartzitic) sandstones generally indurated (hardened) under pressure and by secondary silicification. At the base of the sandstone there is a thin band of softer shale richer in iron and manganese than is the sandstone above. Iron derived from the shale and sandstone was precipitated as a lateritic layer or "koffieklip". A band of koffieklip approximately one metre thick has been encountered in the vicinity of Sandvlei and beneath it (the vlei) and has proved difficult to dredge hydraulically (Heydenrych, 1976). Calcareous material on the Cape Flats leads to slightly alkaline drainage from that area.

Rainfall

Sandvlei lies in a Mediterranean climatic region (Schulze, 1965) receiving the bulk of its rainfall in the winter from about May to September, and having a warm to hot dry summer. During the winter 12 to 15 days of rain per month may be expected whereas in the summer only 4 to 5 rainy days per month generally occur. There are several rain gauge stations in the catchment area with reasonably long-term records. Mean monthly rainfall figures from two of them are presented below: A. Tokai State Forest Station close to the western mountain scarp and B. Plumstead on the eastern edge of the catchment.

A. Tokai State Forest Station: 34°03'S; 18°25'E. 72 year record.

Mean annual rainfall = 983,6 mm

Mean monthly rainfall (mm):

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
26,1	21,1	30,7	76.6	134,2	164,5	152,9	140,5	96,7	68,0	43,3	29,0

B. Plumstead: 34°01'S; 18°28'E. 30 year record.

Mean annual rainfall = 887,4 mm.

Mean monthly rainfall (mm):

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
18,3	13,7	14,0	54,9	124,2	193,8	155,7	129,0	84,8	51,8	32,0	15,2

Run-off

No quantitative data are available; however the Sewerage Branch of the City Engineer's Department is investigating the feasibility of installing flow gauges on the main streams flowing into Sandvlei (CCC City Engineer, pers. comm.).

Several hundred stormwater run-off drains discharge into the major open water courses. It is estimated that the average surface run-off is 10 percent of the rainfall, the remaining 90 percent is either lost to evaporation or goes to replenish the ground water. As more of the catchment area is developed, i.e. as the proportion of impervious surface increases, there will be more canalization as the run-off factor increases. Much will depend upon how close to the watercourses housing development will be permitted since the closer houses are to the streams the greater the need for control and canalization. Run-off is also dependent upon antecedent moisture levels prior to major storms: if moisture levels are high, run-off will approach the maximum possible.

3.1.2 Land Ownership/Uses

Land under control of the CDC and State Departments

This comprises 58 percent of the catchment area and consists mainly of middle- to upper-income group housing (low-density), agricultural land, afforested areas and natural *fynbos* vegetation. The water draining from these areas is likely to contain leached-out fertilizers (from both agricultural and domestic sources) and pesticides or pesticide residues. Agricultural activities consist primarily of viticulture, market gardening, dairy and poultry farming. All these activities can potentially contribute to the eutrophication of the rivers and hence to that of Sandvlei. The agricultural component of the catchment can be expected to diminish with time as urbanisation increases.

Land under the control of the CCC

This area, 42 percent of the catchment, is predominantly urbanised. Light industries and both middle- and lower-income housing are present. A 2 000-unit housing area is to be built between the proposed Princess Vlei Parkway (Proclaimed Main Road 8) and Military Road and bounded in the west by the main Cape Town - Simonstown railway line and in the east by Prince George Drive. The Sand River canal banks are to be incorporated into the open space system of the housing scheme. The construction of the parkway (PMR 8) has been postponed indefinitely as a result of the present economic circumstances. The low-income housing areas are the source of a considerable amount of refuse which enters the influent streams. These areas are also a source of faecal contamination of the river system. Begg (1975a) identified the light industries as potential sources of pollutants. Further development of the Retreat light industrial area, now in progress, will necessitate more stringent control to prevent effluents from entering the Keysers River and hence Sandvlei. The CCC Marina da Gama nursery will be expanded, in the next decade, along the northern edge of Wildwood Bird Sanctuary. The

main railway line will form the western boundary of the nursery while the Princess Vlei Parkway will form the northern boundary. The combination of the parkway and the nursery will serve as a valuable insulator or separator between the low-income housing area and Sandvlei/Marina da Gama.

3.1.3 Obstructions

Langvlei (Figure 5) is a shallow natural system that has become heavily polluted and so infested with *Eichhornia crassipes* (PD Morant, pers. obs.) that it obstructs the water flow. Plans are being drawn up (CCC) for the cleaning, deepening and landscaping of Langvlei which is to become a recreation area/park. It is possible that some aquatic macrophyte cover will be retained to trap nutrients that otherwise would enter Sandvlei.

The level of Little Princess Vlei, on the Diep River, is controlled by a weir at the Southern end. There is a shallow gabion wall on the Keysers River where it passes under the Van der Stel freeway ("Blue Route").

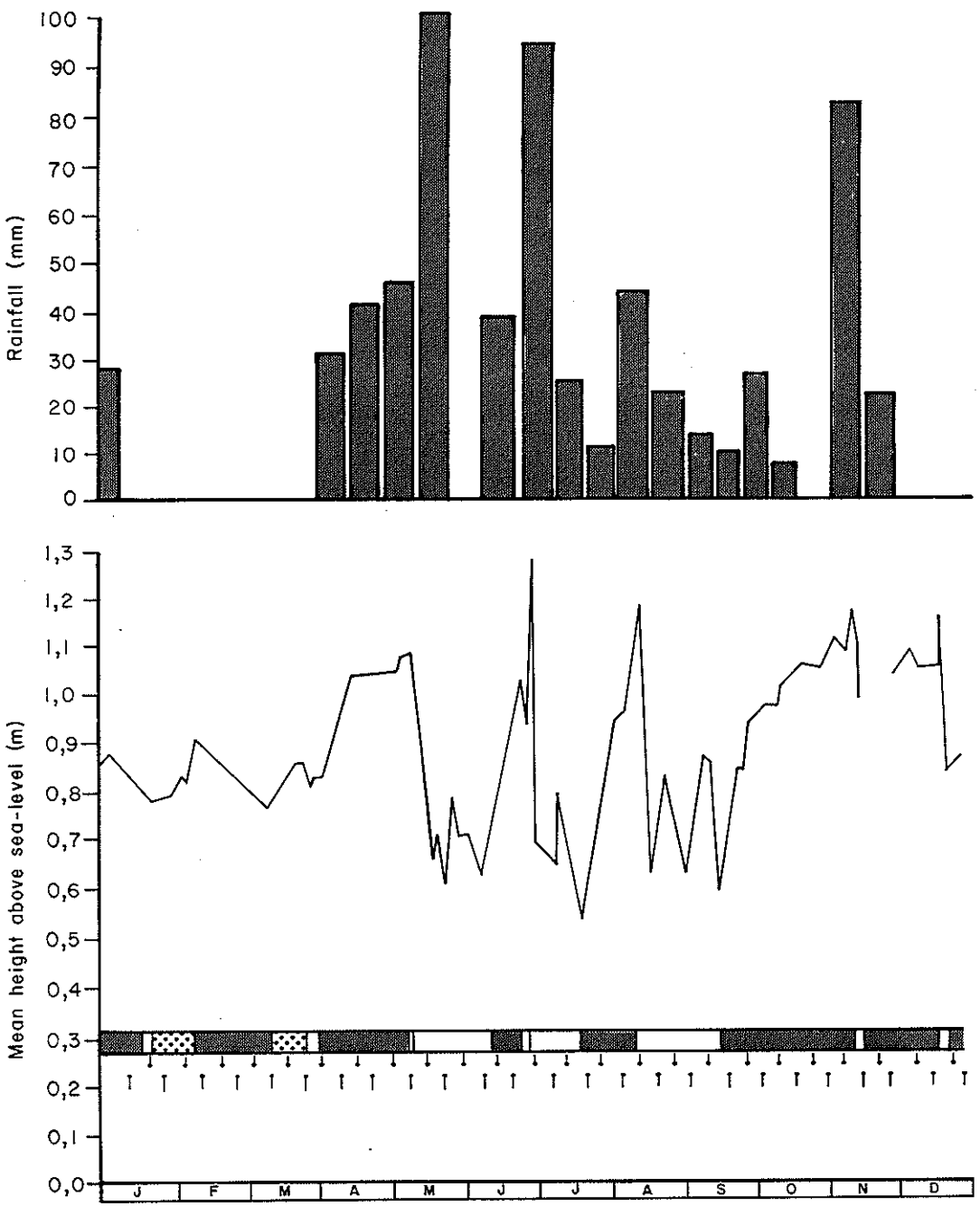
The bridge in the railway embankment between the Westlake wetland and the main body of the vlei restricts water flow. During periods of low rainfall dinghies and canoes have to be manhandled under the bridge in order to pass from the main vlei to the wetland.

3.1.4 Siltation

Loose material blown from unstabilized areas e.g. building sites, farm lands and road grit, enters streams flowing into Sandvlei. A distinct delta is forming where the Sand River enters the vlei. A sediment/garbage trap now being designed in the Sewerage Branch of the City Engineer's Department will be built immediately downstream of the Sand River and Langvlei canal confluence. The extensive *Phragmites* and *Typha* reed beds in the Westlake (north-west) area of Sandvlei trap much of the material which would otherwise enter the main vlei basin from the Keysers and Westlake rivers.

3.1.5 Abnormal Flow Patterns

Flood history is vague. One major reason for the reclamation and deepening of Sandvlei was to prevent seasonal flooding in areas to the north e.g. Retreat and Vrygrond (Stephens, 1929, Cape Town City Engineer's Annual Report, 1947). The highly urbanised nature of much of the Sandvlei catchment has necessitated flood prevention schemes which channel their effluent to Sandvlei e.g. the Sand River Canal. Generally high water levels in Sandvlei correlate with periods of high rainfall i.e. in winter (Figure 6) (Benkenstein, 1981).



RAINFALL IN CATCHMENT AREA
(Kendal Rd)

ESTUARY LEVEL (metres above sea-level)

SAND-BAR FORMATION

Bar closed

Radial well pumps in operation

Bar open

TIDES

↓ Spring tide

↑ Neap tide

FIG 6: HYDROLOGY OF SANDVLEI 1980 (from Benkenstein, 1981)

3.2 Estuary

3.2.1 Estuary characteristics

Sandvlei today is the result of many years of human modification not only to the vlei itself but also to the river catchment feeding it. If early maps can be relied upon (Figure 1) (Walker, 1922) Sandvlei had a wide mouth in which drainage channel(s) moved in response to various physical factors such as outflow volume, tides, longshore drift and wind. At that time, 300 years ago, Sandvlei probably functioned as a true, tidally flushed, estuary for most of the year. Mouth closure occurred probably only towards the end of summer.

Currently the mouth of Sandvlei is subject to contingency management in order to maintain the water levels as close as possible to the designed (for Marina da Gama) optimum level of 0,7 - 0,9 metres above mean sea level. Thus the estuary functions either as a closed or blind estuary or, when open to the sea, as a partially mixed system (Day, 1981).

Estuary area, configuration, morphometry

Sandvlei can be divided into three basic components:

1.	The main vlei basin	57,4	
2.	Marina da Gama canal system	32,6	
3.	The Westlake wetland	31,0	(3,8 ha open water)
	TOTAL AREA	121,0 ha	

Figure 7 shows the water surface areas of the various components of the Sandvlei/Marina da Gama system. Cape Town City Council proposes to dredge the vlei hydraulically to a mean depth of 2 m, remove the small island and sandbank in the northern basin, remove spoil from the west side of Park Island and eliminate the tip of Peninsula Park. This would increase the main vlei area by a further 2 - 3 ha. Dredging operations are tentatively scheduled for late 1983 (Cape Town City Engineer's Dept., 1981). These modifications are aimed at improving the vlei for sailing activities. The greater depth in the main vlei should also improve water circulation to and from the Marina da Gama canal system.

Sandvlei is a shallow basin approximately 2,5 km long and 0,5 km wide at its widest point (excluding Marina da Gama) near the northern end. The main axis of the system lies almost exactly north-south roughly coincident with the direction of the summer southerly and winter northerly winds. The orientation of the vlei thus allows good wind-induced mixing of the water. Water levels in the vlei are reported to fluctuate between m.s.l. + 0,7 m and + 1,3 m. The water level is augmented in summer by pumping saline water from a radial well pumping station at the beach front (Figure 3) into the channel just upstream of the rubble weir.

FIG 7 : Sandvlei water surface areas 1981
(Source: Cape Town City Council)

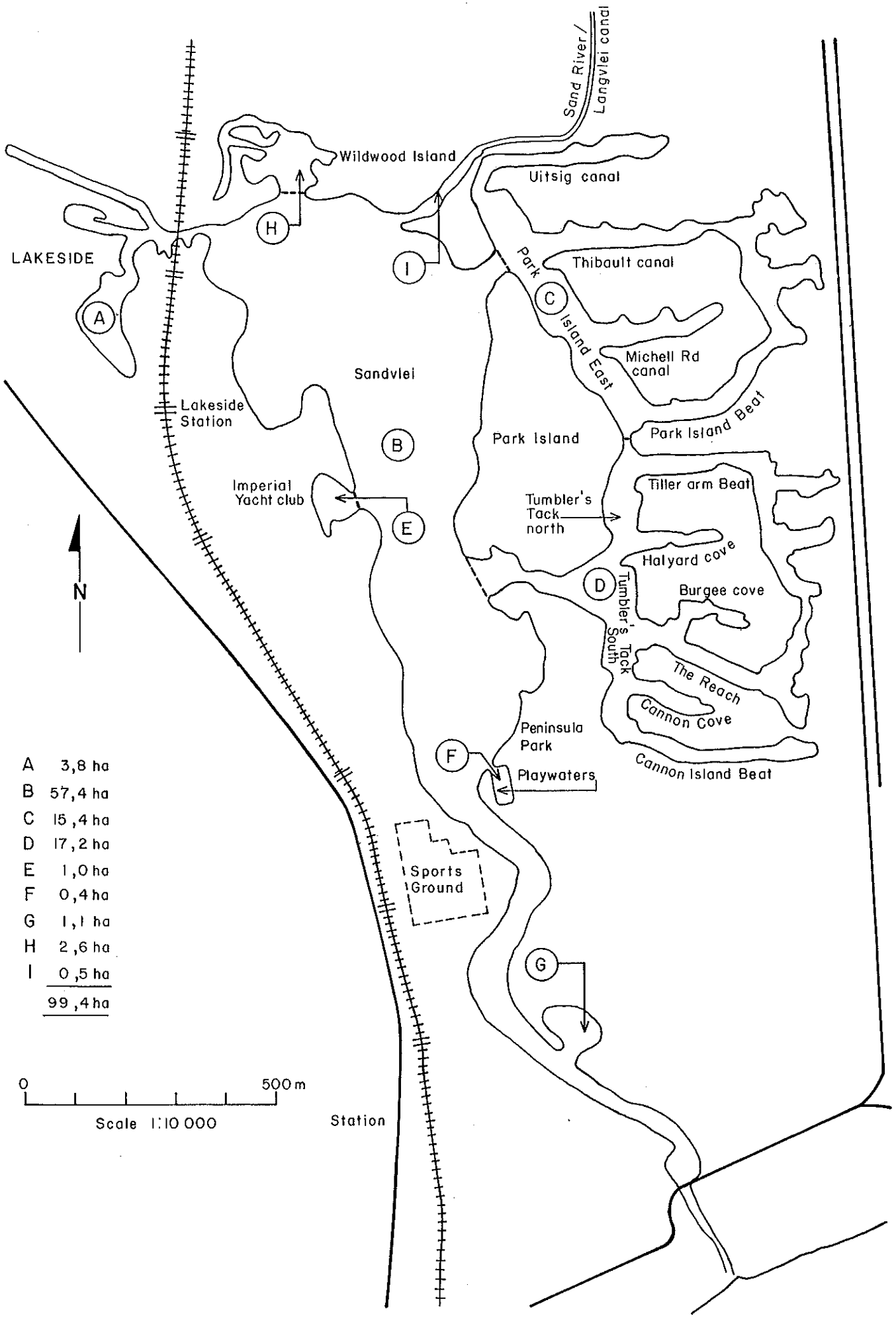
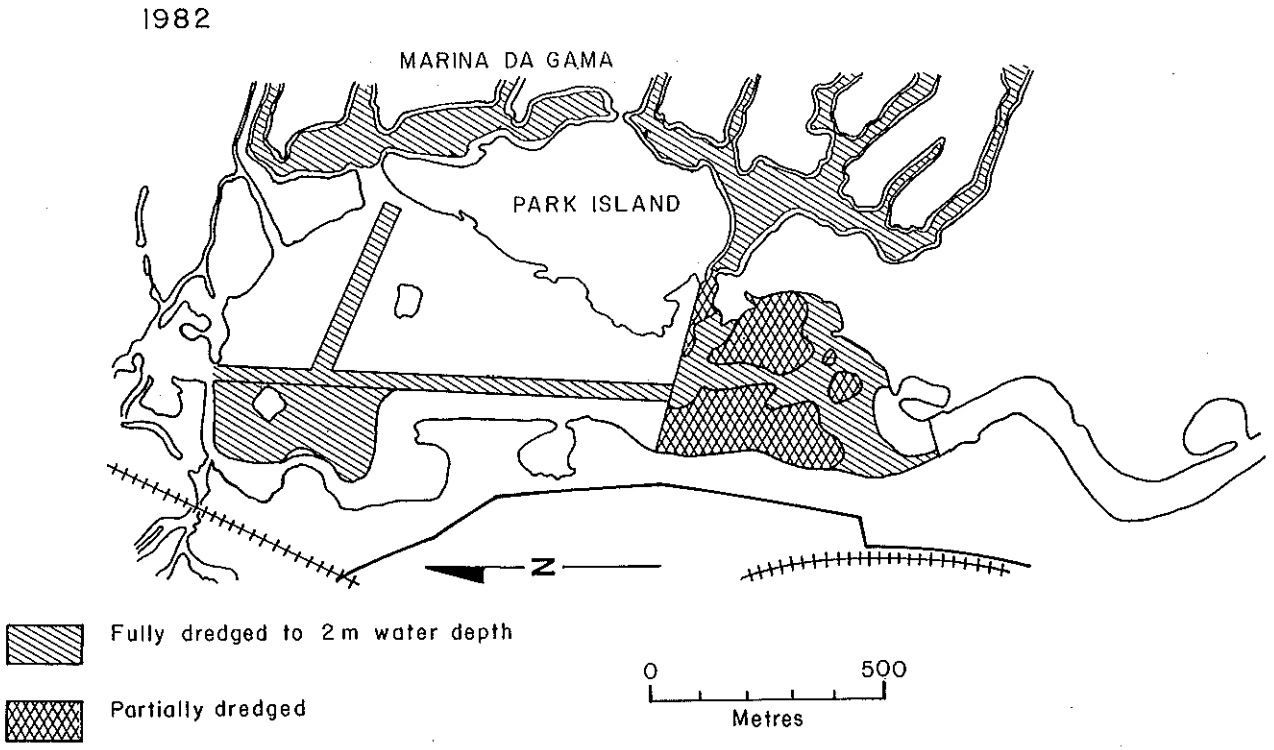
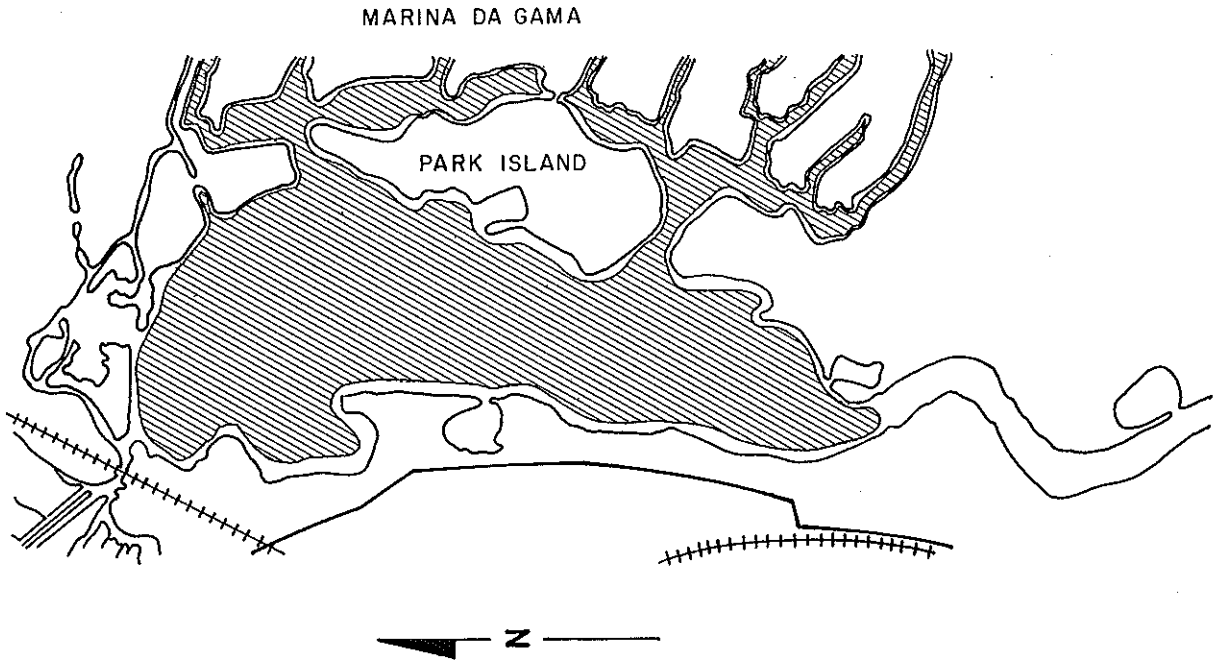


