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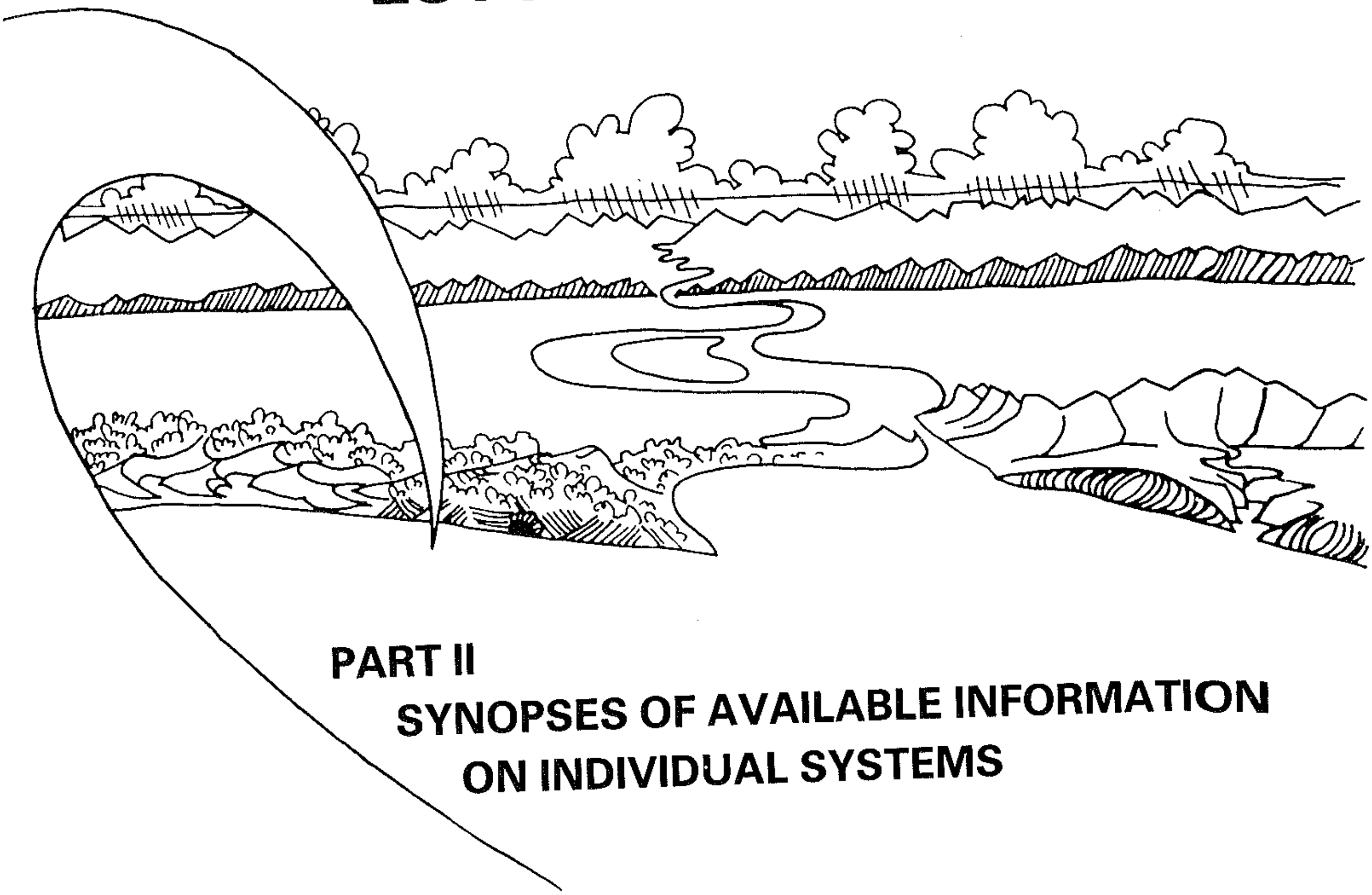
ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 40

KLEIN (CSW 16)