Fig 8: Bathmetry & Shoreline of Sandvlei. (from Cape Town City Engineer's Dept., 1981)



Configuration after proposed dredging



Sandvlei & Marina da Gama dredged to a uniform 2m water depth

The bottom profile is complex since Sandvlei has been subject to a series of dredging programmes since 1947. Currently much of the vlei scarcely exceeds one metre in depth particularly at the northern end (Figures 8 and 9). Two experimental dredged channels of about 2 m deep have been excavated in the main body of the vlei (Figure 8). Dredging has also been undertaken in the area between the Imperial Yacht Club and Playwaters where the depth varies between 1 and 2 m. Two channels, north and south of Park Island, on the east side provide access to Marina da Gama. The Marina da Gama canal system has been excavated to provide a mean water depth of 2 metres.

Geomorphology and Bottom Material

(This section is contributed by by Dr GAW Fromme of the Sediment Dynamics Division, NRIO.)

Sandvlei lies at the south-western extremity of the Cape Flats. The western shore lies close to the steep sandstone slopes of Muizenberg mountain while the eastern and northern shores are bounded by the remains of the sand dunes which formerly were prominent in the area. The present form of Sandvlei bears little resemblance to the original. Prior to dredging of the vlei the shore gradient was gentle and the water was surrounded by extensive muddy marshlands (Stephens, 1929).

Shelton (1975) found that there was no gradation of bottom material particle size from the head of the estuary to the mouth. This is probably due to the severe disturbance of the bottom material caused by the extensive dredging operations undertaken between 1947 and 1961. Generally there is a gradation of particle size in an estuary from fine muds in the upper reaches to course sands at the mouth (Day, 1951).

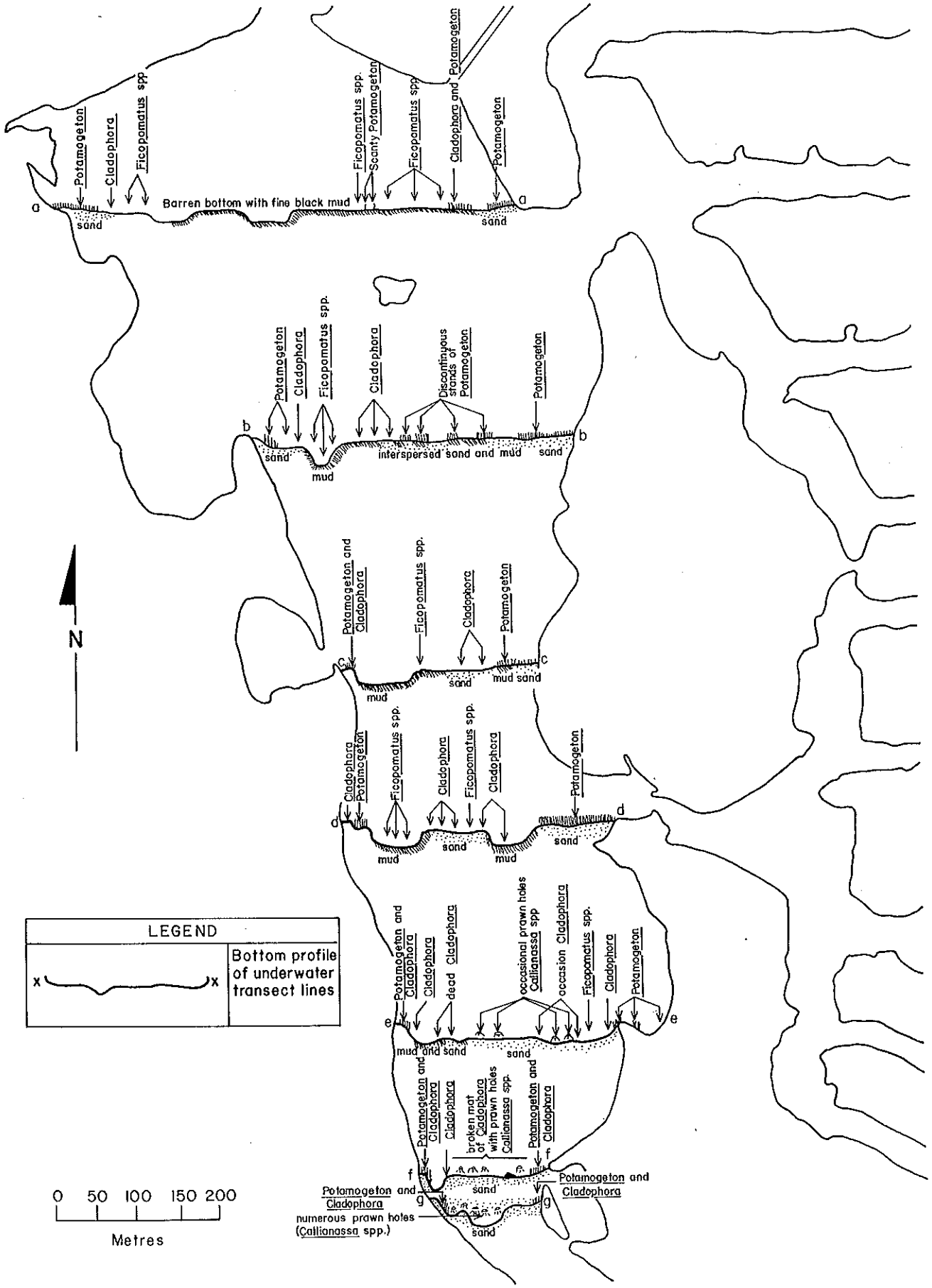
During the ECRU surveys in May and June 1982 medium to coarse shelly sand was found at the mouth of the channel, while at the adjacent beaches the sand was fine.

Results of a detailed on- and off-shore investigation of the Muizenberg beaches is given in a coastal engineering report on the Muizenberg Marina da Gama Project (Muizenberg, Marina Project, 1971). The sand grain sizes were found to be mainly in the fine to medium size range, with some coarse sand occurring occasionally during the summer. Generally, the sand grain sizes were greater at the east beach than at the west beach.

This does not appear to agree with the beach slopes as steeper slopes are usually associated with coarser sand grains. According to the Muizenberg Marina Project (1971) the mean onshore slope was 1:33 at the east beach and about 1:29 at the west beach, thus steeper at the west than the east beach, whereas at the mouth the slope was 1:40. The conditions during the ECRU surveys in May/June 1982 were similar, except that the slope at the mouth was smaller, namely 1:50 and the sand was coarse. This was due to the strong outflow from the mouth channel building up a large flat delta in the surfzone and depositing coarse sand in

Fig. 9: Sandvlei: Bottom features as revealed by seven underwater transects (Bottom profiles after Furness, 1978)

From Benkenstein (1982)



that area. A possible explanation for the disagreement of beach slopes and sand sizes is given in section 3.2.2 below.

3.2.2 Estuary Mouth Dynamics

Inshore Oceanography

The characteristics and dynamics of a river mouth are closely related to:

(a) the topography and geomorphology of the coast;

(b) the wave and current regime of the nearshore and offshore zone.

For an investigation of littoral dynamics it is necessary to assess the wave climate on the coast. Wave data, covering a 20-year period, on deep-sea wave direction, height and period (Swart and Serdyn, 1982) and wave refraction diagrams for False Bay (Vaslbaai Strandverbeteringe, 1980) were used to compute the *total inshore wave energy* and the *average energy wave height* at each river mouth studied for the series of ECRU Part II reports on False Bay.

It was found that the inshore wave energy for the Muizenberg beach (Sandvlei River mouth) was 30 per cent above the mean energy calculated for the ten beaches/river mouths around False Bay (Buffels (west); Elsies; Silvermine; Sand; Seekoe; Eerste; Lourens; Sir Lowry's; Steenbras and Buffels (east)). The average energy-wave height was 1,06 m. This ranks the beach at the Sandvlei River mouth as a medium- to high-energy beach.

During the preparation of the Muizenberg Marina Project Report, 1971, the surfzone currents were also measured. The average current had a low velocity of 0,09 m/s and flowed in an easterly direction. With this predominantly east-bound surfzone current the coarse sand which occurs at the mouth of the channel is also transported eastward, where it is deposited on the beach. Tracer tests and the results of theoretical longshore sand transport computations carried out during the above study confirm a net longshore sand movement in an easterly direction with a sand volume of up to 6 500 m^3/year.

According to a statement in the Muizenberg Marina Project Report (1971) (p5, section 3.2) the onshore beach profiles "displayed a considerable degree of stability throughout the period of investigation" (August 1970 - September 1971). A similar impression was also gained during the ECRU surveys in May/June 1982.

Local erosion and underscour of the channel walls was observed at the mouth where the beach displayed 0,5 to 1 m-high erosion scarps caused by wave attack which also threatens a few beach huts in this area (Figure 10). This should, however, be considered as a normal and natural erosion pattern at a river

mouth. Consideration should therefore be given to the question as to whether costlier deeper foundations to the walls, or preferably an adaptation of the position and shape of the walls and removal of the few threatened huts would not be the answer to this problem.

A brown discolouration of the water which frequently occurs in the vicinity of the Seekoe mouth is mainly caused by a bloom of the marine diatom *Anaulus birostratus* (R Bally, Zoology Department, University of Cape Town, pers. comm.). Diatom blooms are known to occur in the surfzone at other localities in southern Africa and elsewhere (McLachlan and Lewin, 1981). However, in view of the large volume (80 Mℓ/day) of nutrient-rich treated sewage effluent entering the sea at the Seekoe mouth, it is highly probable that this local nutrient enhancement promotes the persistent phytoplankton blooms in the area.

During the ECRU surveys observation of the spreading of intense brown discoloured water in the surfzone east and west of the adjacent Seekoe River mouth (2,25 km east of the Sandvlei mouth) gave an indication of prevailing surfzone current directions. On 28 May, 1982, the discoloured water was seen approximately 2 km east and about 1 km west of the Seekoe mouth. On 7 June 1982 the discoloured water almost reached the Sandvlei mouth 2,25 km to the west (including the popular Sunrise Beach) and also spread about 1 km to the east. This indicates that the current is rather intermittent and implies that the Muizenberg beaches are within reach of treated sewage effluent from the Seekoe River mouth. This does not, however, have any health hazard implications.

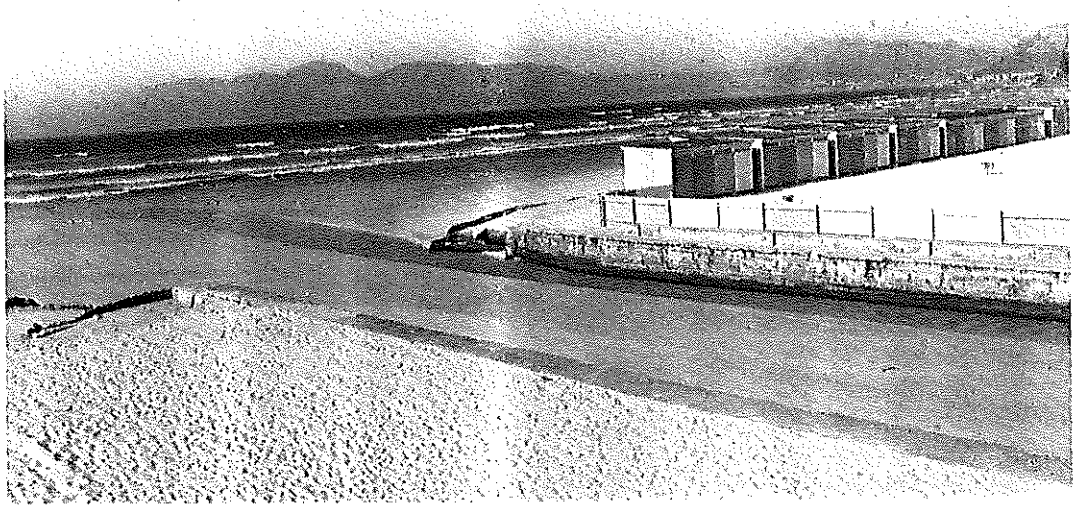


FIG. 10: The canalized mouth of Sandvlei. Note the collapse of the concrete walls at the seaward end.

3.2.3 Land Ownership/Uses

Most of the shoreline is owned by the Cape Town City Council except for the residential and commercial components of Marina da Gama. The north-western area, Westlake, is also to be acquired by the City Council. The CCC-owned land is reserved almost entirely for public open space as is the water surface and is used for land- and water-based recreational and educational purposes. To this end nature trails are to be laid out and an information centre constructed (CCC Engineer, pers. comm.).

Park Island is to be developed as a limited access recreational area and Peninsula Park is to be provided with facilities for board sailors. It is also planned to improve existing recreational facilities on the eastern and western shoreline in the southern portion of the vlei (Cape Town City Engineer's Dept., 1981). The western part of Sandvlei is bounded by middle-income housing fronted by recreational facilities including the Imperial Yacht Club, the Sea Scout Headquarters and the S.A. Navy League property.

3.2.4 Obstructions

Weirs

A rubble weir (Figure 11) at the mouth of Sandvlei helps to control the water level of the vlei which is affected by a combination of tidally-induced changes and those caused by rainfall in the catchment area. A sandbar forms at the mouth when there is no outflow (usually in summer). The crest level of this sandbar usually reaches a level of 1,5 - 2,0 metres above mean sea level (Heydenrych, 1976). During flood periods the sand bar is bulldozed to allow free egress of water from the vlei. Begg (1975) indicated that the rubble weir and bulldozer approach

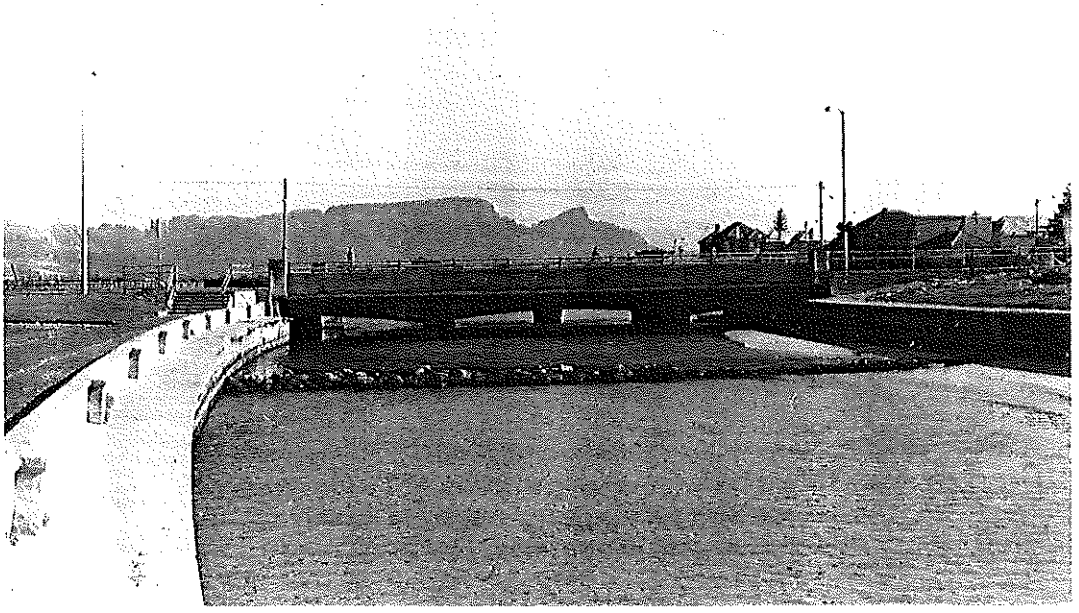


FIG. 11: The rubble weir used to control the water level in Sandvlei, Royal Road bridge in the background.

was insufficiently flexible for the management of the water level and that there was a need to control such levels by a more sophisticated means.

Bridges

The most important obstruction is the 700 metre-long railway embankment running north-south across the north-western part of the vlei (Figures 2 and 3). A single culvert allows the passage of water from the Keysers and Westlake rivers into the main body of the vlei. Behind this barrier there is an extensive *Phragmites* and *Typha* reed marsh very different in character from the main body of the vlei.

Royal Road bridge spans the canalised outlet portion of the systems some 200 metres from the sea (Figure 11).

3.2.5 Physico-chemical Characteristics

Various physico-chemical characteristics of Sandvlei have been analysed since 1973. The results have been summarised in the Cape Town City Engineer's Annual Reports for 1973 - 1978, and by Begg (1975a), Benkenstein (1981, 1982) and Furness (1978). The results are not always directly comparable since sampling stations have been changed and the Marina da Gama canal system was connected to the main body of Sandvlei during this period. The physico-chemical data are summarised in Table 1. For a more detailed picture of the physico-chemical regime of Sandvlei the reader is referred to the above-mentioned reports and publications.

The value of the physico-chemical data is, however, somewhat limited since no flow data are available. In order to be able to understand the nutrient regime of Sandvlei i.e. the loading and retention parameters, a knowledge of flushing time and the input from marine and freshwater sources volumetric flow data are essential. Allanson (1977) stated that ".... the determination of phosphate or nitrogen concentration levels without consideration of the rate at which these elements are being delivered to and discharged from a vlei system is of very little consequence". The installation of flow gauges on the influent streams and at the mouth has been recommended by three environmental consultants retained by the Cape Town City Council (Howard-Williams 1976, Allanson 1977, 1978a, 1978b and BR Davies, Zoology Department, University of Cape Town, pers. comm.) and should, therefore, receive very high priority.

pH

The pH of the influent rivers tends to be circumneutral to slightly alkaline. The Sand River/Langvlei canal system tends to be the most alkaline with pH values reaching 9,1 in summer. The elevated pH values may be due to photosynthetic activity: in vleis containing actively photosynthesising macrophyte vegetation there is a diurnal fluctuation in pH. The lowest values occur at dawn and the highest in the late afternoon (Schutte and Elsworth,

TABLE 1: Sandvlei: Physico-chemical data for 10 sampling sites

	Sand River		Langvlei Canal		Keysers River		Westlake River		Sandvlei North		Sandvlei Centre		Sandvlei South		Sandvlei Mouth		Tiller Arm Beat		Burgee Cove	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Surface Temperature °C	13,0	27,0	13,0	31,0	11,0	24,2	12,3	27,0	11,7	24,2	11,0	24,3	11,5	24,0	11,0	23,5	13,5	24,1	11,8	24,2
Bottom Temperature °C	No data		No data		No data		No data		13,5	24,2	12,2	23,1	12,0	23,7	15,8	23,5	15	23,2	12,0	23,7
pH	6,3	9,1	6,9	8,5	6,5	8,5	5,8	8,5	6,8	9,2	8,0	9,2	6,5	8,9	5,9	8,6	7,1	8,6	7,6	8,9
Salinity $^{o}/_{oo}$	0,04	1,09	0,26	1,24	0,04	0,38	0,22	10,67	5,62	19,52	2,23	19,34	0,89	21,33	4,54	21,69	6,85	26,20	4,78	25,30
Surface DO mg/ℓ	8,6	16,6	1,5	20,0	0,3	12,0	1,5	10,8	6,4	11,8	6,8	17,0	2,5	14,1	3,2	13,4	6,3	10,2	4,5	12,0
Bottom DO mg/ℓ	No data		No data		No data		No data		0	8,8	0	12,0	0,5	9,7	2,9	6,5	0	10,8	0	11,0
Transparency m	No data		No data		No data		No data		0,2	1,2	0,2	1,8	0,2	1,7	-	-	0,4	1,5	0,5	1,6
Sulphate as SO_4 mg/ℓ	26	120	19	116	12	58	39	525	189	1 477	330	1 580	330	1 499	235	1 670	477	1 709	529	1 627
PV_4 mg/ℓ	4,1	12,3	5,5	43,5	4,1	33,2	5,1	33,5	0	11,5	0	12,7	2,1	9,7	2,1	9,0	3,1	20,6	3,9	55,8
BOD mg/ℓ	0,1	12,3	0,6	17,0	0,1	14,0	1,1	19,3	3,9	11,0	0,5	18,1	0,4	10,1	1,2	8,1	1,6	7,9	1,4	7,9
Ammonia as N mg/ℓ	0,16	1,32	0,06	30,9	0,04	0,79	0,03	5,28	0,01	1,12	<0,01	2,6	<0,01	0,34	0,09	0,42	0,09	0,42	<0,01	3,4
Nitrite as N mg/ℓ	<0,01	0,18	<0,01	0,11	<0,01	0,1	<0,01	0,06	<0,01	0,2	<0,01	0,29	<0,01	0,27	<0,01	0,42	<0,01	0,42	<0,01	0,03
Nitrate as N mg/ℓ	0,21	4,20	0,23	7,45	0,01	1,89	0,04	2,08	<0,01	0,46	0,01	1,18	<0,01	1,48	0,02	1,28	0,01	0,27	0,01	0,16
Alkalinity as $CaCO_3$ mg/ℓ	40	221	165	303	37	94	54	153	89	230	64	257	61	229	52	226	126	253	113	270
TDS mg/ℓ	262	1 304	658	1 348	258	638	344	11 866	6 660	21 874	2 536	21 838	984	21 155	2 014	25 422	7 580	25 791	7 194	23 916
Conductivity mS/m	43	116	83	180	43	95	43	1 890	740	2 700	375	2 700	149	2 730	280	3 080	860	3 100	820	2 910
Total Phosphorus as P mg/ℓ	<0,01	0,54	<0,01	1 780	<0,01	0,4	<0,01	0,58	<0,01	0,26	<0,01	0,26	<0,01	0,27	0,01	0,25	<0,01	0,20	0,01	0,16

1954). Thus for comparative purposes observations should always be made at the same time of the day. The short Westlake Stream draining almost directly off Table Mountain sandstone is the most acid of the influent streams. The Sand River/Langvlei Canal System is more alkaline but not conspicuously so. Seasonal fluctuations occur with the highest values being obtained in the late spring - early summer period (October - December) which probably correlates with maximum photosynthetic activity in the vlei (Benkenstein, 1981). The vlei itself is generally more alkaline than the influent streams. However, wide pH ranges occur as the result of the influx of seawater, fresh water (from stormwater drains) and photosynthesis. These fluctuations are indicative of an environment under stress and probably contribute to a reduced species diversity.

Temperature

Sandvlei displays a high degree of thermal homogeneity not only with respect to depth but also from head to mouth. Thermal stratification occurs infrequently because of the shallowness of the vlei and the general windiness of the area. Only under calm conditions in late autumn (May - June) do surface temperatures differ significantly from bottom temperatures (Benkenstein, 1982).

Transparency

Water transparency (Secchi disc method) varies from 0,2 m to 1,8 m with a mean value for the whole system of 0,7 m. Benkenstein (1982) reports a marked decrease in transparency in early spring, a time when phytoplankton blooms could be expected. However, no correlation with an increase of phytoplankton chlorophyll *a* nor with the suspended solid load in the water column could be made. Light penetration is sufficient for *Potamogeton pectinatus* to become established throughout the main basin of the vlei. Should the vlei be dredged to 2 m as planned, *Potamogeton* growth should be considerably restricted at present levels of water clarity. Benkenstein (pers. comm.) reports that during a dive in February 1982 no *Potamogeton* growth was seen at the bottom of the dredged channels and that light penetration was extremely poor. However, should the waters become clearer the *Potamogeton* will have to be controlled by regular harvesting since Begg (1975a) reported *Potamogeton* plants rooted in up to 4 m of water.

Nutrients

Sandvlei is considered to be an eutrophic system: nitrogen (TKN) levels in the vlei are between 1 and 2 mg/ℓ while levels in the influent rivers can reach 6 - 7 mg/ℓ (Furness, 1979). Phosphorus levels in the vlei range between 0,01 and 0,3 mg/ℓ; in the influent rivers concentrations can be between 1 and 2 mg/ℓ. Sandvlei supported extensive beds of *Potamogeton pectinatus* until 1978 when it virtually disappeared as a result of an extensive weed harvesting programme (Furness, 1979).

Unlike Seekoevlei (Harrison, 1962) the expected consequent phytoplankton blooms did not occur. Furness (1979) reported a negative correlation between chlorophyll *a* levels and salinity: during winter the salinity of the surface water drops and the nutrient concentration rises creating a condition beneficial to phytoplankton growth. In summer there is little or no freshwater input and vertical mixing occurs as a result of the southerly wind; the salinity of the surface water rises with a consequent inhibition of phytoplankton growth.

Salinity

Noble and Hemens (1978) reported that Sandvlei water is fresh to saline and shallow with no vertical salinity stratification. However, Benkenstein (1982) clearly demonstrates that a salt water wedge penetrates Sandvlei and can be detected at the northern end of the main basin. Salinity stratification occurs mainly in winter when the estuary mouth is open and seawater penetrates the vlei under the outflowing fresh water (Furness, 1978). Salinity differentials of up to 21 parts per thousand have been detected in the Marina da Gama canal system (Scientific Services Branch, Cape Town City Council, pers. comm.).

Dissolved Oxygen

Surface dissolved oxygen levels throughout the Sandvlei system are similar. Dissolved oxygen levels in the influent streams are lower than in the vlei itself. Bottom dissolved oxygen values of zero have been recorded in the Marina canal system and in the main vlei basin. The anoxic conditions in the main vlei basin are probably due to large amounts of organic matter accumulating on the bottom in calm conditions e.g. during the winter die-back of *Potamogeton* and phytoplankton.

The anoxic conditions in the canals are associated with salinity stratification which occurs primarily as a result of the orientation of the canals so that they are sheltered from the prevailing winds. Sea water is rich in sulphur (900 ppm sulphur, Sverdrup *et al.*, 1942) in the form of sulphate. The penetration of the Marina canal system by salt water, stratification and subsequent development of anaerobic conditions during periods of calm leads to the formation of hydrogen sulphide gas (H_2S). The H_2S is released when wind-induced mixing occurs.

Water from the radial well is saline and reaches a concentration of about 20 parts per thousand at times (Scientific Services Branch, CCC, pers. comm.). The radial well water is, therefore, a less significant contributor of sulphate to Sandvlei than is the seawater.

Potamogeton in the canals assists in their oxygenation but a balance has to be maintained so that the weed does not obstruct yachting activity. There is a marked drop in dissolved oxygen levels after *Potamogeton* harvesting in the canals (Scientific Services Branch, CCC, pers. comm.).

Wind

The wind regime at Sandvlei and particularly at Marina da Gama is probably the most important physical factor affecting the system. The main winds affecting Sandvlei are those from the south in summer and the north in winter. The Marina da Gama canals are orientated east-west with the housing designed to deflect the wind upwards thus providing sheltered conditions for those living there and using the canals. However, as mentioned above (see *Dissolved Oxygen*) this orientation severely restricts mixing of the water in the canals with the result that a halocline forms between the dense saline bottom water and the less dense fresh surface water. Anoxic conditions rapidly develop below the halocline with the result that hydrogen sulphide gas (H_2S) is released when the wind is sufficiently strong to break up the halocline. The foul-smelling H_2S gas is not compatible with the concept of luxury waterside living promoted by the developers of Marina da Gama. Calm periods occur mainly in the winter months (Figure 12).

Water circulation

There are no data on the circulation pattern(s) of the water under the influence of the main wind regimes (summer southerly and winter northerly). Drift drogue studies performed quarterly would assist greatly in elucidating the pattern of water movement in the system. Any such experiments would have to be related to wind velocity data (see *Wind*, above). The circulation pattern in Sandvlei and Marina da Gama can be expected to change considerably after the main vlei body has been dredged to a 2 m water depth. Currently the Marina da Gama canals are deeper than the main vlei basin and act as "sumps" which trap the denser salt water which rapidly becomes anoxic during calm periods. Should the circulation in the canals not improve as a result of dredging the CCC will investigate the feasibility of installing pumps at a number of points in the Marina to ensure adequate oxygenation (CCC City Engineer, pers. comm.).

3.2.6 Pollution

Sewage

There are nine sewage pump stations near Sandvlei and its influent rivers. Some of these are liable to overflow periodically (CCC City Engineer, pers. comm.). The following information gives an indication of the scale of the problem:

Uxbridge Station:	overflows once every 5 years
Clifton Road Station (a major regional station with large capacity):	overflows once every 10 years

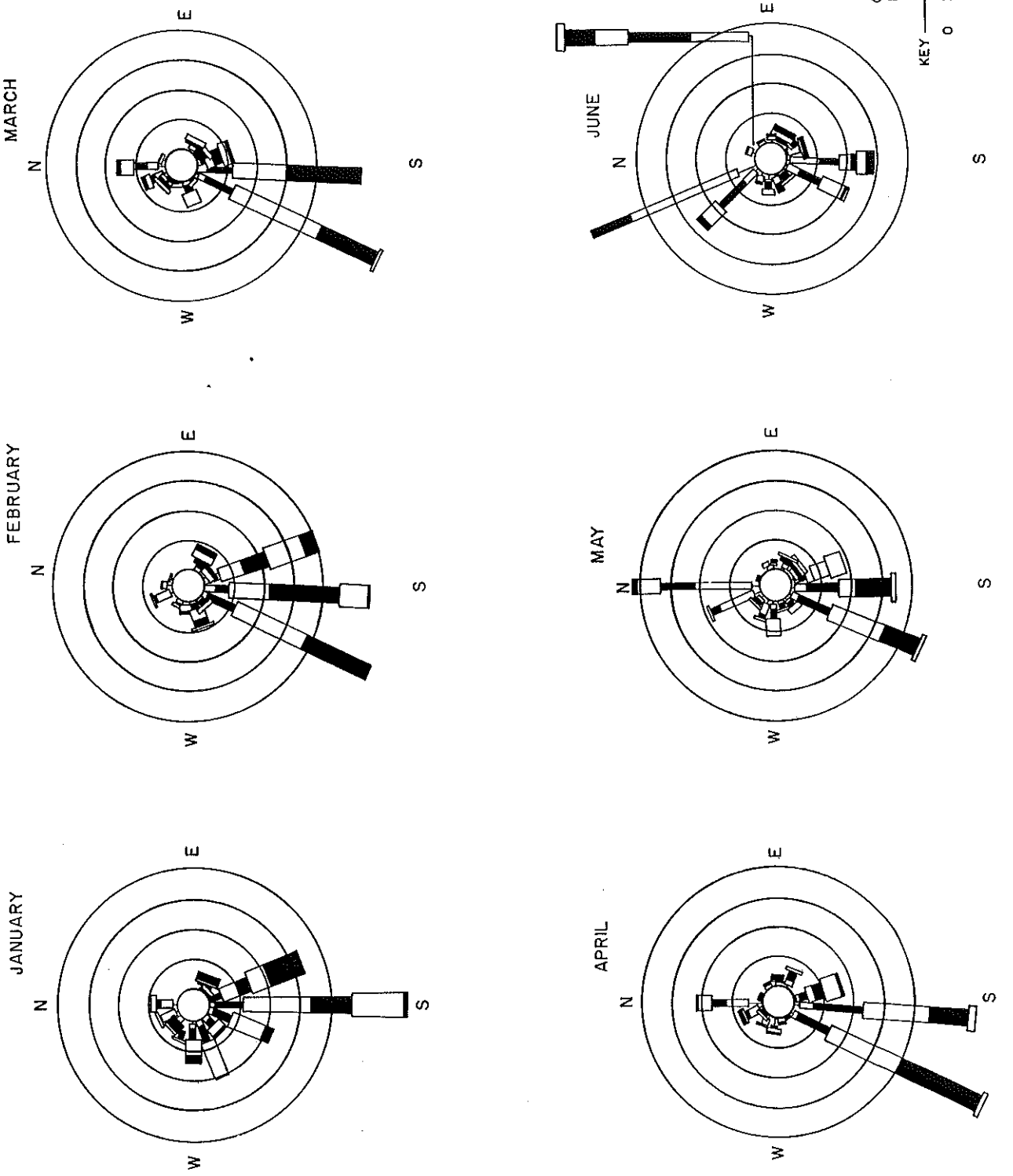
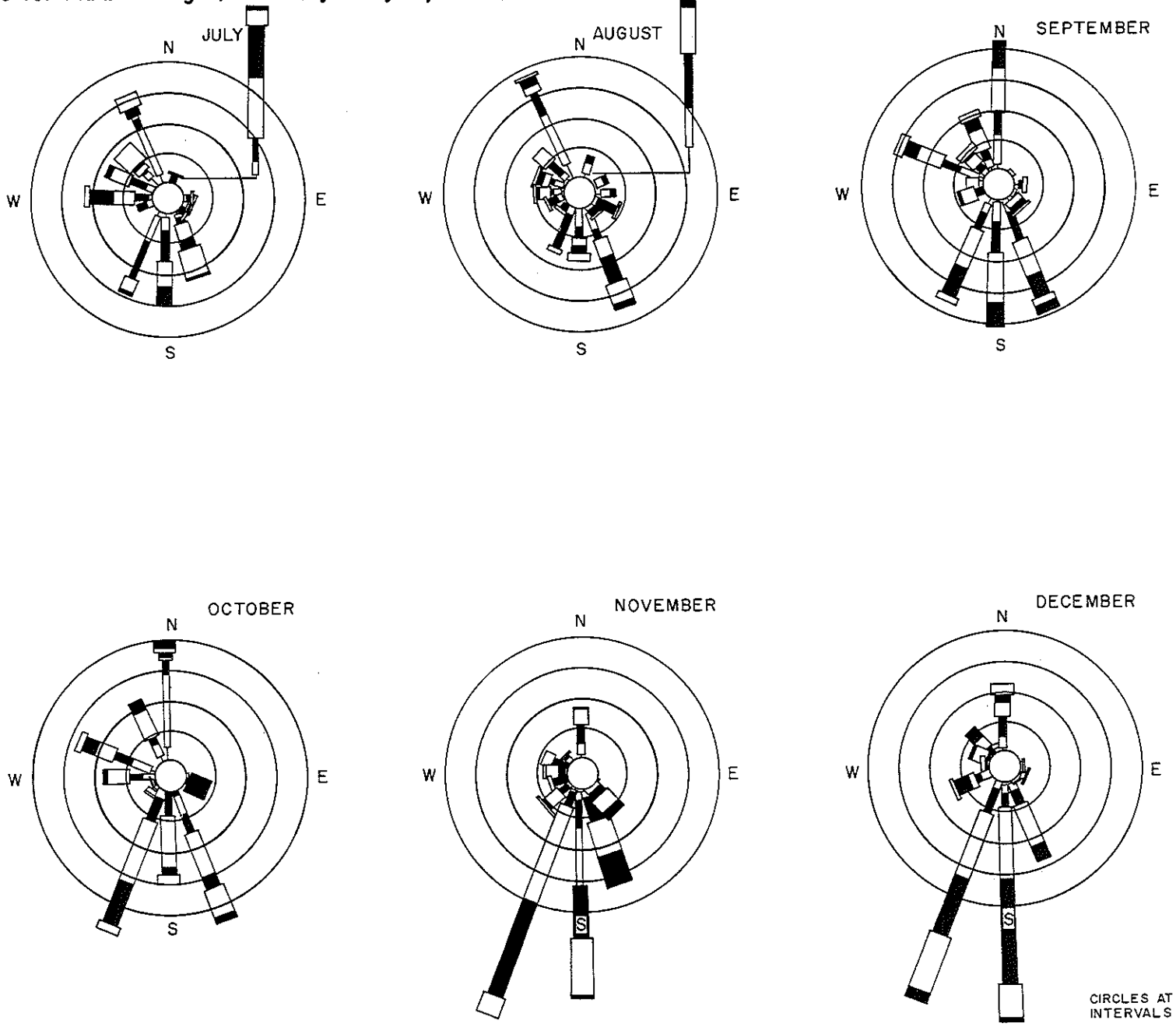


FIG. 12: Wind Roses for Muizenberg. (from Heydenrych, 1976)

FIG. 12: Wind Roses for Muizenberg. (from Heydenrych, 1976)



Keysers River Station: overflows once every 3 years

Sand River Station: overflows once every 2 years

Lavender Hill Station (prone to clogging by rags): overflows twice a year.