CSIR RESEARCH REPORT 439

Stellenbosch, South Africa
October 1989

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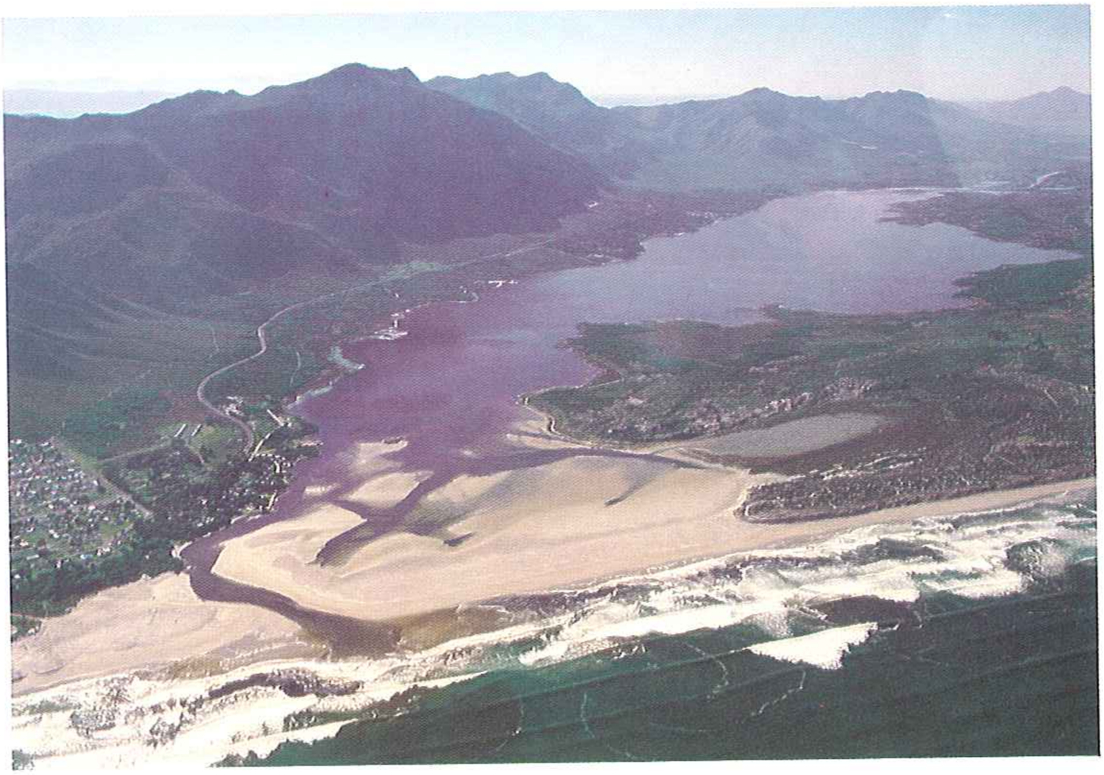
PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
A E F HEYDORN and P D MORANT
Division of Earth, Marine and Atmospheric Science and Technology
CSIR, Stellenbosch



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REPORT NO. 40: KLEIN (CSW 16)

(CSW 16 – CSIR Estuary Index Number)

BY: H P DE DECKER
Department of Zoology,
University of Cape Town

ESTUARINE AND COASTAL RESEARCH UNIT – ECRU
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY
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PREFACE

The Estuarine and Coastal Research Unit was established by the National Research Institute for Oceanology 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 from the Kei to 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 undertake investigations 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 "Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley, CSIR Research Report 380). The report 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 "Estuaries of the Cape, Part II". These reports summarize, in language understandable to the layman, all available information on individual estuaries. 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, 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.

On 1 April 1988 the National Research Institute for Oceanology was incorporated into the new Division of Earth, Marine and Atmospheric Science and Technology (EMA) of the CSIR. In the process of restructuring, the Estuarine and Coastal Research Unit (ECRU) ceased to exist as an entity. However, the tasks undertaken by the ECRU continue to be performed by the Coastal Processes and Management Advice Programme of EMA.

D H SWART
PROGRAMME MANAGER
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY

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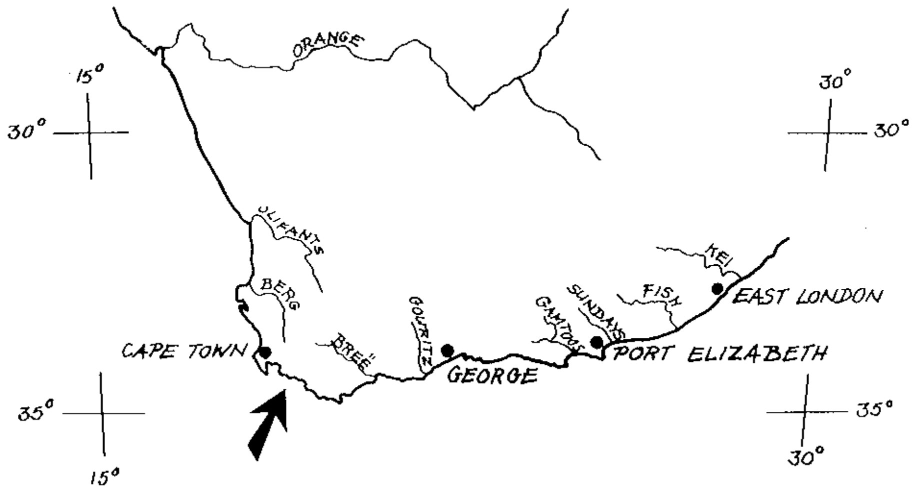
KLEIN

1. LOCATION

The estuary of the Kleinrivier lies at 34°24'S, 19°18'E, between the towns of Hermanus and Stanford on the south-west coast of South Africa. The estuary drains into Walker Bay in the Atlantic Ocean.



1.1 Accessibility

The coastal road (R43) between Hermanus and Stanford runs along the northern shore of the estuary. Access may be gained via the municipal areas at the mouth (Die Plaat) or slipways at Prawn Flats and Maanskynbaai. The rest of the northern shoreline including the Yacht Club is private land. The southern shore is only accessible at Wortelgat (private) and at Lê-Bos, an old forestry station used during the stabilization of the dunefield (Figure 1). At Stanford the river can be reached either at the municipal slipway or at the R43 roadbridge, which crosses the river above the town.

1.2 Managing Authorities

Overberg Regional Services Council - the entire catchment
Hermanus Municipality -Northern shore between the mouth and Maanskynspruit and recreation on the vlei
Stanford Municipality - Stanford township
CPA Chief Directorate Nature and Environmental Conservation (CDNEC) - Conservation Forestry - Walker Bay forest reserve and dunes in the coastal area south east of the estuary (area between the mouth and Groot Sanddraai)

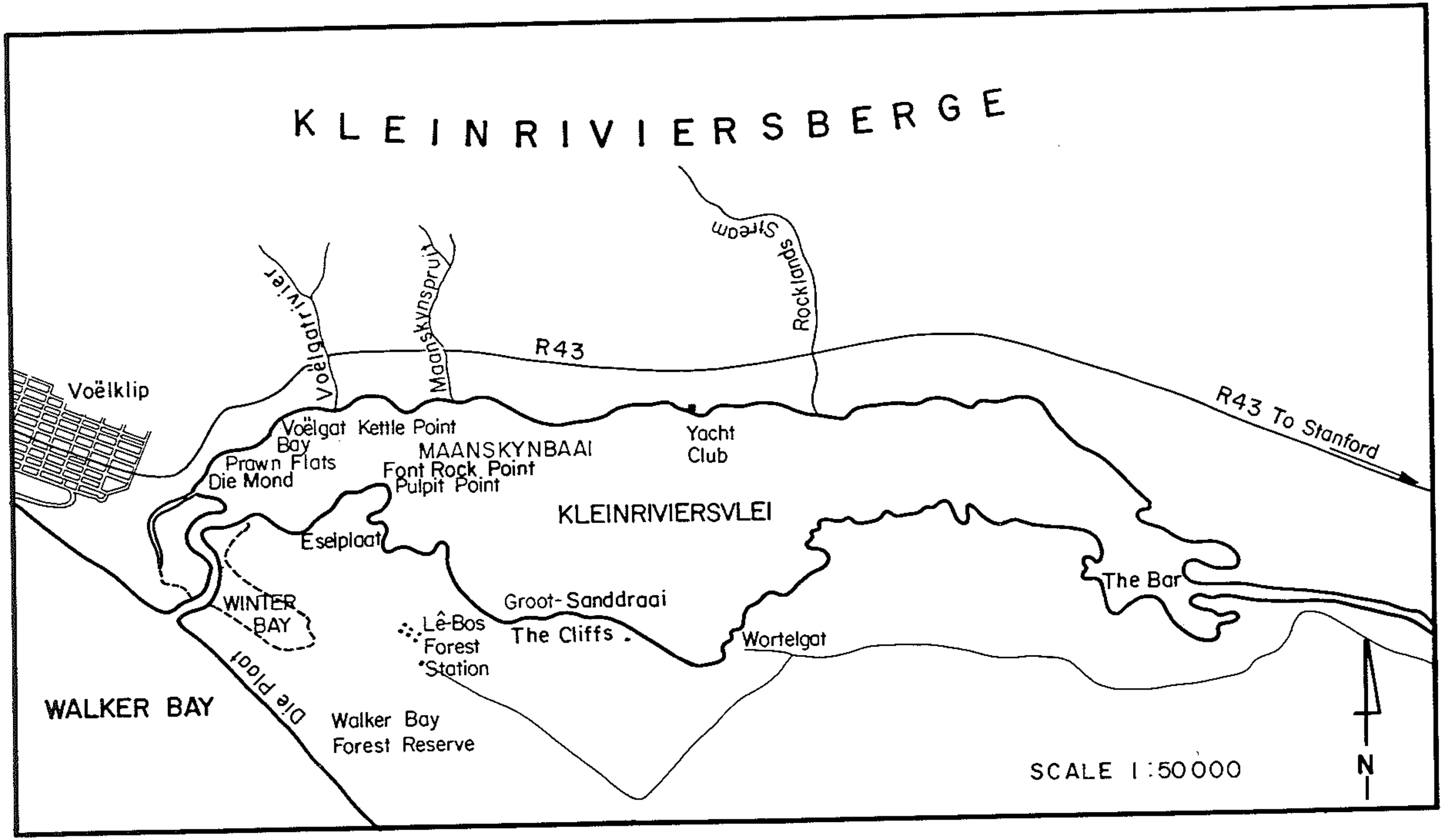


FIG I: Kleinriviersvlei.

2. HISTORICAL BACKGROUND

2.1 Synonyms

Kleinrivier, Kleineriviersvlei: 1:50 000 topographical Map 3419 AD Stanford
Kleine Rivier: Burman, 1970
Literally means 'small river'

Kleinriviersvlei is popularly known as "Hermanus Lagoon". In some of the accounts of Kleinriviersvlei it is difficult to determine exactly to which component of the system the author is referring. However, for the purposes of this report the estuary is that part of the system between an imaginary line joining Kettle and Pulpit points and the sea. (see Figure 1). The lagoon is the main lacustrine water body between the Kettle Point - Pulpit Point line and the point of entry of the Kleinrivier in the east. When the system as a whole is being discussed it is referred to as Kleinriviersvlei or, more simply, the vlei.

2.2 Historical Aspects

Kleinriviersvlei and nearby Hermanus have an interesting and intimately linked history, described in detail by Tredgold (1965). Stone tools (Bally, 1985) and numerous middens found in the coastal dunes and surrounding area (Tredgold, 1965; Van Heerden, 1985) indicate that the region has been inhabited since the late Stone Age. Although no archaeological survey has as yet been done in Hermanus, the middens have yielded artifacts dating from 300 000 to 200 years BP (W J van Rijssen, South African Museum, pers. comm.). The more recent inhabitants were probably Khoi-Khoi (Hottentot) or San (Bushman) hunter-gatherer groups often referred to as Strandlopers.