Following sewage discharges which contaminate water entering Sandvlei it is standard practice to add a proprietary hypochlorite powder ($Ca(OCl)_2$) to the affected canal and water area. However, the power supplies of almost all the City's sewage pump stations will soon be monitored by an automatic early warning system. This will alert standby staff to station malfunctions, thereby greatly reducing the risk of sewage pollution of the main water courses (City Engineer, pers. comm.).

Industrial effluent

Cape Town City Council Sewage Branch inspectors regularly inspect the Retreat industrial area which borders on the Keysers River. Begg (1975a) identified nine potential polluters along this river including a food factory, saw mill, textile mill, electronics and engineering factories. Toxic effluents from these plants include organic solvents and heavy metals. As further industrialisation occurs in the Retreat area greater surveillance will be required to ensure that no pollutants enter the Keysers River.

Domestic and other refuse

Refuse disposal affects the whole of the Sandvlei system from influent streams to the waterbody itself. The Sand River/Langvlei Canal system poses a particular problem since it passes through a low income housing and squatter area. Every conceivable form of rubbish constantly finds its way into the stream and, ultimately, into Sandvlei. A refuse trap has been in use on the canal but has recently been removed for modification. Under flood conditions it has proved difficult to clear the trap quickly enough to avoid damming the canal and overtopping its walls. An entirely new rubbish trap is presently being designed to overcome this problem. It is proposed to construct this immediately north of Wildwood Bird Sanctuary and will result in the Sand River/Langvlei Canal entering the vlei to the west of the sanctuary and not to the east of it as at present.

Refuse also enters the vlei directly from rubbish bins which are either overturned by dogs and vandals or blown over by the strong winds prevailing in the area. Broken glass and rusty cans pose a hazard to board-sailors who are advised to wear shoes when sailing at the vlei.

3.2.7 Public Health Aspects

The most important public health aspect of any recreational water in which swimming occurs (accidental or intended) is the presence

of faecal coliforms, particularly *Escherichia coli*. The influent streams, particularly the Sand River/Langvlei canal system, pass through low-income residential areas and squatter camps, the latter with little or no sanitation. Such areas and the occasional sewage pumping station breakdown (see 3.2.6 above) are the main sources of faecal contamination.

There are no official South African standards for the bacteriological quality of recreational waters. Considerable controversy exists as to the health risks posed by bathing in sewage-polluted sea water. A British committee established to consider the problem concluded that "a serious health risk is probably not incurred unless the (sea) water is so fouled as to be aesthetically revolting" (Edington & Edington, 1977). Nevertheless it would be desirable to limit faecal contamination of recreational waters to the minimum which can be realistically achieved. Edington and Edington (1977) give bacteriological standards for bathing waters from a number of countries: those of the European Economic Community (EEC) are listed below as a reference against which the quality of recreational waters may be judged:

TABLE 2: EEC bacteriological standards for bathing waters (Edington & Edington, 1977)

Total coliform standards	
Upper limit for total coliforms/100 ml	10 000
Faecal coliform standards	
Upper limit for faecal coliforms/100 ml	5 000 < 20°C seawater
	2 000 > 20°C seawater
	2 000 freshwater

Note: 95% of samples must be lower than the value specified.

The influent streams contain markedly greater numbers of coliforms than do samples taken from various parts of the Vlei (see Cape Town City Engineer's Reports 1974 - 1979; Benkenstein 1982). Counts of 21 x 10^4 and 11 x 10^5 *E. coli*/100 mℓ have been recorded in the Sand and Keysers rivers, respectively. The higher salinity of Sandvlei is probably the main agent responsible for the reduction in numbers of coliforms. The water in Sandvlei would not comply with the EEC standards (Table 2) particularly in summer when the greatest use is made of the vlei for recreation. However, the EEC limits are not greatly exceeded (2 400 *E. coli*/100 mℓ in summer) and Sandvlei does not have a reputation for causing gastric or other ill-effects in those who use it. Tighter controls on the quality of the influent streams would ensure that the vlei complied with EEC standards throughout the year.

4. BIOTIC CHARACTERISTICS

4.1 Flora

(This section is contributed by Mr M O'Callaghan of the Botanical Research Institute.)

4.1.1 Phytoplankton/Diatoms (Appendix I)

Annual reports on the ecological condition of Sandvlei by the Cape Town City Engineer's department include some chlorophyll *a* measurements. These give an indication of the phytoplankton standing crop and show that the amount of chlorophyll *a* in these waters is variable.

Begg (1971a) reports *Oscillatoria* blooms which result in an unsightly surface phenomenon in the vlei during certain times of the year. Begg (1976) also reported that the toxic alga *Prymnesium parvum* caused fish deaths in the vlei (see Section 4.2.7). Approximately 18 species of diatoms have been found in Sandvlei (Begg, 1975a) many of these are epiphytic on the submerged plants (Appendix I).

4.1.2 Algae (Appendix I)

Bourgeois (1948) mentions the presence of Cyanophyta from the lower parts of Sandvlei while kelps (mainly *Ecklonia maxima*) are sometimes washed in from the sea (Begg, 1975a).

Numerous algae have been reported to grow in Sandvlei. These include *Enteromorpha* spp., *Chara fragilis*, *Spirogyra* sp., *Cladophora* sp., *Lyngbya* sp. (Shelton, 1975), *Nitella* sp., and *Lamprothamnium* sp. (Begg, 1975a). Some of these grow on the artificially stabilized canal banks, causing unpleasant conditions when they decay.

The soil cement bank used in the marina to stabilise the edge provides an ideal surface for the growth of filamentous algae (Figure 13a). Attempts to remove these algae manually have proved to be difficult and expensive. It was noticed (Begg 1981) however, that in certain areas where the bank edge had been covered by sand, resulting in sand to water contact, the algae did not grow. The continual movement of water over the sand apparently prevented algal growth establishing itself. As a consequence of this observation a new bank profile (Figure 13b) was adopted for the later stages of the development of Marina da Gama.

4.1.3 Aquatic Vegetation (Appendix II)

Numerous aquatic angiosperms are present in the waters of Sandvlei. The most common of these are *Potamogeton pectinatus* (pond weed) (Figure 14) and *Ruppia maritima* (Shelton, 1975). Other free floating and/or emergent aquatic plants include *Myriophyllum aquaticum* (parrot's feather). *Ceratophyllum demersum* (hornwort), *Lemna gibba* (duck weed), *Eichhornia crassipes* (hyacinth), *Nymphaea* (water lily) and *Aponogeton*

FIG 13: Bank profiles used in the Marina da Gama canal system. (From Heydenrych, 1976.)

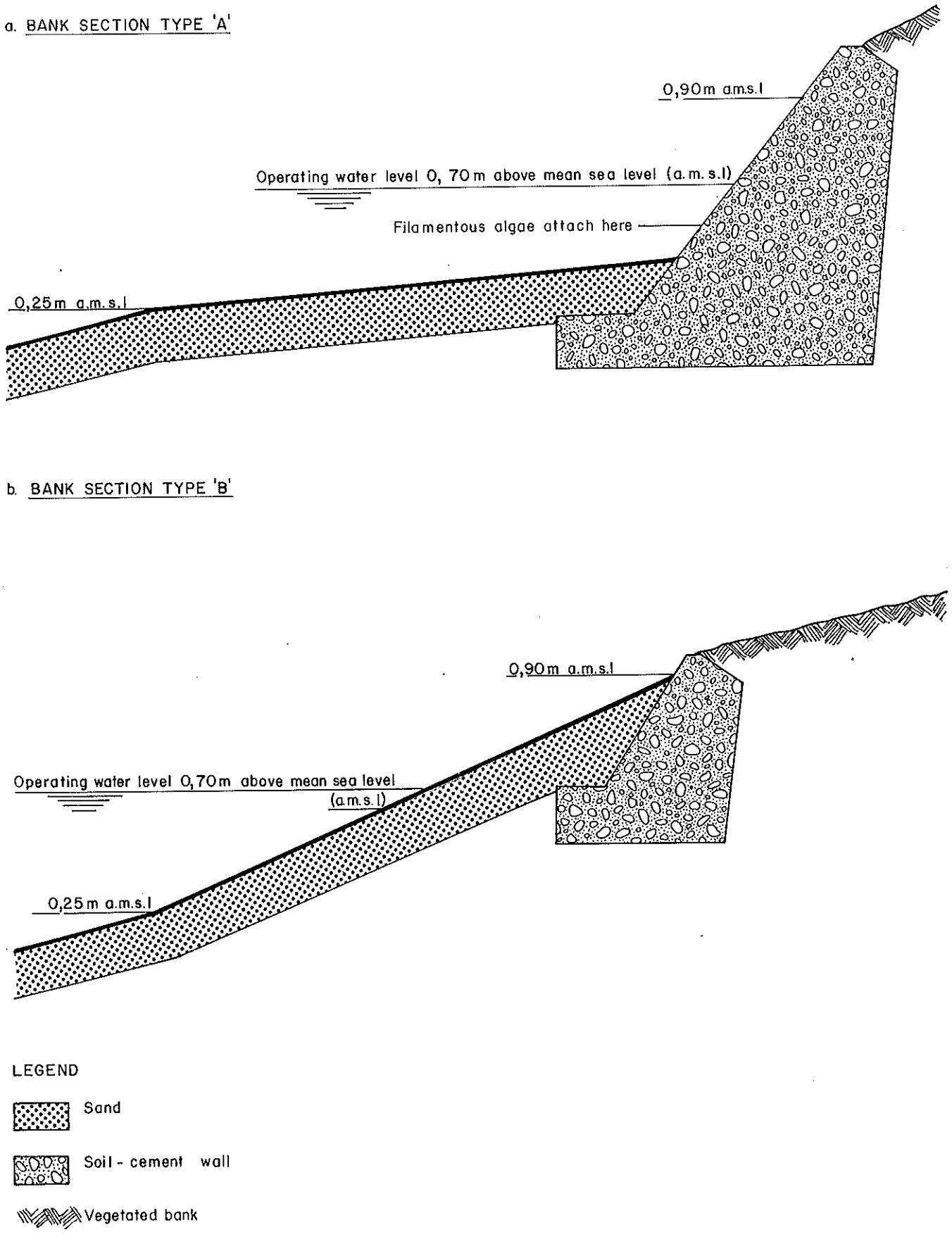
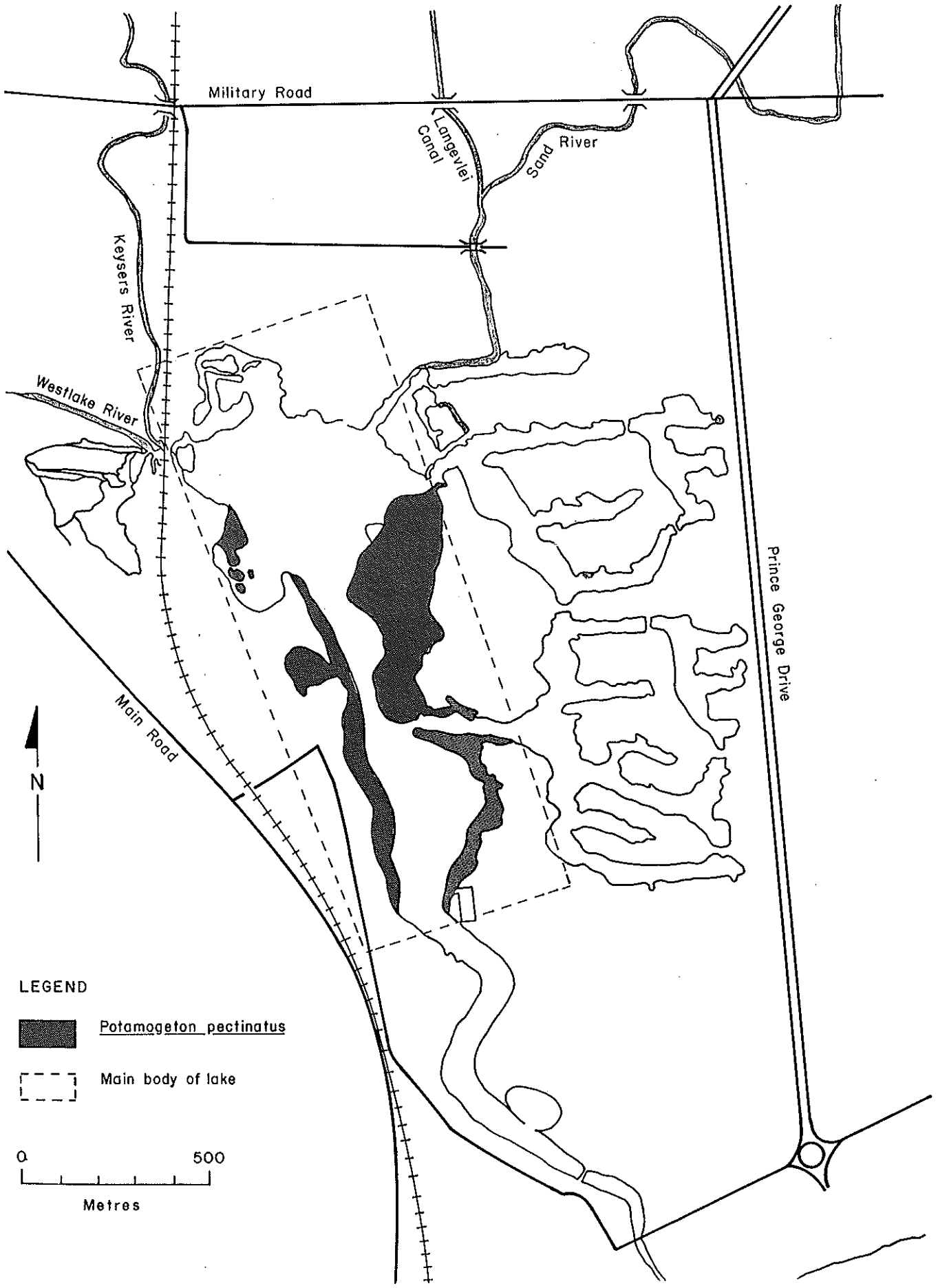


FIG. 14: Distribution of Potamogeton pectinatus in the main body of Sandvlei in November 1981. (from Benkenstein, 1982)



distachyos (Begg, 1975a). These latter occur mainly in the streams entering the vlei and the prolific growth of these aquatic plants indicates high nutrient levels in these waters.

The growth *per se* of these aquatics might not be environmentally deleterious (except in some cases to restrict water flow) and may, in fact, be beneficial (stabilization of sand, utilization of excess nutrients, re-oxygenation of the water, etc.). However, due mainly to the restrictions that these plants place on boating, they (especially *Potamogeton pectinatus* and *Ruppia maritima)* are harvested. Formerly much of this plant matter was not removed from the water where it rotted and led to very unpleasant conditions. The most effective method of controlling the growth of these weeds would be to control the nutrient input via the rivers. As this is obviously difficult to achieve, the present weed harvester provides an alternative through the complete removal of the weed from the vlei. It therefore provides another means of nutrient removal from the system.

4.1.4 Semi-Aquatic Vegetation (Appendix II)

The semi-aquatic vegetation of Sandvlei can be divided into two basic types, namely, reed swamps and marshes.

(a) Reed Swamps: Large areas to the north-west of the vlei are covered by *Phragmites australis* which may also be utilizing excessive nutrients in the water. Patches of this reed also occur near the bird sanctuary and on the vlei side of Park Island.

There are numerous small patches of *Typha capensis* (bulrushes) and sedges (e.g. *Scirpus nodosus, S. littoralis, S. maritimus, Juncus kraussii*) near the bird sanctuary and along undeveloped canals.

(b) Marsh Vegetation: This vegetation type includes plants typical of salt marshes. It is well established at the bird sanctuary and remnants are to be found on Park Island. Species include *Sarcocornia natalensis, Triglochin bulbosa, Plantago carnosa* together with *Cotula vulgaris* (Begg, 1975a) and sedges including *Scirpus maritimus*.

4.1.5 Terrestrial Vegetation (Appendix II)

For the sake of convenience, the terrestrial vegetation around Sandvlei was divided into five basic mapping units. The spatial distribution of these is shown in Figure 15 while Appendix II gives some of the species and physical features of each unit.

(a) Fore Dune Area: These dunes are typical of the area and have a sparse covering of *Ehrharta villosa* (pypgras), *Ammophila arenaria* (marram grass), *Tetragonia decumbens* (klappiesbrak) and numerous other grasses, herbs and shrubs.