The first account of the valley of the Kleinrivier was written by Lady Anne Barnard, who travelled along the river in 1798 in a party on a hired wagon drawn by horses. Burman (1970) gives a vivid description of this excursion. The town of Hermanus derives its name from one Hermanus Pieters, a Dutch shepherd and teacher who frequented the area in the 1830s for pasture and fishing. Others soon followed and in 1875 Hermanuspietersfontein, as it was known, was declared Crown Land and erven were sold for between £5 and £10 (Waldron, 1986). The name was shortened to Hermanus in 1902 (by the postmaster) and in September 1904 the settlement was declared a municipality. It consisted of a small fishing village with a tiny natural harbour approximately 5km west of the lagoon. The potential value of the area as a holiday resort was soon realised by speculators and the land between Hermanus and the lagoon, as well as its northern bank, was subdivided and sold as a 'health and pleasure resort' (Marloth, 1906). The Hermanus Yacht Club, on the same side of the lagoon, was established in 1910 (Waldron, 1986).

The earliest report of a natural breaching of the sandbar separating the vlei from the sea dates from the records of a Dutch traveller, M P Teenstra, in 1825 (Tredgold, 1965). Artificial breaching of the vlei began at least as early as the 1860s (Coetzee and Pool, 1986) and occurred whenever low-lying properties and farmlands in the upper reaches were flooded by high water levels. The estuary was usually opened by hand, often with two teams competing at opposite ends of the sandbar (eastern and western sides), due to a popular controversy concerning the "best" position for the breaching (Tredgold, 1965). The Chief Directorate Nature and Environmental Conservation now holds the responsibility for the management of the mouth. Its present policy is to open the mouth when the water level reaches a mark of +2.1 m (MSL) at the jetty at Prawn Flats, as recommended in a CSIR study (CSIR, 1988). An interesting practice in the early 1860s, was the setting of nets across embayments in the lagoon prior to an artificial breaching, thereby allowing the collection of trapped fish from the enclosed areas once the vlei had drained (Coetzee and Pool, 1986 quoting McFarlane *in litt.*, 1913).

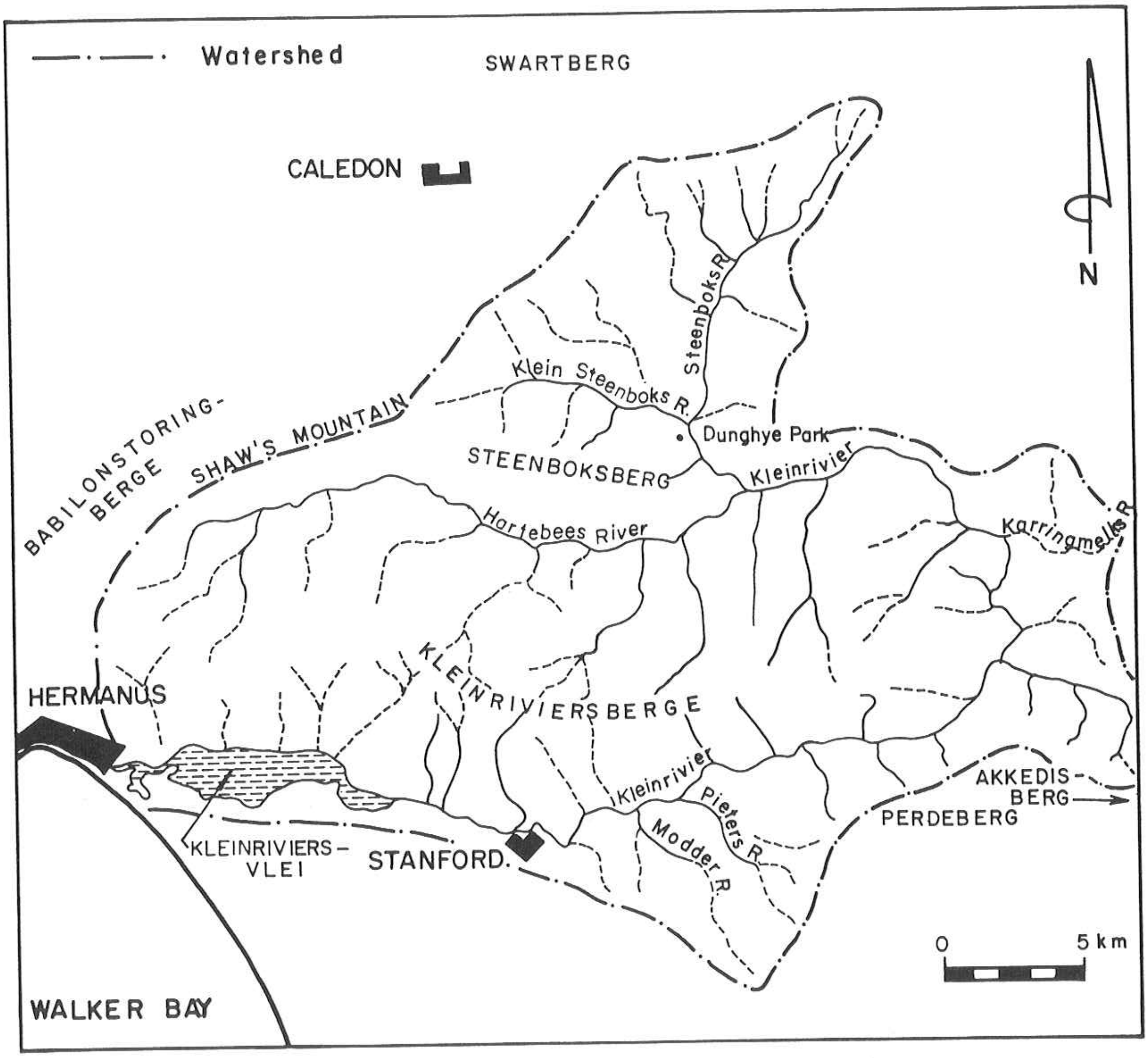


FIG. 2 : The catchment of the Kleinrivier.

More recently, both the then Caledon Divisional Council and the then Department of Forestry have opened the sandbar whenever water levels had reached an arbitrarily defined "Forestry mark" on a jetty near the mouth.

At the furthest limit of tidal influence (7km upstream of the head of the lagoon) lies the village of Stanford, named after Captain (later, Sir) Robert Stanford, who owned the farm Klein River on which the town was established in 1856. The village became a municipality in December 1919 (Bulpin, 1980).

3. ABIOTIC CHARACTERISTICS

3.1 Catchment

3.1.1 Catchment Characteristics

Area

750km^2 (Heydorn and Tinley, 1980)
741km^2 (Noble and Hemens, 1978)
906km^2 (Crowther, 1987)

The discrepancy in these figures is due to different assessments of the catchment boundary.

The Kleinrivier catchment encompasses the Kleinriviers, Shaw's-, Steenboks-, Swart-, Akkedis- and Perde Mountains (Figure 2).