(b) Disturbed Dune Areas: Numerous dune remnants are found

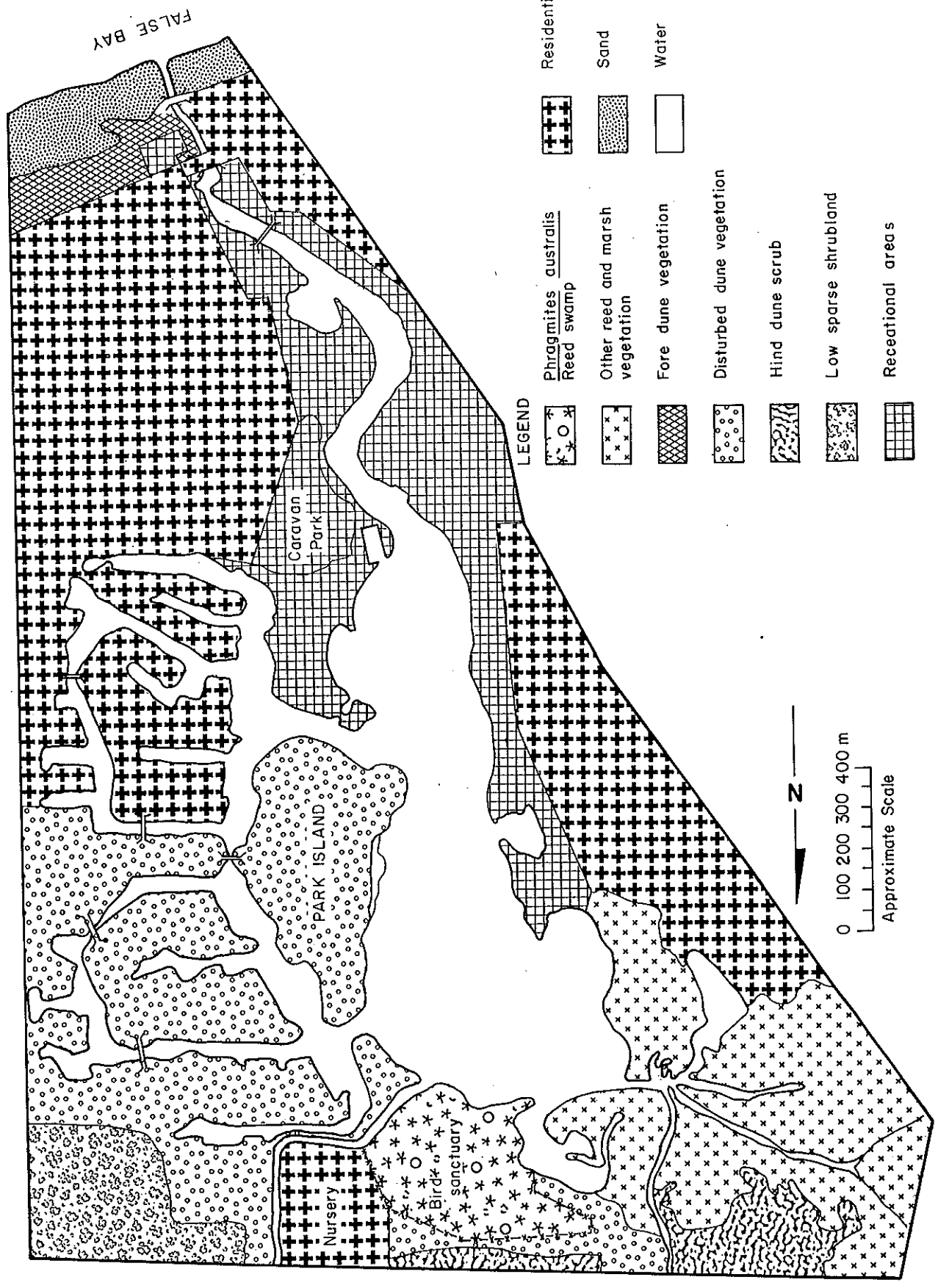


FIG. 15: Vegetation mapping units of the area studied at Sandvlei.

between the houses and over fairly large areas to the east of the vlei. These include species such as *Metalasia muricata* (blombos), *Carpobrotus acinaciformis* (sour fig), and others.

(c) Hind Dune Scrub Forest: North of the bird sanctuary there are still some areas covered with hind dune scrub vegetation. Species found here include *Rhus laevigata* (duinetaaibos), *Colpoon compressum* (basbessie), *Tetragonia fruticosa* (kinkelbos) and others.

(d) Low Sparse Shrubland: To the north-east of the vlei a low shrubland exists on an area that might have been disturbed at some stage. *Psoralea fruticosa, Helichrysum teretifolium* and *Senecio burchellii* are found here.

(e) Recreational Areas: These areas are covered mainly with grasses such as *Pennisetum clandestinum* (kikuyu) and *Stenotaphrum secundatum* (buffalo grass) with *Paspalum vaginatum* along the water's edge. A number of trees have been planted in patches. These include *Myoporum serratum, Metrosideros tomentosa, Cassine peragua* and others.

Most of what is left of the natural vegetation is threatened by alien trees and grasses e.g. *Acacia cyclops, A. saligna, Paspalum urvillei,* Graminea (O'Callaghan 154)+ etc. It was noticed that some attempts have been made to control these weeds, for example, by bush-cutting to the north-west of the vlei. Care must be taken as bush-cutting, although effective against rooikrans *(A. cyclops)*, may cause Port Jacksons *(A. saligna)* to coppice, thus resulting in denser alien stands.

Possibly the most effective way to control these aliens would be manual removal by hack parties, although this might sometimes be an unpleasant task e.g. in the *Phragmites* swamps. However, if attempts are not made to control these aliens, large areas might eventually be overrun by them, possibly causing environmental and aesthetic problems.

+(O'Callaghan species numbers (e.g. O'Callaghan 154) refer to the legit and specimen number of species not identified at the time of writing.)

4.2. Fauna

4.2.1 Zooplankton

Hutchinson *et al* (1932) reported that the zooplankton consisted largely of the copepod *Paradiaptomus capensis* which was very abundant in all its stages and two species of rotifer, *Brachionus plicatilis* and *Pedalia fennica*. Both of these rotifers favour alkaline waters and avoid neutral or acid waters. Cladocera included *Moina dubia, Ceriodaphnia guadrangula* and *Echinisca capensis*. Ostracoda included a small indeterminate species. Less common Copepoda included *Lovenula* sp. and *Elaphoidella bidens subtropica*. Begg (1975a) reported 3 species of Ostracoda, 2 species of Copepoda, 3 species of Cladocera and 5 species of Rotifera. Bourgeois (1948) listed 9 species of Cladocera. Begg

(1975a) stressed that the zooplankton is primarily dominated by the copepod *Pseudodiaptomus hessei* which, as a result, is important in the feeding of several species of fish. Shelton (1975) reported that *Pseudodiaptomus hessei* made up 25 percent of the gut contents of *Liza richardsoni*. The rotifer *Brachionus plicatilis* becomes abundant at times and sampling in June 1975 revealed a massive development of this species. As *Pseudodiaptomus hessei* dominates the zooplankton today and Hutchinson *et al* (1932) recorded *Paradiaptomus capensis* as the most abundant species it is possible that the early record is unreliable for *P. hessei* was not known for South Africa until recorded by Grindley (1963). (See Appendix III for list of species.)

4.2.2 Fauna on hard substrata

The only common invertebrate on hard substrata such as concrete structures is the polychaete worm *Ficopomatus enigmatica*. Masses of *Ficopomatus* tubes 1,5 metres and more in length have been recorded and photographed (Scientific Services Branch, CCC, pers. comm.).

4.2.3 Fauna on soft substrata

The burrowing sand prawn *Callianassa kraussi* is abundant in sandy areas particularly in the channel between the mouth and the main vlei. Numbers of up to 576/m^2 were recorded in April 1975, by Shelton (1975). Illegal exploitation for bait takes place frequently (Shelton, 1975). CCC by-laws prohibit the removal of sand prawns from any part of Sandvlei.

The burrowing polychaete worm *Ceratonereis hircinicola*, the amphipods *Melita zeylanica* and *Austrochiltonia subtennis (=Afrochiltonia capensis)*, the isopod *Munna* and the mollusc *Tomichia ventricosa* have been recorded by Shelton (1975).

Where decomposing masses of *Potamogeton* had washed up on the banks, Shelton (1975) found *Tubifera* to be dominant in the resulting anoxic conditions where the mud surface was covered by the sulphur bacterium, *Chromatium chenni*. The polychaete, *Capitella capitata*, is also characteristic of sediments rich in organic matter.

The amphipod *Orchestia ancheidos* was recorded on a sandy beach on the western side of the vlei by Shelton (1975).

The crown crab, *Hymenosoma orbiculare* (Begg, 1975a) is common but other crabs which have been recorded are *Ovalipes punctatus*, *Varuna litterata* and the freshwater crab *Potamonautes perlatus*.

The shrimp *Palaemon pacificus* is abundant in Sandvlei.

Further details of aquatic invertebrata recorded from Sandvlei are given in Appendix IV.

The Muizenberg beach outside the mouth of Sandvlei supports a rich mollusc fauna probably because of the phytoplankton blooms which are common in this area. The sand mussel, *Donax serra* and the clams *Schizodesma spengleri*, *Lutraria lutraria*, and other species burrow in the sandy beach and in infratidal banks.

This corner of False Bay accumulates many pelagic and bottom-living specimens which wash up on the beach. A list of specimens recorded from Muizenberg beach is given in Appendix V.

4.2.4 Fauna on vegetation

A wide range of organisms depend on the aquatic vegetation and particularly *Potamogeton* for food. Fauna recorded on vegetation include the amphipods *Melita zeylanica*, *Austochiltonia subtenuis*, Ostracoda, Nematoda, the Mollusca *Tomichia* and *Physa* and numerous insects and insect larvae (see next section). Muir (1974) stated that the bulk of the fauna of Sandvlei is a diverse weed epifauna, predominantly associated with the weedbeds at the head of the estuary. Shelton (1975) noted a marked decrease in both diversity and abundance of fauna between summer and winter. He related this to both the die-back of *Potamogeton* in the winter and to the weed cutting activities of the Cape Town City Council.

4.2.5 Insects

Insects recorded by Muir (1974), Shelton (1975) and Begg (1975a, 1976) are listed in Appendix VI. The mayfly *Cloeon lacunosum* is ubiquitous in summer while the dragonflies *Crocothemis erythraea* and *Ischnura senegalensis* appear. The larvae of diptera including chironomids such as *Tendipes chironimus* are abundant. The larvae of the dipteran *Pentaneura*, the hemipteran *Plea pallula* and the larvae of Hydrophilid coleoptera appear on the bottom. Where dissolved oxygen concentrations are low the rat-tailed maggots *Eristalis* and *Tubifera* appear. The hemipterans *Sigara meridionalis* and *Anisops aglaea* are common in some areas (Muir, 1974).

4.2.6 Other Invertebrata

The terrestrial isopod *Niambia* has been recorded by Shelton (1975).

4.2.7 Fish

Sandvlei, the only estuary of any significance in False Bay, is important as a fish nursery. The extensive *Potamogeton* weed beds provide shelter and food for fry. However, Sandvlei's role as a nursery has been adversely affected by the manipulation of the mouth in order to maintain the water level in the vlei.

Two reports have been published on the fish fauna of Sandvlei: Begg (1976) reviewed the situation up to that year and Gaigher and Thorne in Furness (1979) reported on two gill-net surveys undertaken on behalf of Cape Town City Council and the developers of Marina da Gama. Since there is a salinity gradient from sea water at the mouth to virtually fresh water at the head of the vlei, a wide range of fish species can make use of Sandvlei (Appendices VII and VIII). The Sandvlei system appears to have contained only a single freshwater species, the indigenous Cape Galaxias, *Galaxias zebratus* (Castelnau), prior to the introduction of Mirror and Full-scale carp *Cyprinus carpio* in 1896 (Begg, 1976). Sandvlei contains the *punctifer* form of *G. zebratus* (Jubb, 1967). Besides the carp, three introductions (totalling *ca* 6 500 fish) of *Oreochromis mossambicus* (Peters) have been made by the Cape Department of Nature and Environmental Conservation between 1973 and 1976 (Begg, 1976). *O. mossambicus* is a salinity-tolerant species which appears to be well established at the northern, less saline, end of Sandvlei (Begg, 1976).

The Haarder or Southern Mullet, *Liza richardsoni*, and the Springer or Flathead Mullet *Mugil cephalus* are both common in Sandvlei. They are herbivores subsisting largely on epiphytic diatoms and detritus in the weed beds. The large numbers of juvenile mullet form the major food of the piscivorous birds and attract predatory fish. Predatory fish which appear in smaller numbers include White Steenbras, *Lithognathus lithognathus*, White Stumpnose, *Rhabdosargus globiceps*, Elf, *Pomatomus saltatrix* and Leervis, *Lichia amia*. Common smaller fish include the Silverside *Hepsetia breviceps* and the Gobies *Gobius nudiceps* and *Psammogobius knysnaensis*.

A fish "kill" occurred in Sandvlei in June 1973: Begg (1976) states "... on Saturday, June 16, 1973 thousands of fish were seen to be crowding the mouth of Sandvlei, gasping or dying if not already dead." The causative agent of the fish kill was identified as *Prymnesium parvum*, a microscopic alga. This organism has been identified as being responsible for fish kills in high salinity lakes in Israel, Denmark and Holland. The environmental conditions under which the alga becomes toxic are unknown but it has been shown that toxin production and cell multiplication do not depend upon identical factors i.e. the amount of toxin in the water cannot be directly correlated with the concentration of *P. parvum*. Possibly the water influent to Sandvlei contained some compound which triggers toxin production by *P. parvum*. No major fish kills have occurred since then, although the occasional carp is washed out of the vlei by flood waters and dies on contact with sea water. A small fish mortality of unknown cause occurred in March 1980 (JR Grindley, pers. obs.).

4.2.8 Amphibians and Reptiles

Messrs RC Boycott and AL de Villiers *(in litt.)* of the Cape Department of Nature and Environmental Conservation have produced a checklist of the amphibians and reptiles occurring in the area covered by the 1:50 000 topographic map 3418 AB and AD, Cape

Peninsula. Sixteen species of frogs and toads; 23 species of snakes, 15 species of lizards and three species of tortoises have been recorded in this area (Appendix IX).

4.2.9 Birds

150 bird species have been recorded at Sandvlei (Winterbottom 1981) which constitutes more than 50 percent of all the species known to occur in the Cape Peninsula. Seventy species may be present in any one month, 41 species are present throughout the year and 23 species breed at Sandvlei. Sandvlei is an important refuge for water birds during the summer months when seasonal water bodies dry up. Begg (1975b) reported the presence of over 4 000 birds in March/April, 1975, of which 50 percent were Red-knobbed Coot (Appendix X).

As can be expected the change in the avifauna of Sandvlei over the years reflects the changes in the habitat mainly brought about by dredging but also by increased human activity. Broadly there has been a shift from a predominance of wading birds feeding in shallow water (Winterbottom, 1960) to piscivorous species and those making use (directly or indirectly) of the dense mats of *Potamogeton*. Wading birds such as flamingos and Little Stint were common in the 1950s (Winterbottom, 1960) but are now very rarely present or completely absent (Begg, 1975b). Conversely, piscivores such as the White Pelican, Darter, cormorants and grebes are now present in far greater numbers than previously e.g. Winterbottom (1960) did not record any Darters.

Three species, Red-knobbed Coot, Hartlaub's Gull and European Starling, considerably exceed in number any other bird species recorded at Sandvlei. The Hartlaub's Gull and European Starling can be considered "urban" species which prosper as the result of human activity which provides food and shelter. The Red-knobbed Coot uses Sandvlei as a dry season refuge although there is a resident population. Winterbottom (1981) states that "Coot numbers fluctuate widely, from 60 in August 1975 to 2 263 in February the same year. To a considerable extent, they depend on the growth of *Potamogeton* and from January to June 1975 this was profuse and when it was cut in July, there was a catastrophic drop in Coot numbers". It is clear that the Red-knobbed Coot has suffered the greatest impact as a consequence of the weed cutting programme at Sandvlei. However, the Coot population should stabilize provided adequate areas of *Potamogeton* are left undisturbed. Unfortunately the main beds of *Potamogeton* (Figure 14) lie in areas which are scheduled for dredging so that a permanent, large-scale reduction of coot numbers can be expected.

There has been a general decline in the numbers of birds recorded during the Cape Bird Club counts over the period December 1974 to December 1979 (Winterbottom, 1981). This no doubt has been as a consequence of the much increased sailing activity on the vlei, the increased development of housing at Marina da Gama and the cutting of the *Potamogeton*. Of these impacts the harvesting of

Potamogeton probably has had the greatest effect since its removal also removes food for fish and insects which in turn are preyed upon by the birds. A study should be made to determine the minimum width of a *Potamogeton* fringe that can be used effectively by birds for feeding, roosting and nesting. However, there is little doubt that the increased recreational use of the vlei has also had a marked effect. Up to 1974 the use of the vlei showed a marked seasonal pattern with little activity in the winter months. In summer, except over the December holiday period, most of the activity was at the weekends. The surge of interest in board sailing has introduced year-round use of the vlei not only at weekends but also during the week after working hours. The increased use of the main body of the vlei makes it imperative that the Westlake reed marsh be managed as a low-impact, "quiet" recreation area for bird watchers, anglers and educational purposes.

4.2.10 Mammals

The mammalian fauna of Sandvlei and environs (Appendix XI) can be expected to be further impoverished as development continues. Few of the carnivores will be able to exist, particularly when the Princess Vlei parkway is completed, since Sandvlei will then be completely and closely bounded by busy highways. The mammalian fauna of Sandvlei will then be virtually confined to rodent species.

5. SYNTHESIS

We do not know what Sandvlei was like when it was first seen by settlers in the 1650s but Sandvlei today probably bears almost no resemblance to the original vlei. Sandvlei has been continually modified by dredging and alterations of the water level since the railway causeway was built. The original shallow water body had gently graded shores, was subject to wide seasonal fluctuations in water level and was fringed by wetland vegetation. Since the Second World War the vlei has been dredged, the gently graded shores have been replaced by steep banks often artificially stabilised, the surrounding area heavily urbanised and the waters themselves extensively used for recreation. Thus at best Sandvlei can be considered as a semi-natural system. However, the condition of the natural components of Sandvlei is still of vital significance to the overall viability of the system. It is crucial, therefore, that Sandvlei be managed in such a way as to allow the natural components to function in as close to optimal conditions as possible.

The main area of conflict today between human and natural requirements lies in the management of the weed *Potamogeton*. *Potamogeton* helps to oxygenate the water and provides food and shelter for a large number of organisms from birds and fish to a host of invertebrates. However, *Potamogeton* also severely restricts boating activities which constitute the main recreational use of the vlei.