River length

The Kleinrivier has its origin at the confluence of the Hartebees and Steenboks Rivers south-east of Dunghye Park, 47km upstream from the sea (Figure 2). The latter two rivers have their sources 23km and 15km upstream of the confluence respectively. The Hartebees River drains the valley between Shaw's Mountain and the Kleinriviersberge, while the Steenboks River drains the plains north of the Steenboks Mountain and southeast of Caledon.

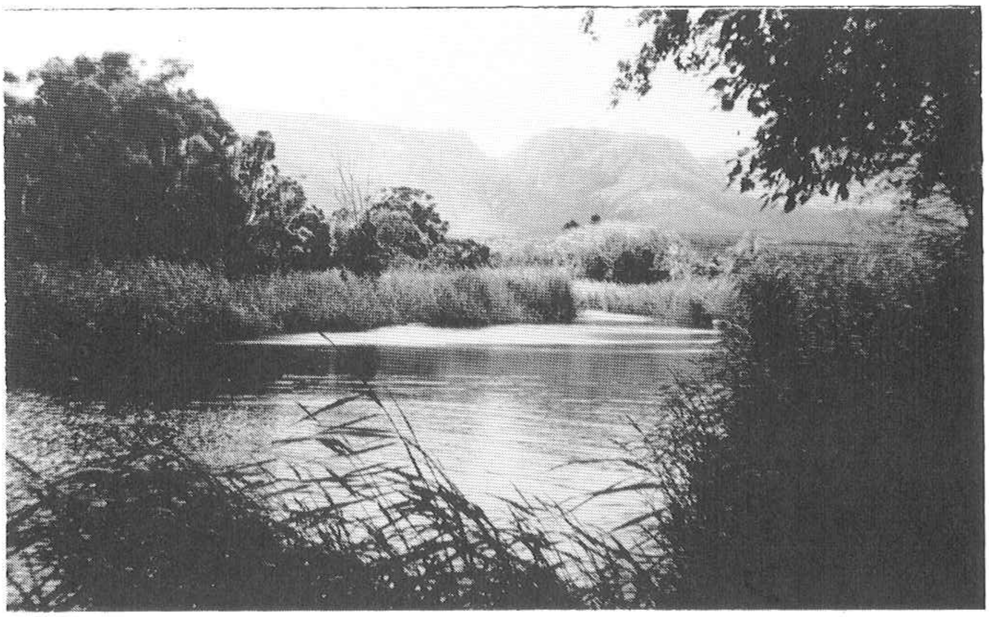


FIG. 3: The Kleinrivier at Stanford about 6 km from the head of the estuary (86-12-09).

Tributaries

The Klein Steenboks River, which drains the area south of Caledon, joins the Steenboks River 4km upstream of its confluence with the Hartebees River.

Tributaries of the Kleinrivier include the Karringmelks-, Pieters- and Modder Rivers, as well as several smaller streams. Approximately 10 streams drain directly from the slopes of the Kleinriviersberge into Kleinriviersvlei.

Geology, soils and water quality

The catchment is composed mainly of rock of the Table Mountain and Bokkeveld Groups, interspersed with a few outcrops of Cape Granite (Figure 4). The resistant Table Mountain Group sandstone form the mountainous relief features, while the shales and sandstones of the Bokkeveld Group form the fertile valleys (Sloman, 1983). The area to the south of the estuary consists of coastal sand dunes and aeolianites.

The major soil types within the catchment area are comprised of residual soils (formed by *in situ* weathering) and soils associated with mountains including a variety of shallow soils (Figure 5). Most of the Kleinrivier drains duplex loams which are acidic and have low nutrient levels (Schloms *et al.*, 1983). The soils in the mountains consist of highly leached, low nutrient white sands, which are mostly derived from Table Mountain Group quartzites (Heydorn and Tinley, 1980).

The Table Mountain Group soils produce highly acid water (a minimum pH of 3,5 has been measured), while highly saline water leaches into the river from the Bokkeveld shales (S van Rooyen, Agricultural Technical Services, Caledon, pers. comm.). Sediment yield is low, being of the order of 100-150 tonnes per square kilometre per year (Noble and Hemens, 1978). These are typical characteristics of black water (pale variant) rivers, as defined by Heydorn and Tinley (1980).