Potamogeton is mainly confined to the middle reaches of Sandvlei particularly off the western shore of Park Island and off the Imperial Yacht Club, where it interferes with sailing activities (Figure 14). The Cape Town City Council harvests the *Potamogeton*

using an Aquamarine 650 Trio System harvester (Figure 16). This machine cuts a swathe 2,4 m wide and 1,2 m deep (Begg, 1976, and lifts the cut weed into a hopper via a conveyor belt system. The cut weed is used for making compost. Removal of the *Potamogeton* also removes the filamentous alga *Cladophora* attached to it, thereby reducing the occurrence of mats of decomposing algae which are both unsightly and unpleasant-smelling. Furthermore the removal of *Potamogeton* results in an export of nutrients from the Sandvlei system thus reducing the possibility of eutrophication (see Physico-chemical characteristics, Section 3.2.5 above).

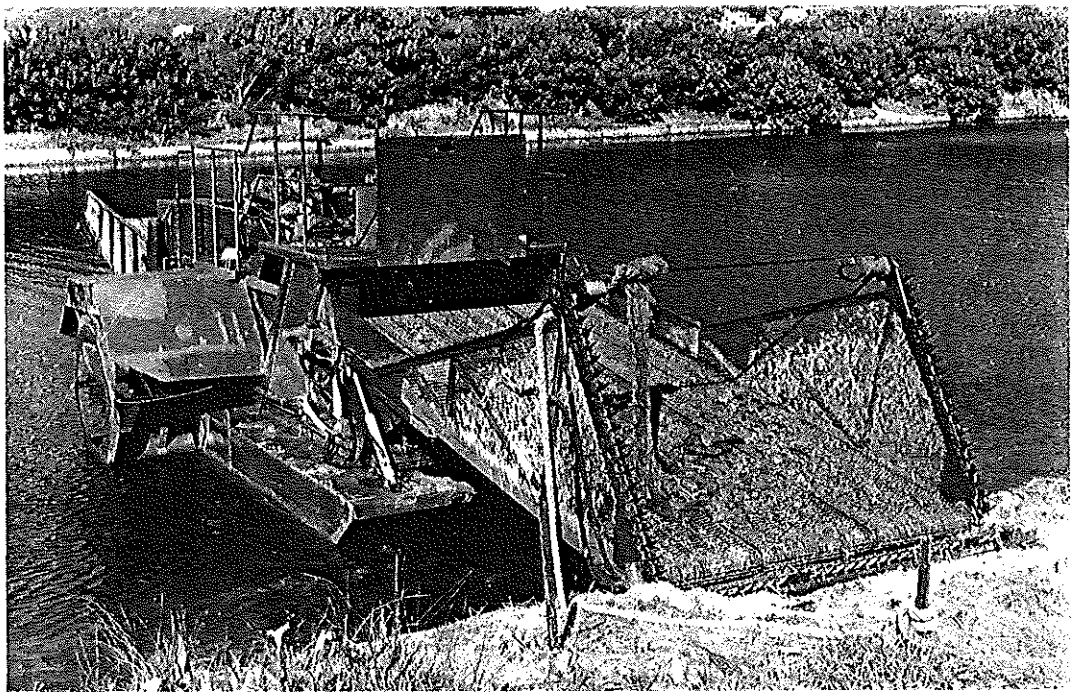


FIG. 16: Aquamarine 650 Trio System harvester used for the removal of *Potamogeton* from Sandvlei.

Approximately 750 tonnes (wet mass) or 600 harvester loads were removed from Sandvlei/Marina da Gama in 1981 (Benkenstein, 1982). Approximately 50 percent of the weed was harvested from the Marina da Gama canals. Little weed harvesting was undertaken in the years 1978 - 1980 during which period the *Potamogeton* recovered from the intensive harvesting undertaken in 1977 when approximately 1 000 tonnes (wet mass) were harvested. Initially the weed harvesting was undertaken by the Parks and Forests Department, CCC without liaison with the Scientific Services Branch. Weed cutting is now undertaken according to a plan drawn up in conjunction with the Scientific Services Branch. It is essential that controlled harvesting should be undertaken in conjunction with a study of *Potamogeton* ecology so that management of the weed can be placed on a sound scientific basis.

Any harvesting programme should embody the following goals:

1. Sufficient *Potamogeton* should be retained to ensure that the bottom waters of the vlei and, more particularly, the Marina da Gama canals are adequately oxygenated.

2. The maintenance of enough *Potamogeton* to provide food and/or shelter for birds, fish and aquatic invertebrates (see Sections 4.2.5, 6, 7 and 9).

It is absolutely essential not to eradicate *Potamogeton* from the Sandvlei system because, as mentioned earlier, the correct management of *Potamogeton* is perhaps the single most important factor in the maintenance of Sandvlei for both human activity and as a healthy natural system. Complete removal of *Potamogeton* will open a niche which will almost certainly be occupied by rapidly-growing phytoplankton species. In that event the water will become opaque, light penetration reduced and submerged macrophytes unable to re-establish themselves. *Potamogeton* beds should at least be maintained in the vicinity of Wildwood Island Bird Sanctuary and the railway embankment where they will not affect yachting. Should the main vlei basin be dredged to 2 m it should be possible to maintain one metre tall stands of *Potamogeton* without fouling the centre boards and rudders of boats sailing there.

Growth studies of undisturbed *Potamogeton* and studies of the response of the plant to various harvesting strategies are urgently required and such studies should be performed in relation to the physico-chemical regime of the vlei. Management of *Potamogeton* requires the installation of flow gauges on the influent streams and at the mouth so that the total nutrient input to the Sandvlei system can be determined (See Section 3.2.5 on Physico-chemical characteristics). Furthermore the flow gauges would assist in the management of the water level in the vlei; this is a matter of considerable importance to the residents of Marina da Gama.

A comprehensive study of all aspects of *Potamogeton* ecology should be instituted so that the optimum harvesting regime can be put into effect. Controlled harvesting experiments should be undertaken; close liaison between the Parks and Forests and the Scientific Services branches of the CCC is essential for a successful management study. Because *Potamogeton* must be seen as an essential biotic component of the overall system rather than as a pest, the current harvesting programme needs to be refined. This could be achieved through the appointment of a research officer or postgraduate student assigned to the intensive study of *Potamogeton*.

The reed marsh in the north-west (Westlake) area (Figures 2, 3 and 15) should be retained in its present form to provide a nutrient and silt trap. Any development in this area should be restricted to the removal of alien vegetation and the provision of simple footbridges and viewing hides for the observation of bird and other marsh life.

Water circulation in the Marina da Gama canals is a problem: during calm periods particularly in autumn and spring (Figure 12), a halocline forms below which anoxic conditions develop rapidly (see Section 3.2.5 on physico-chemical characteristics). When the halocline is disrupted by wind action, foul-smelling hydrogen sulphide gas is released in the vicinity of the houses. The problem is aggravated by the fact that the Marina da Gama canals are deeper than the main body of the vlei (Figure 8) and thus act as sumps or traps for the sulphur-rich seawater entering the system. Should Sandvlei be dredged to the same depth as Marina da Gama (as proposed) it is probable that better water circulation would occur and the problem may be solved. In that event it should not be necessary to instal pumps for the circulation of water in the canals during calm periods. However, it is essential that a full investigation into the ecological and physical consequences of the proposed dredging of the main vlei body is undertaken before operations begin. Management of *Potamogeton* in the canals may also help to solve the problem of anaerobic conditions as more frequent but less drastic harvesting might leave adequate weed for oxygenation without obstructing boating.

Sandvlei is probably the only estuary of real significance as a fish nursery on the entire coast of False Bay and, as such, consideration should be given to enhancing its role in this context (see Section 4.2.7). This requires the modification of the estuary mouth to provide greater access for the entry of fish fry and the exit of young fish. The proposed deepening of the vlei would allow the water level to be maintained at a lower level than the present 0,9 m above mean sea level thus allowing greater tidal interchange. A greater tidal exchange would favour estuarine fauna and would improve the replacement of stagnant water. A feasibility study by sedimentologists, engineering consultants and ecologists should be undertaken to determine whether the estuary mouth can be modified to enhance tidal interchange and reduce the tendency for it to become closed by a sandbar. Currently this sandbar is removed by a bulldozer so as to allow the egress of floodwater from the vlei (see Section 3.2.4 on obstructions). A wider and deeper mouth is desirable if Sandvlei is to fulfil an estuarine function more effectively.

Marine sand penetration is a problem in many estuaries as a result of the difference between flood and ebb velocities. Such sand deposits may be scoured out by exceptional floods which clear mouth channels but the Sandvlei system seldom has extreme floods. This sand penetration takes place and during 1982 became quite a serious problem reaching farther up the channel than in previous years (Figure 17). The CCC Scientific Services Branch have had to abandon a sampling station immediately upstream of Royal Road bridge. Formerly the average water depth at this point was about 1,5 metres but due to sand penetration the depth has been reduced to 50 - 100 mm (Scientific Services Branch, CCC, pers. comm.). In the event of a wider and deeper mouth being established this sand penetration problem might be even more serious and might require routine maintenance dredging.

FIG. 17: Marine sand penetration upstream from the Royal Road bridge. Previously the water was *ca* 1,5 metres deep in the area now occupied by the sandbank.

The risk of pollution of Sandvlei by effluents of various kinds, including industrial effluents from the developing industrial areas in the catchment, and the introduction of floating litter and garbage is likely to increase in future years (see section on pollution, 3.2.7). It will probably be necessary to impose rigid pollution control measures on the influent rivers and to set up effective litter traps where the rivers enter the vlei.

The Cape Town City Council's imaginative public recreation plans for the surroundings of Sandvlei (Cape Town City Engineer's Dept. 1981) should improve the amenity value of the area substantially. It is to be hoped that the development of this and related schemes will be carefully controlled and co-ordinated by the ecologists in the employ of the Council. One feature of this project which is somewhat alarming is the proposal to use alien tree species, especially *Acacia* spp., to form windbreaks. It would be more desirable to use artificial screens e.g. fine mesh net windbreaks to protect endemic species while they are becoming established.

A South African Transport Services (SATS) proposal to site a staging yard parallel to the existing embankment across the north-western corner of Sandvlei constitutes a serious threat to the integrity of the entire area (Die Burger, 5 August 1981). The yard in its completed form will contain several sidings on either side of the existing twin track. This yard is required to

stockpile suburban passenger trains to ensure sufficient capacity to cater for morning and evening peak commuter demand. Construction of the yard would entail major earthworks and the reclamation of parts of the reed marsh and constitute a gross industrial intrusion into a residential and recreational area. Beside the loss of wetland, the marshalling yard could be unsightly, consisting of a forest of overhead gantries, security lights, signals and security fences. The yard could be a potential source of rubbish and a variety of pollutants including herbicides routinely used by SATS to control weeds. The existing culvert through which the Keysers and Westlake Rivers enter the main body of Sandvlei will have to be extended thereby further reducing contact between the two components of Sandvlei (i.e. between Westlake and the main vlei). The reduction in the rate of flow through the extended culvert may cause back-up of flood waters. The proposed yard may well have a negative effect on the continued development of Marina da Gama: large marshalling yards are hardly compatible with the concept of prestige water-side dwellings. This negative effect may well overspill into the entire Muizenberg-Lakeside area and thus hamper the redevelopment and general upgrading of the area.

In conclusion, it is pointed out that Sandvlei must be seen as an area in which human interests have priority. However, this does not mean that the natural components of the system are unimportant to its well-being. Sandvlei should be used as a model and laboratory for the management and study of estuarine wetland systems subject to intensive human activity. There has been extensive modification of this water body and its catchment so that the survival of the system now depends on active management. The optimum management of Sandvlei and the other water bodies under the control of the Cape Town City Council can best be achieved by placing them under a single controlling authority which will ensure adequate liaison between the various departments involved.

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7. GLOSSARY OF TERMS USED IN PART II REPORTS

abiotic: non-living (characteristics).
aeolian (deposits): materials transported and laid down on the earth's surface by wind.
alien: plants or animals introduced from one environment to another, where they had not occurred previously.
alluvium: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.
anaerobic: lacking or devoid of oxygen.
anoxic: the condition of not having enough oxygen.
aquatic: growing or living in or upon water.
arcuate: curved symmetrically like a bow.
barchanoid (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.
bathymetry: measurement of depth of a water body.
benthic: bottom-living.
berm: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.
bimodal: having two peaks.
biogenic: originating from living organisms.
biomass: a quantitative estimation of the total weight of living material found in a particular area or volume.
biome: major ecological regions (life zones) identified by the type of vegetation in a landscape.
biotic: living (characteristics).
breaching: making a gap or breaking through (a sandbar).
calcareous: containing an appreciable proportion of calcium carbonate.
calcrete: a sedimentary deposit derived from coarse fragments of other rocks cemented by calcium carbonate.
Chart Datum: This is the datum of soundings on the latest edition of the largest scale navigational chart of the area. It is -0,900 m relative to land levelling datum which is commonly called Mean Sea Level by most land surveyors.
coliforms: members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract.
community: a well defined assemblage of plants and/or animals clearly distinguishable from other such assemblages.
conglomerate: a rock composed of rounded, waterworn pebbles 'cemented' in a matrix of calcium carbonate, silica or iron oxide.
cusp: a sand spit or beach ridge usually at right angles to the beach formed by sets of constructive waves.
"D" net: a small net attached to a "D" shaped frame riding on skids and pulled along the bottom of the estuary, used for sampling animals on or near the bottom.
detritus: organic debris from decomposing plants and animals.
diatoms: a class of algae with distinct pigments and siliceous cell walls. They are important components of phytoplankton.
dynamic: relating to ongoing and natural change.
ecology: the study of the structure and functions of ecosystems, particularly the dynamic co-evolutionary relationships of organisms, communities and habitats.
ecosystem: an interacting and interdependent natural system of organisms, biotic communities and their habitats.
eddies: a movement of a fluid substance, particularly air or water, within a larger body of that substance.
endemic: confined to and evolved under the unique conditions of a particular region or site and found nowhere else in the world.
enon: most striking formation in the Cape. Crammed with pebbles and boulders, phenomenally embedded and massive, yellow or brilliantly red in colour, producing remarkable hills. Curiously carved into crags and hollows.

epifauna: animal life found on the surface of any substrate such as plants, rocks or even other animals.

epiphyte: a plant living on the surface of another plant without deriving water or nourishment from it.

episodic: sporadic and tending to be extreme.

estuary: a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage (Day 1981).

eutrophication: the process by which a body of water is greatly enriched by the natural or artificial addition of nutrients. This may result in both beneficial (increased productivity) and adverse effects (smothering by dominant plant types).

flocculation (as used in these reports): the settlement or coagulation of river borne silt particles when they come in contact with sea water.

fluvial (deposits): originating from rivers.

food web: a chain of organisms through which energy is transferred. Each "link" in a chain feeds on and obtains energy from the preceding one.

fynbos: literally fine-leaved heath-shrub. Heathlands of the south and south-western Cape of Africa.

geomorphology: the study of land form or topography.

gill net: a vertically placed net left in the water into which fish swim and become enmeshed, usually behind the gills.

habitat: area or natural environment in which the requirements of a specific animal or plant are met.

halophytes: plants which can tolerate salty conditions.

HAT (Highest Astronomical Tide) and LAT (Lowest Astronomical Tide): HAT and LAT are the highest and lowest levels respectively, which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions; these levels will not be reached every year. HAT and LAT are not the extreme levels which can be reached, as storm surges may cause considerably higher and lower levels to occur (South African Tide Tables 1980).

hummock (dune): a low rounded hillock or mound of sand.

hydrography: the description, surveying and charting of oceans, seas and coastlines together with the study of water masses (flow, floods, tides etc.).

hydrology: the study of water, including its physical characteristics, distribution and movement.

indigenous: belonging to the locality; not imported.

intertidal: generally the area which is inundated during high tides and exposed during low tides.

isohyets: lines on maps connecting points having equal amounts of rainfall.

isotherms: lines on maps joining places having the same temperature at a particular instant, or having the same average, extremes or ranges of temperature over a certain period.

lagoon: an expanse of sheltered, tranquil water. (Thus Langebaan lagoon is a sheltered arm of the sea with a normal marine salinity; Knysna lagoon is an expanded part of a normal estuary and Hermanus lagoon is a temporarily closed estuary (Day 1981)).

limpid: clear or transparent.

littoral: applied generally to the seashore. Used more specifically it is the zone between high- and low-water marks.

longshore drift: a drift of material along a beach as a result of waves breaking at an angle.

macrophyte: any large plant as opposed to small ones. Aquatic macrophytes may float at the surface or be submerged and/or rooted on the bottom.
marls: crumbly mixture of clay, sand and limestone, usually with shell fragments.
matrix: medium in which a structure is embedded.
meiofauna: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the macrofauna, or benthos.
metamorphic: changes brought about in rocks within the earth's crust by the agencies of heat, pressure and chemically active substances.
MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23°, of the height of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of MLWS is the average height obtained by the two successive low waters during the same periods (South African Tide Tables 1980).
morphometry: physical dimensions such as shape, depth, width, length etc.
osmoregulation: the regulation in animals of the osmotic pressure in the body by controlling the amount of water and/or salts in the body.
pathogenic: disease producing.
photosynthesis: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.
phytoplankton: plant components of plankton.
piscivorous: fish eating.
plankton: microscopic animals and plants which float or drift passively in the water.
quartzite: rock composed almost entirely of quartz recemented by silicon. Quartzite is hard, resistant and impermeable.
riparian: adjacent to or living on the banks of rivers, streams or lakes.
rip current: the return flow of water which has been piled up on the shore by waves, especially when they break obliquely across a longshore current.
salinity: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand, written 34,5°/$_{oo}$.
secchi disc: a simple instrument used to measure the transparency of water.
sheet flow: water flowing in thin continuous sheets rather than concentrated into individual channels.
slipface: the sheltered leeward side of a sand-dune, steeper than the windward side.
teleost: modern day bony fishes (as distinct from cartilaginous fishes).
trophic level: a division of a food chain defined by the method of obtaining food either as primary producers, or as primary, secondary or tertiary consumers.
trough: a crescent shaped section of beach between two cusps.
wetlands: areas that are inundated or saturated by surface or ground water frequently enough to support vegetation adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.
zooplankton: animal components of plankton.

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APPENDIX I: Algae

Species of algae including diatoms, recorded from Sandvlei:

Microalgae (Begg, 1976):

Cyanophyta

Anabaena, Anacystis, Nodularia, Oscillatoria.

Chrysophyta

Amphipleura, Campylodiscus, Chaetoceros, Cocconeis, Cyclotella, Cymbella, Diploneis, Dysmorphococcus, Gyrosigma, Melosira, Nitzchia, Prymmesium, Rhizosolenia, Stauroneis, Surinella, Synedra and Naviculoid and Pennate diatoms.

Chlorophyta

Ankistrodesmus, Chlorella, Closterium, Cosmarium, Oocystis, Scenedesmus, Spirogyra and Desmids.

Macroalgae (Skelton, 1976):

Chara, Cladophora, Enteromorpha intestinalis, Ulva, Lyngbya, Nitella, Lamprothammium.

APPENDIX II: Species composition and physical features of the vegetation mapping units of the area studied around Sandvlei

Mapping Unit	+Area (ha)	% of area studied	Cover (%)	Average height (m)
Phragmites australis Reed Swamps	39,76	9,86	100	2,00
Other Reed and Marsh Vegetation	11,55	2,86	50	0,20
Fore Dune Vegetation	4,68	1,16	20	0,8
Disturbed Dune Areas	62,37	15,47	90	1,2
Hind Dune Scrub Forest	9,51	2,36	100	1,5
Low Sparse Scrub	11,93	2,96	20	0,2
Recreational Areas	44,01	10,91		
Residential Areas	115,27	28,58		
Sand	7,02	1,74		
Water	97,15	24,09		
Total	403,25			

(+Estimated values)

APPENDIX II (Cont.)

Phragmites australis Reed Swamps

Acacia cyclops (1); *Phragmites australis* (5).

Other Reed and Swamp Vegetation

Acacia cyclops (1); *A. saligna* (1); *Gnidia spicata* (+); *Juncus kraussii* (+); *Limonium foliosum* (+); *Paspalum vaginatum* (+); *Plantago carnosa* (+); *Sarcocornia natalensis* (2); *Scirpus maritimus* (1); *S. nodosus* (1); *S. littoralis* (+); *Triglochin bulbosa* (1); *Typha capensis* (1).

Fore Dune Vegetation

Acacia cyclops (1); *Agropyron distichum* (+); *Arctotheca populifolia* (+); *Ammophila arenaria* (1); *Atriplex vestita* (+); *Carpobrotus acinaciformis* (r); *Ehrharta villosa* (2); *Chrysanthemoides monolifera* (r); *Geranium incanum* (+); *Metalasia muricata* (1); *Myrica cordifolia* (+); *Passerina rigida* (r); *P. vulgaris* (1); *Pelargonium capitatum* (+); *Psoralea repens* (+); *Senecio elegans* (+); *Sporobolus virginicus* (+); *Tetragonia decumbens* (+); *Trachyandra divaricata* (+).

Disturbed Dune Areas

Acacia cyclops (2); *A. saligna* (4); *Atriplex vestita* (1); *Carrisa* sp. (+); *Carpobrotus acinaciformis* (1); *C. edulis* (+); *Chrysanthemoides monolifera* (+); *Cynodon dactylon* (+); *Geranium incanum* (+); *Gramineae* (O'Callaghan 154) (2); *Metalasia muricata* (1); *Myoporum serratum* (+); *Oxalis pes-caprae* (+); *Paspalum urvillei* (+); *Passerina* spp. (+); *Pelargonium capitatum* (+); *Pennisetum clandestinum* (+); *Scirpus nodosus* (+); *Senecio halimifolius* (+); *Stenotaphrum secundatum* (1); *Tetragonia decumbens* (+); *T. fruticosa* (+); *Trachyandra divaricata* (1); *Zantedeschia aethiopica* (+).

Hind Dune Scrub Forest

Acacia cyclops (r); *A. saligna* (1); *Asparagus* cf *racemosus* (+); *Aspalathus ericifolia* (r); *Carpobrotus edulis* (+); *Cissampelos capensis* (+); *Chrysanthemoides monolifera* (+); *Cliffortia obcordata* (+); *Colpoon compressum* (+); *Cynodon dactylon* (+); *Ehrharta villosa* (2); *Geranium incanum* (+); *Haemanthus* sp. (+); *Kedrostis nana* (+); *Leucojum aestivum* (+); *Myoporum serratum* (+); *Oxalis pes-caprae* (r); *Rhus glauca* (+); *R. laevigata* (2); *Senecio halimifolius* (+); *Stenotaphrum secundatum* (1); *Tetragonia fruticosa* (1).

Low Sparse Scrub

Acacia cyclops (1); *A. saligna* (+); *Carpobrotus acinaciformis* (+); *Cynodon dactylon* (+); *Ehrharta villosa* (1); *Felicia* sp. (+); *Ficinia dunensis* (+); *Helichrysum* cf *teretifolium* (+); *Lightfootia burchellii* (r); *Metalasia muricata* (+); *Passerina* sp. (+); *Psoralea fruticosa* (+); Restioids (O'Callaghan 137, 140) (+); *Scirpus nodosus* (+); *Senecio burchellii* (r); *Sporobolus virginicus* (+).

APPENDIX II (Cont.)

Note: The symbols in brackets following each species name represents Braun-Blanquet Cover Classes as follows:

r - 1/few individuals, cover less than 0,1% of area
+ - occasional plants, cover less than 1% of area
1 - abundant, cover 1-5% of area
2 - any number, cover 6-25% of area
3 - any number, cover 26-50% of area
4 - any number, cover 51-75% of area
5 - any number, cover 76-100% of area.

APPENDIX III: Zooplankton

Species of zooplankton recorded from Sandvlei

PROTOZOA

Actinophrys
Amphora
Astomata
Carchesium
Euglena
Euplotes
Flagellate (indet)+
Golenkinia
Gymnodinium
Halteria
Holotrichia
Paramoecium
Phacus
Prymnesium
Schizomeris
Spirotaenia
Stokesia
Vaguicola

TURBELLARIA Indet (Begg, 1976)
TARDIGRADA Indet (Begg, 1976)
GASTROTRICHA Indet (Begg, 1976)
ROTIFERA *Brachionus plicatilus* (Hutchinson, 1932)
Filinia (Begg, 1976)
Keratella (Begg, 1976)
Loricate sp. (Begg, 1976)
Pedalia fennica (Hutchinson, 1932)
Rotaria (Begg, 1976)
NEMATODA Indet (Begg, 1976)
OSTRACODA 3 spp. Indet (Begg, 1975)
AMPHIPODA *Afrochiltonia capensis* (=Austrochiltonia)
Austrochiltonia subtennis (Shelton, 1975)
Melita zeylanica (Shelton, 1975)
COPEPODA Cyclopoid Indet (Begg, 1976)
Elaphoidella bidens subtropica (Hutchinson, 1932)

+indet - not classified

APPENDIX III: (Cont.)

	Harpacticoid Indet (Begg, 1976)
	Lovenula sp. (Hutchinson, 1932)
	Nauplii
	Paradiaptomus capensis (Hutchinson, 1932)
	Pseudodiaptomus hessei (Begg, 1975)
CLADOCERA	Cladoceran Indet (Begg, 1976)
	Ceriodaphnia quadrangula (Hutchinson, 1932)
	Daphnia sp. (Begg, 1976)
	Echinisca capensis (Hutchinson, 1932)
	Moina dubia (Hutchinson, 1932)
DECAPODA	Zoaea of *Hymenosoma orbiculare* (Begg, 1976).

APPENDIX IV: Aquatic Invertebrata

Species of aquatic invertebrates other than insects and zooplankton recorded from Sandvlei.

Bryozoa	Bryozoa (Shelton, 1975)
Nematoda	Nematoda (Muir, 1974)
Oligochaeta	*Aelosoma* (Begg, 1976)
Polychaeta	*Capitella capitata* (Muir, 1974)
	Ceratonereis hircinicola (Shelton, 1975)
	Ficopomatus enigmatica (Muir, 1974)
	Mercierella enigmatica (=Ficopomatus)
Ostracoda	Ostracoda (Muir, 1974)
Amphipoda	*Afrochiltonia capensis* (=Austrochiltonia)
	Austrochiltonia subtenuis (Muir, 1974)
	Melita zeylanica (Muir, 1974)
	Orchestia ancheidos (Shelton, 1975)
	Talorchestia capensis (Muir, 1974)
Isopoda	*Munna* (Shelton, 1975)
Mysidacea	*Gastrosaccus* (Muir, 1974)
Decapoda	*Callianassa kraussi* (Muir, 1974)
	Hymenosoma orbiculare (Muir, 1974)
	Ovalipes punctatus (Grindley, unpublished)
	Palaemon pacificus (Grindley, unpublished)
	Potamonautes perlatus (Muir, 1974)
	Varuna litterata (Grindley, unpublished)
	Zoaea larvae
Mollusca	*Assiminea* (Shelton, 1975)
	Physa (Begg, 1976)
	Tomichia ventricosa (Muir, 1974)
	Tomichia sp. (Muir, 1974)
	Sediment contained shells of:
	Assiminea
	Nassa
	Natica
	Solen (Muir, 1974).

APPENDIX V: Beach Fauna

Specimens recorded from Muizenberg Beach adjoining the Sandvlei estuary (JR Grindley).

Scientific name		Common name
Nautilocorystes ocellata	–	Masked crab
Ovalipes punctatus	–	Three-spot swimming crab
Aulacomya ater	–	Ribbed mussel
Choromytilus meridionalis	–	Black mussel
Donax serra	–	White mussel
Perna perna	–	Brown mussel
Crassostrea margaritacea	–	Cape oyster
Pecten sulciocostatus	–	Scallop
Schizodesma spengleri	–	Surf clam
Chlamys tinctus	–	–
Kellya rubra	–	–
Lima rotundata	–	–
Lutraria lutraria	–	–
Mactra glabrata	–	–
Tellina trilatera	–	–
Tivella compressa	–	–
Venus verrucosa	–	–
Bullia rhodostoma	–	Whelk
Glaucus atlanticus	–	Blue sea slug
Argonauta argo	–	Paper nautilus
Sepia typica	–	Cuttlefish
Spirula spirula	–	Squid

APPENDIX VI: Insecta

Species of insects recorded from Sandvlei by Muir (1974), Shelton (1975) and Begg (1975, 1976).

Order	Species
Collembola	Collembola (Shelton, 1975)
Ephemenoptera	*Cloeon lacunosum* (Muir, 1974)
Odonata	*Crocothemis erythraea* (Muir, 1974)
	Ischnura senegalensis (Muir, 1974)
	Isotomus (Muir, 1974)
Hemiptera	*Anisops aglaea* (Muir, 1974)
	Plea pallula (Muir, 1974)
	Sigara meridionalis (Muir, 1974)
Coleoptera	*Dytiscus* (Shelton, 1975)
	Gyrinidae (Muir, 1974)
	Hydroporus (Muir, 1974)
	Hydrophylidae (Shelton, 1975)
Diptera	*Chironomus* (Shelton, 1975)
	Culex (Muir, 1974)
	Ephydra (Muir, 1974)
	Eristalis (Begg, 1976)
	Nematelus (Muir, 1974)
	Pentaneura (Muir, 1974)
	Tendipes chironimus (Shelton, 1975)
	Tubifera (Shelton, 1975).

APPENDIX VII: Freshwater fish species reported from Sandvlei

Cape Galaxias	-	*Galaxius zebratus* (Castelnau)
Wild Carp/Full-scale Carp	-	*Cyprinus carpio* (Linnaeus)
Mirror Carp	-	*Cyprinus carpio* (Linnaeus)
Bream	-	*Oreochromis mossambicus* (Peters)

Begg (1976) also lists the following fish species which have also been reported from Sandvlei:

1917	Cape Kurper	-	*Sandelia capensis*
1934	Largemouth Bass	-	*Micropterus salmoides* (Lacepede)
1947	Sand Goby	-	*Psammogobius knysnaensis* (Smith)
1973	Goldfish	-	*Carassius auratus*
1973	Cape Lady/Moony	-	*Monodactylus falciformis* (Lacepede)
1973	Pipefish	-	*Syngnathus acus* (Linnaeus)
1973	Surf Sardine	-	*Iso natalensis* (Regan)

APPENDIX VIII: Marine fish species reported from Sandvlei

Species		Begg 1976	Gaigher & Thorne *in* Furness 1979
Common name			
Southern Mullet	*Liza richardsoni* (Smith)	+	+
Flathead Mullet	*Mugil cephalus* (Linnaeus)	+	+
White Steenbras	*Lithognathus lithognathus* (Cuvier)	+	+
White Stumpnose	*Rhabdosargus globiceps* (Cuvier)	+	+
Leervis	*Lichia amia* (Linnaeus)	+	+
Kob	*Argyrosomus hololepidotus* (Lacepede)	+	+
Elf	*Pomatomus saltatrix* (Linnaeus)	+	+
Blacktail/Dassie	*Diplodus sargus* (Linnaeus)		+
Goby/Dikkop	*Gobius nudiceps* (Cuvier)	+	
Silverside/Whitebait	*Hepsetia breviceps* (Cuvier)	+	
Whitebait	*Gilchristella aestuarius* (Gilchrist & Thompson)	+	
Sole	*Heteromycteris capensis* (Kaup)	+	
Evil-eyed Blaasop	*Amblyrhynchotes honckenii* (Bloch)	+	
Klip Fish	*Clinus superciliosus* (Linnaeus)	+	

APPENDIX IX: A checklist of amphibians and reptiles recorded for the area covered by the 1:50 000 Topographic map 3418 AB & AD Cape Peninsula (RC Boycott, *in litt.*)

Class Amphibia - Frogs and toads

Records from Poynton (1964): Greig, Boycott and De Villiers (1979); Boycott (personal records); Cape Department of Nature and Environmental Conservation (records).

APPENDIX IX: (Cont.)

Common name		Scientific name
Common Platanna/Clawed Toad	-	*Xenopus laevis*
Gill's Platanna	-	*Xenopus gilli*
Sand Toad	-	*Bufo angusticeps*
Leopard Toad	-	*Bufo pardalis*
Cape Mountain Toad	-	*Capensibufo rosei*
Cape Rain Frog	-	*Breviceps gibbosus*
Cape Mountain Rain Frog	-	*Breviceps montanus*
Sand Rain Frog	-	*Breviceps r. rosei*
Cape Sand Frog	-	*Tomopterna delalandii*
Cape Rana	-	*Rana fuscigula*
Spotted Rana	-	*Rana grayii*
Cape Grass Frog	-	*Rana montana*
Dainty Frog	-	*Cocosternum boettgeri*
Cape Caco	-	*Cacosternum capense*
Cape Chirping Frog	-	*Arthroleptella lightfooti*
Arum Frog	-	*Hyperolius horstockii*

Class Reptilia

Suborder Serpentes - Snakes

Records from FitzSimons (1962); Broadley (1975); Dyer (personal records).

Common name		Scientific name
Pink Earth Snake	-	*Rhinotyphlops lalandei*
Black Worm Snake	-	*Leptotyphlops nigricans*
Brown Water Snake	-	*Lycodonomorphus rufulus*
Yellow-bellied House Snake	-	*Lamprophis fuscus*
Aurora House Snake	-	*Lamprophis aurora*
Olive House Snake	-	*Lamprophis inornatus*
unnamed	-	*Prosymna sundevalii*
Mole Snake	-	*Pseudaspis cana*
Russet Garden Snake	-	*Duberria lutrix*
Common Egg-eating Snake	-	*Dasypeltis scabra*
Herald Snake	-	*Crotaphopeltis hotamboeia*
Cape Many-spotted Snake	-	*Amplorhinus multimaculatus*
Boomslang	-	*Dispholidus typus*
Spotted Skaapsteker	-	*Psammophylax rhombeatus*
Whip Snake	-	*Psammophis notostictus*
Leighton's Sand Snake	-	*Psammophis leightoni*
Cross-marked Sand Snake	-	*Psammophis crucifer*
Garter Snake	-	*Elaps lactens*
Rinkals	-	*Hemachatus haemachatus*
Cape Cobra	-	*Naja nivea*
Puff Adder	-	*Bitis arietans*
Bergadder	-	*Bitis atropos*
Many-horned Adder	-	*Bitis cornuta*

APPENDIX IX (Cont.)

Suborder Sauria - Lizards

Records from FitzSimons (1943) and Broadley & Greer (1969).

Common name		Scientific name
Marbled Gecko	-	*Phyllodactylus porphyreus*
Ocellated Gecko	-	*Pachydactylus geitjie*
Rock Agama	-	*Agama atra*
Spiny Agama	-	*Agama hispida*
Cape Dwarf Chameleon	-	*Bradypodion pumilum*
Silver Sand Lizard	-	*Scelotes bipes*
Speckled Skink	-	*Mabuya homalocephala*
Common Skink	-	*Mabuya capensis*
Golden Sand Lizard	-	*Acontias meleagris*
Yellow-throated Plated Lizard	-	*Gerrhosaurus flavigularis*
Plated Lizard	-	*Tetradactylus seps*
Long-tailed Seps	-	*Tetradactylus tetradactylus*
Ocellated Sand Lizard	-	*Meroles knoxii*
Anguine Lizard	-	*Chamaesaura anguina*
Girdled Lizard	-	*Cordylus cordylus*

Order Chelonia - Tortoises

Records from Rose (1962) and Greig & Burdett (1976).

Common name		Scientific name
Angulate Tortoise	-	*Chersina angulata*
Padloper	-	*Homopus areolatus*
Cape Terrapin	-	*Pelomedusa subrufa*

APPENDIX X: Counts of birds at Sandvlei

Roberts No.	Species	Begg (1975b) 12/74-12/75 (13 months)			Summers *et al* (1976) 12.1.76 (Waders only)	Western Cape Wader Study Group (unpublished data) 24.1.81 (Water birds only)
		Min.	Max.	Mean		
4	Great Crested Grebe	0	49	12	-	18
6	Dabchick	1	233	62	-	22
42	White Pelican	0	74	16	-	8
47	White-breasted Cormorant	4	71	36	-	10
48	Cape Cormorant	0	59	21	-	-
50	Reed Cormorant	5	106	43	-	94
52	Darter	0	18	6	-	66
54	Grey Heron	3	34	15	-	26
55	Black-headed Heron	0	2	<1	-	-
57	Purple Heron	0	6	1	-	8
59	Little Egret	0	15	7	-	22
60	Yellow-billed Egret	0	3	<1	-	4
61	Cattle Egret	0	6	<1	-	-
67	Little Bittern	0	2	<1	-	-

APPENDIX X (Cont.)