Rainfall, run-off and river flow patterns

The Kleinrivier catchment lies within the Winter Rainfall Region, with maximum precipitation in June/July (Heydorn and Tinley, 1980). The mean annual precipitation (MAP) for the whole catchment is 568mm (Midgley and Pitman, 1969), with a range of 400-800mm (O Lategan, Agricultural Extension Officer, Caledon, memorandum dated 2/6/1975). The strong orographic control of rainfall, typical of the Cape coast (Heydorn and Tinley, 1980) also occurs here, so that maximum rainfall is usually recorded on the Steenboks (MAP of 636mm) and Kleinriviersberge (MAP of 634mm) adjacent to the vlei. Detailed rainfall records are kept by the Hermanus Municipality.

The mean annual run-off (MAR) of the Kleinrivier is 40,00 x $10^6 m^3$ for the period 1924-1979 (Crowther, 1987), and not 96 x $10^6 m^3$ as given by Noble and Hemens (1978) and quoted by Heydorn and Tinley (1980). From figures supplied by the Department of Water Affairs (Pretoria) for the period 1962 to 1979 for the gauging station G4M06, the mean annual run-off was calculated at 29,30 x$10^6 m^3$. This calculation does not include the very wet years 1953-57 when the run-off varied from 102 to 428 percent of the MAR (Crowther, 1987).

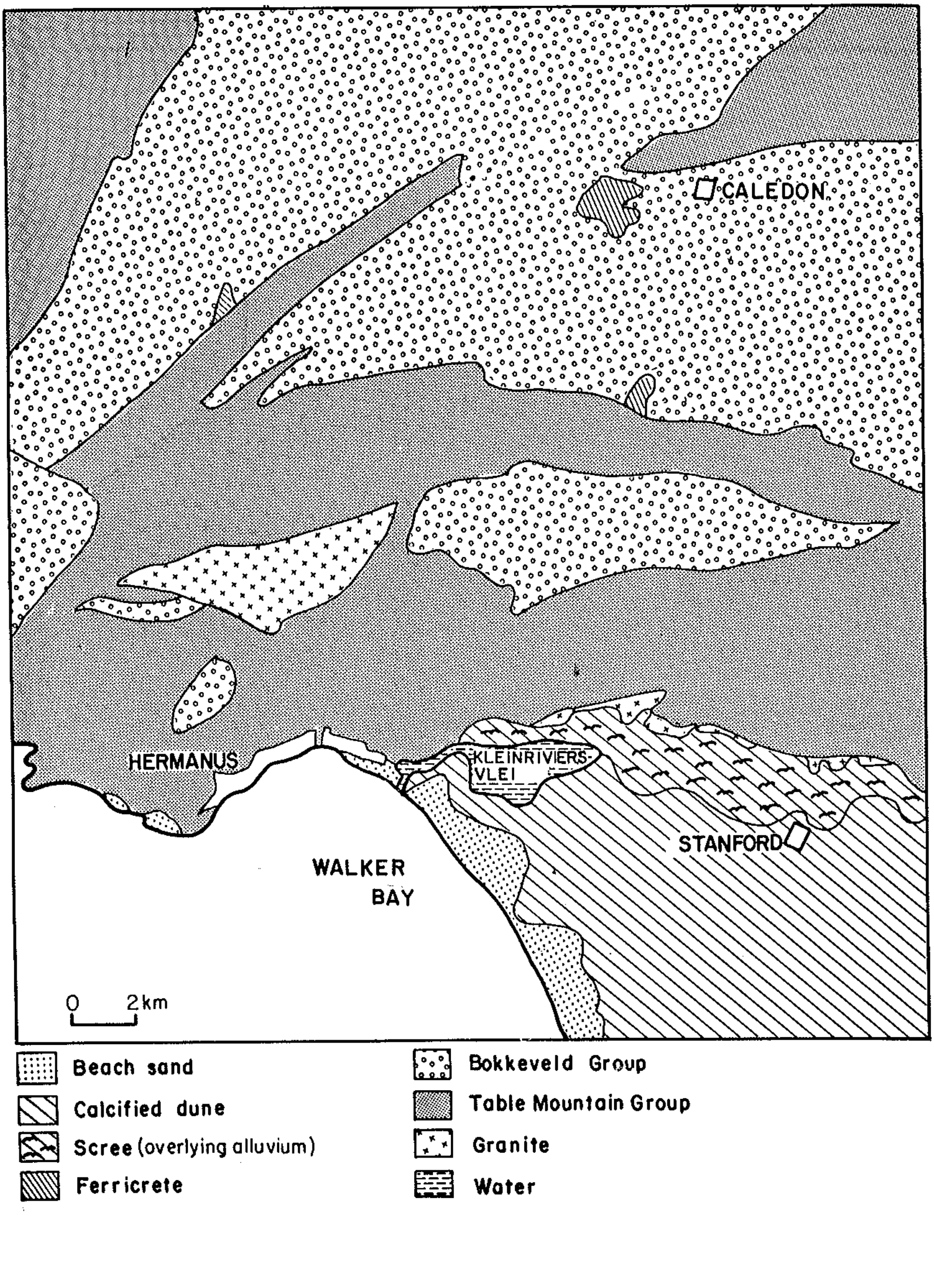


FIG. 4 : Geology of the Kleinrivier catchment (from 1 : 125 000 geology map 3319C - Worcester 3419 A - Caledon)