Roberts No.	Species	Begg (1975b) 12/74-12/75 (13 months)			Summers *et al* (1976) 12.1.76 (Waders only)	Western Cape Wader Study Group (unpublished data) 24.1.8 (Water birds only)
		Min.	Max.	Mean		
69	Night Heron	0	13	6	–	24
72	Hamerkop	0	1	<1	–	–
85	African Spoonbill	0	4	<1	–	4
87	Lesser Flamingo	0	8	<1	–	–
88	Spur-winged Goose	0	4	<1	–	2
89	Egyptian Goose	0	11	3	–	16
90	South African Shelduck	0	2	<1	–	–
94	Cape Shoveler	5	77	33	–	54
96	Yellow-billed Duck	3	55	19	–	166
97	Red-billed Teal	0	20	6	–	6
98	Cape Teal	12	74	39	–	142
102	Red-eyed Pochard	0	39	9	–	–
103	Maccoa Duck	0	2	<1	–	–
–	(Mandarin Duck)	0	1	<1	–	–
123	Rock Kestrel	0	5	1	–	–
130	Black-shouldered Kite	0	15	5	–	–
152	Jackal Buzzard	0	3	<1	–	–
167	African Marsh Harrier	0	1	<1	–	–
181	Cape Francolin	0	2	<1	–	–
192	Crowned Guinea-fowl	0	30	4	–	–
208	Purple Gallinule	0	5	2	–	6
210	Moorhen	5	36	19	–	16
212	Red-knobbed Coot	87	2 263	848	–	1 444
230	Painted Snipe	0	3	<1	–	–
233	Ringed Plover	0	4	<1	–	–
235	White-fronted Sand-plover	0	5	<1	–	–
237	Kittlitz's Sandplover	6	38	19	14	18
238	Three-banded Sand-plover	2	18	11	5	12
241	Grey Plover	–	–	–	2	–
242	Crowned Plover	5	37	13	3	26
245	Blacksmith Plover	11	37	23	24	92
250	Ethiopian Snipe	0	7	<1	2	–
251	Curlew Sandpiper	0	206	36	184	320
253	Little Stint	0	83	27	134	30
256	Ruff	0	8	1	13	10
258	Common Sandpiper	0	10	3	1	10
262	Marsh Sandpiper	0	1	<1	–	20
263	Greenshank	0	11	4	8	14
264	Wood Sandpiper	0	7	2	2	8
266	Bar-tailed Godwit	0	1	<1	–	–
269	Avocet	0	8	2	2	30
270	Stilt	5	33	14	36	88
274	Water Dikkop	0	4	<1	–	–
275	Dikkop	1	12	5	–	–
287	Kelp gull	5	70	24	–	12
289	Hartlaub's Gull	45	1 194	398	–	772
290	Caspian Tern	1	11	5	–	–
291/294	Common/Arctic Tern	17	90	45	–	80
296	Sandwich Tern	0	11	3	–	8

APPENDIX X (Cont.)

Roberts	Species	Begg (1975b) 12/74-12/75 (13 months)			Summers *et al* (1976) 12.1.76 (Waders only)	Western Cape Wader Study Group (unpublished data) 24.1.81 (Water birds only)
		Min.	Max.	Mean		
298	Swift Tern	0	9	4	-	-
304	White-winged Black Tern	0	143	18	-	64
305	Whiskered Tern	0	6	<1	-	-
314	Red-eyed Turtle Dove	0	6	<1	-	-
316	Cape Turtle Dove	15	63	43	-	-
317	Laughing Dove	1	43	18	-	-
318	Namaqua Dove	0	2	<1	-	-
356	White-browed Coucal	0	2	<1	-	-
368	Spotted Eagle Owl	0	2	<1	-	-
380	Black Swift	0	90	25	-	-
383	White-rumped Swift	0	16	3	-	-
385	Little Swift	0	2	<1	-	-
386	Alpine Swift	0	7	2	-	-
391	White-backed Mousebird	0	12	2	-	-
394	Pied Kingfisher	4	19	10	-	10
395	Giant Kingfisher	0	1	<1	-	4
396	Half-collard Kingfisher	0	1	<1	-	-
397	Malachite Kingfisher	0	9	3	-	2
432	Pied Barbet	0	1	<1	-	-
488	Red-capped Lark	0	5	<1	-	-
493	European Swallow	0	22	2	-	-
495	White-throated Swallow	0	31	5	-	-
502	Greater Striped Swallow	0	38	9	-	-
506	Rock Martin	0	40	4	-	-
509	African Sand Martin	44	482	140	-	-
524	White-necked Raven	0	1	<1	-	-
543	Cape Bulbul	1	11	5	-	-
553	Olive Thrush	0	1	<1	-	-
570	Familiar Chat	0	1	<1	-	-
576	Stone Chat	0	1	<1	-	-
581	Cape Robin	2	20	10	-	-
583	Karoo Scrub Robin	0	1	<1	-	-
604	Cape Reed Warbler	3	28	13	-	-
606	African Marsh Warbler	0	9	1	-	-
609	African Sedge Warbler	0	25	7	-	-
618	Grassbird	0	1	<1	-	-
631	Cloud Cisticola	0	6	<1	-	-
637	Neddicky	0	5	<1	-	-
638	Grey-backed Cisticola	0	8	1	-	-
646	Le Vaillant's Cisticola	5	33	22	-	-
651	Karoo Prinia	8	33	20	-	-
655	Dusky Flycatcher	0	1	<1	-	-
686	Cape Wagtail	31	86	63	-	128
692	Richard's Pipit	0	14	3	-	-

APPENDIX X (Cont.)

Roberts	Species	Begg (1975b) 12/74-12/75 (13 months)			Summers *et al* (1976) 12.1.76 (Waders only)	Western Cape Wader Study Group (unpublished data) 24.1.81 (Water birds only)
		Min.	Max.	Mean		
694	Plain-backed Pipit	0	1	<1	-	-
703	Orange-throated Longclaw	3	12	7	-	-
707	Fiscal	2	16	9	-	-
709	Boubou	0	1	<1	-	-
722	Bokmakierie	0	15	4	-	-
733	European Starling	24	169	93	-	-
745	Red-winged Starling	0	11	2	-	-
753	Orange-breasted Sunbird	0	3	<1	-	-
760	Lesser Double-collared Sunbird	0	4	1	-	-
775	Cape White-eye	4	33	13	-	-
784	House Sparrow	0	5	2	-	-
786	Cape Sparrow	6	83	27	-	-
799	Cape Weaver	2	28	12	-	-
803	Masked Weaver	0	4	1	-	-
808	Red Bishop	0	30	2	-	-
810	Cape Widow	0	9	1	-	-
843	Common Waxbill	0	40	9	-	-
846	Pin-tailed Whydah	0	3	<1	-	-
857	Cape Canary	2	59	32	-	-
863	Bully Seed-eater	0	5	1	-	-
866	Yellow Canary	0	27	4	-	-

Note: Nomenclature follows Roberts (1978).

APPENDIX XI: Mammals: the following species, likely to occur at Sandvlei, have been extracted from the list of mammals recorded by Stuart *et al* (1980) for the area covered by the 1:50 000 topographic sheet 3418 AB and CD Cape Peninsula.

Bats	*Miniopterus schreibersi*
	Eptesicus capensis
	Rhinolophus clivosus
+Forest shrew	*Mysorex varius*
Red musk shrew	*Crocidura flavescens*
+Cape golden mole	*Chrysochlosis asiatica*
+Chacma baboon	*Papio ursinus*
+Cape fur seal	*Arctocephalus pusillus*
+Leopard seal	*Hydrurga leptonyx*
+Cape dassie	*Procavia capensis*
Vlei rat	*Otomys* sp.
Saunders vlei rat	*Otomys saundersi*
Krebs fat mouse	*Steatomys krebsi*

+These species can be expected to occur extremely infrequently if at all.

APPENDIX XI (Cont.)

Striped mouse	*Rhabdomys pumilio*
Cape spiny mouse	*Acomys subspinosus*
Pygmy mouse	*Mus minutoides*
House mouse	*Mus musculus*
Verraux's rat	*Praomys verrauxi*
Black rat	*Rattus rattus*
Cape porcupine	*Hystrix africaeaustralis*
Cape dune mole rat	*Bathyergus suillus*
Cape mole rat	*Georychus capensis*
American grey squirrel	*Sciurus carolinensis*
Striped polecat	*Ictomyx striatus*
Small-spotted genet	*Genetta genetta*
Large-spotted genet	*Genetta tigrina*
Cape grey mongoose	*Herpestes pulverulentus*
Water mongoose	*Atilax paludinosus*
Wild cat	*Felis lybica*
Caracal	*Felis caracal*

APPENDIX XII Summary of available information

ESTUARY/RIVERMOUTH/LAGOON: SAND (Rivermouth/Lagoon)

		Sources of Information	Allanson	Allanson	Allanson	Begg	Begg	Begg	Begg	Benkenstein	Benkenstein	Bourgeois	Broadley	Broadley and Greer	Burman	Burman	Cape Town City Engineer's Department	Cape Town City Engineer's Annual Report		Day
		YEAR (DATE OF INFORMATION)	1977	1978a	1978b	1975a	1975b	1976	1981	1981	1982	1948	1975	1969	1962	1977	1981	(1947-61)	(1973-79)	1951
BIOTIC		Food Webs																		
	Fauna	Mammals																		
		Birds				*	*		*											
		Reptiles & Amphibians											*	*						
		Fish				*		*	*	*	*									
		Fauna on soft substrates										*								
		Fauna on hard substrates																		
		Insects										*								
		Other invertebrates										*								
		Zooplankton										*								
	Flora	Terrestrial							*											
		Phytoplankton						*		*	*	*								
		Halophytes							*			*								
ABIOTIC	Other	Historical							*						*	*			*	
		Utilization	*	*	*				*	*	*						*		*	
		Conservation								*	*									
		Modelling																		
		Aquaculture																		
		Management	*	*	*	*			*	*	*						*		*	
		Bacteriology				*				*	*									
	Chemistry	Pesticide residues																		
		Metal residues																		
		Eutrophication	*	*	*				*	*	*									
		General chemistry	*	*	*	*				*	*								*	
	Geomorphology	Sediment transport & deposition				*														*
		Paleoenvironment																		
		Geology																		
	Physics	Circulation & mixing				*			*	*	*									
		Density variations								*	*									
		Hydrology	*	*	*	*				*	*									
	Physiography	Morphology							*											
		Catchment characteristics							*											

(Column label for the marks: Summary of available information)

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																					BIOTIC											
		Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other								Flora			Fauna								
SAND (Rivermouth/Lagoon)		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenvironment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues		Management	Aquaculture	Modeling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals	Food Webs
Sources of Information		Summary of available information																																
Day	1981		*	*		*				*					*				*	*	*	*	*	*				*					
Edington and Edington	1977													*																			
FitzSimons	1943																												*				
FitzSimons	1962																												*				
Furness	1978					*				*				*	*						*												
Furness	1979					*				*					*						*							*					
Greig and Burdett	1976																												*				
Greig *et al*	1979																												*				
Grindley	1963																						*										
Haughton	1969						*	*																									
Harrison	1962									*												*											
Heydenrych	1976	*	*	*		*	*		*	*	*			*	*				*			*	*					*		*			
Hutchinson *et al*	1932																						*										
Hocking	1972																		*	*													
Howard-Williams	1976			*						*	*				*			*	*														
Jubb	1967																											*					
McLachlan and Lewin	1981																					*											
Muir	1974																				*	*	*	*			*	*		*			

APPENDIX XII (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: SAND (Rivermouth/Lagoon)

		Sources of Information	Summary of available information	Muizenberg Marina Project	Noble and Hemens	Poynton	Roberts	Rose	Schulze	Schutte and Elsworth	Shelton	Stephens	Stuart *et al*	Summers *et al*	Sverdrup *et al*	Swart and Serdyn	Valsbaai Strandverbeteringe	Walker	Winterbottom	Winterbottom
		YEAR (DATE OF INFORMATION)		1971	1978	1964	1978	1962	1965	1954	1975	1929	1980	1976	1942	1982	1980	1922	1960	1981
BIOTIC		Food Webs																		
BIOTIC	Fauna	Mammals											*							
BIOTIC	Fauna	Birds					*							*					*	*
BIOTIC	Fauna	Reptiles & Amphibians				*		*			*									
BIOTIC	Fauna	Fish																		
BIOTIC	Fauna	Fauna on soft substrates									*									
BIOTIC	Fauna	Fauna on hard substrates									*									
BIOTIC	Fauna	Insects																		
BIOTIC	Fauna	Other invertebrates																		
BIOTIC	Fauna	Zooplankton									*									
BIOTIC	Flora	Terrestrial									*									
BIOTIC	Flora	Phytoplankton								*	*									
BIOTIC	Flora	Halophytes									*									
ABIOTIC	Other	Historical										*						*		
ABIOTIC	Other	Utilization																		
ABIOTIC	Other	Conservation																		
ABIOTIC	Other	Modelling																		
ABIOTIC	Other	Aquaculture																		
ABIOTIC	Other	Management																		
ABIOTIC		Bacteriology																		
ABIOTIC	Chemistry	Pesticide residues																		
ABIOTIC	Chemistry	Metal residues																		
ABIOTIC	Chemistry	Eutrophication																		
ABIOTIC	Chemistry	General chemistry								*					*					
ABIOTIC	Geomorphology	Sediment transport & deposition		*							*					*	*			
ABIOTIC	Geomorphology	Paleoenvironment																		
ABIOTIC	Geomorphology	Geology																		
ABIOTIC	Physics	Circulation & mixing			*															
ABIOTIC	Physics	Density variations			*															
ABIOTIC	Physics	Hydrology		*	*				*			*								
ABIOTIC	Physiography	Morphology		*	*													*		
ABIOTIC	Physiography	Catchment characteristics																		

APPENDIX XII (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: SAND (Rivermouth/Lagoon)

Summary of available information

			G. Avery (pers. comm.)	R. Bally (pers. comm.)	H. Benkenstein (pers. comm.)	R.C. Boycott and A.L. de Villiers (*in litt.*)	CCC City Engineer (pers. comm.)	B.R. Davies (pers. comm.)	J.R. Grindley (pers. obs.)	P.D. Morant (pers. obs.)	Scientific Services Branch, CCC (pers. comm.)	Maps	SA 1:10 000 3418 AB 10	SA 1:50 000 3418 AB and AD	SA Navy 1:150 000 Chart SAN 119
BIOTIC		Food Webs													
	Fauna	Mammals													
		Birds													
		Reptiles & Amphibians				*									
		Fish							*						
		Fauna on soft substrates													
		Fauna on hard substrates													
		Insects													
		Other invertebrates													
		Zooplankton													
	Flora	Terrestrial													
		Phytoplankton		*							*				
		Halophytes			*										
ABIOTIC	Other	Historical	*				*						*	*	
		Utilization					*				*				
		Conservation													
		Modelling													
		Aquaculture													
		Management					*	*			*				
		Bacteriology					*				*				
	Chemistry	Pesticide residues													
		Metal residues													
		Eutrophication								*	*				
		General chemistry					*	*			*				
	Geomorphology	Sediment transport & deposition					*				*				
		Paleoenvironment													
		Geology					*								
	Physics	Circulation & mixing			*			*			*				
		Density variations					*								
		Hydrology					*	*							
	Physiography	Morphology					*						*	*	*
		Catchment characteristics					*							*	
YEAR (DATE OF INFORMATION)			1982	1982	1982	1982	1982	1982	1980	1982	1982		1973	1978	1979

Sources of information

PLATE I:

The canalized mouth of the Sand Estuary. A characteristic feature of the summer months is the sandbar closing the mouth. (ECRU, 79-04-05).

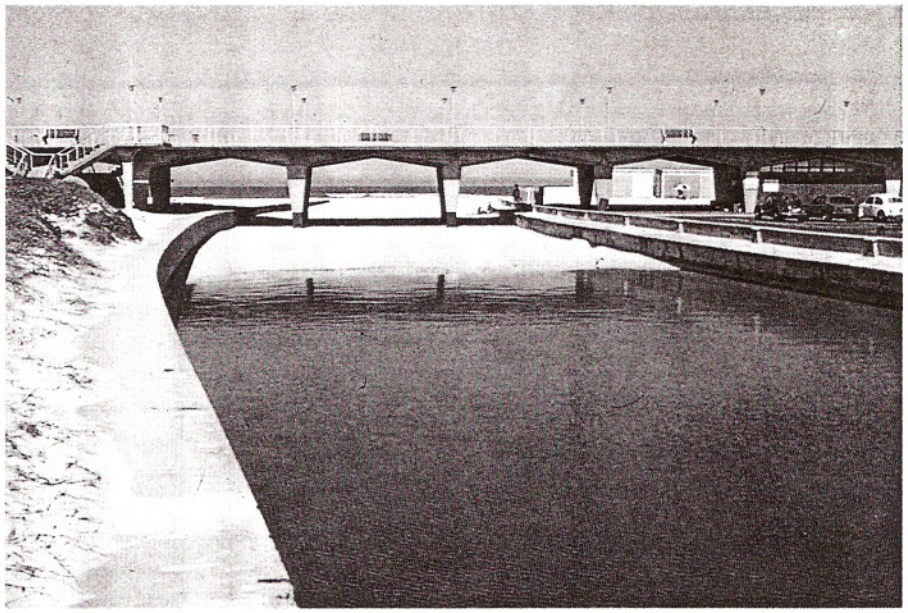

PLATE II:

View south-east over the lower reaches of the Sand Estuary. Photograph taken from Boyes Drive, Muizenberg; False Bay in the background. (ECRU, 79-04-05).

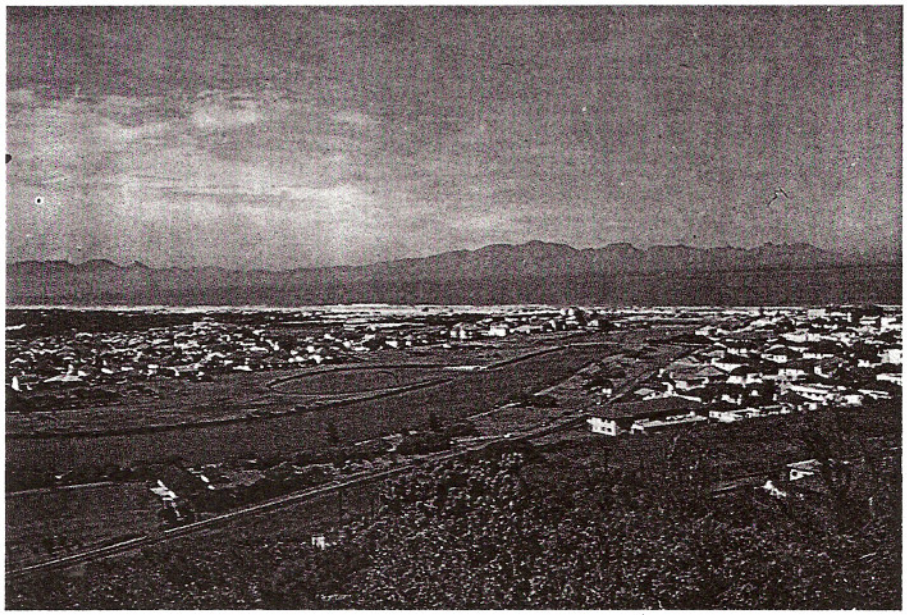

PLATE III:

Sandvlei: boardsailors make extensive use of the vlei particularly during the summer months. Conflicts of interest between sailors and other users e.g. anglers and bird-watchers can be expected as a result of the increasing popularity of sailing on the vlei. (ECRU, 83-03-27).