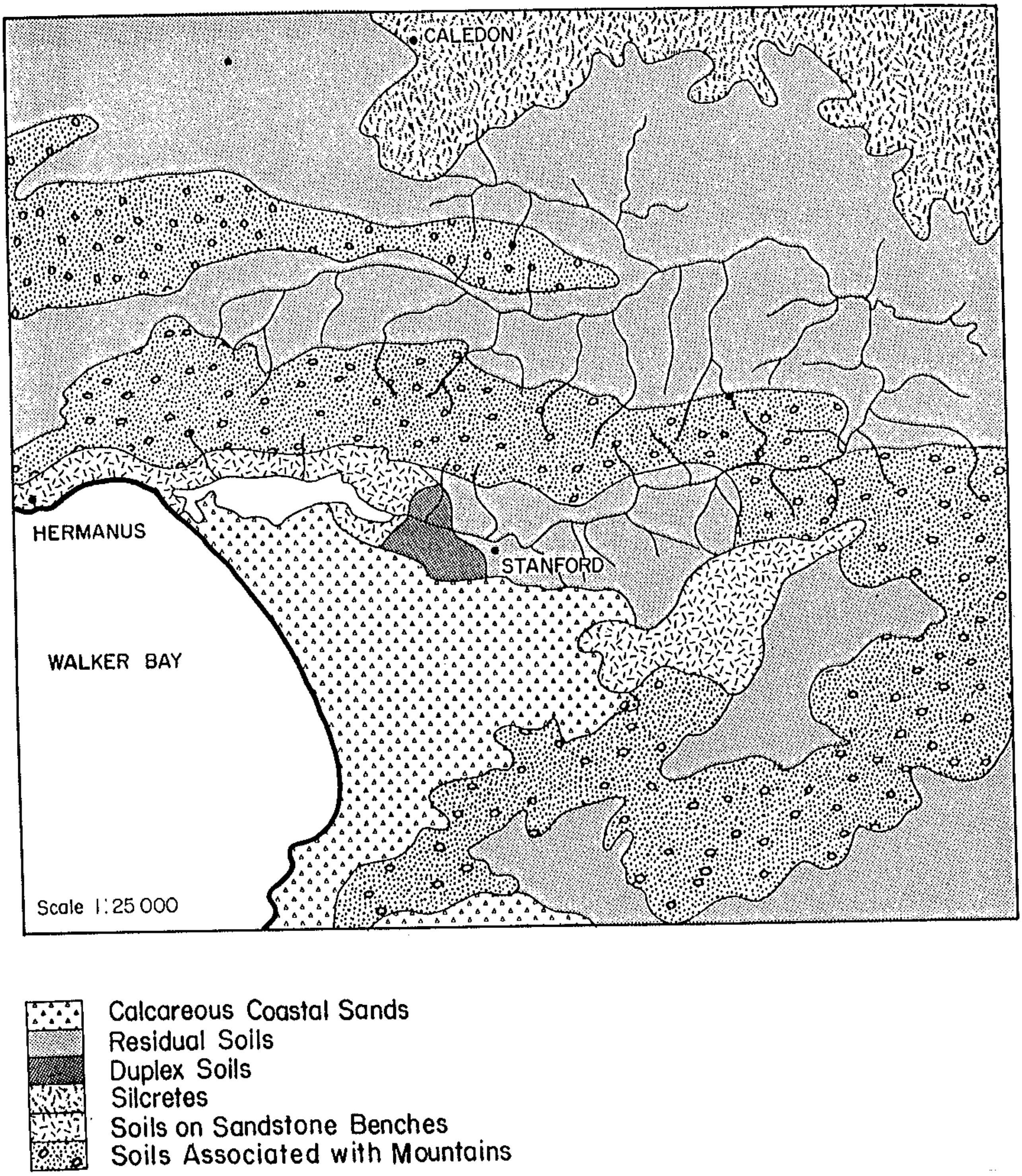


FIG. 5 : Soil types in the Kleinrivier catchment. (Schloms, Ellis and Lambrechts, 1983)

FIG.6 : Simulated annual run-off for the Kleinrivier catchment, 1924 - 1979 (Crowther, 1987)

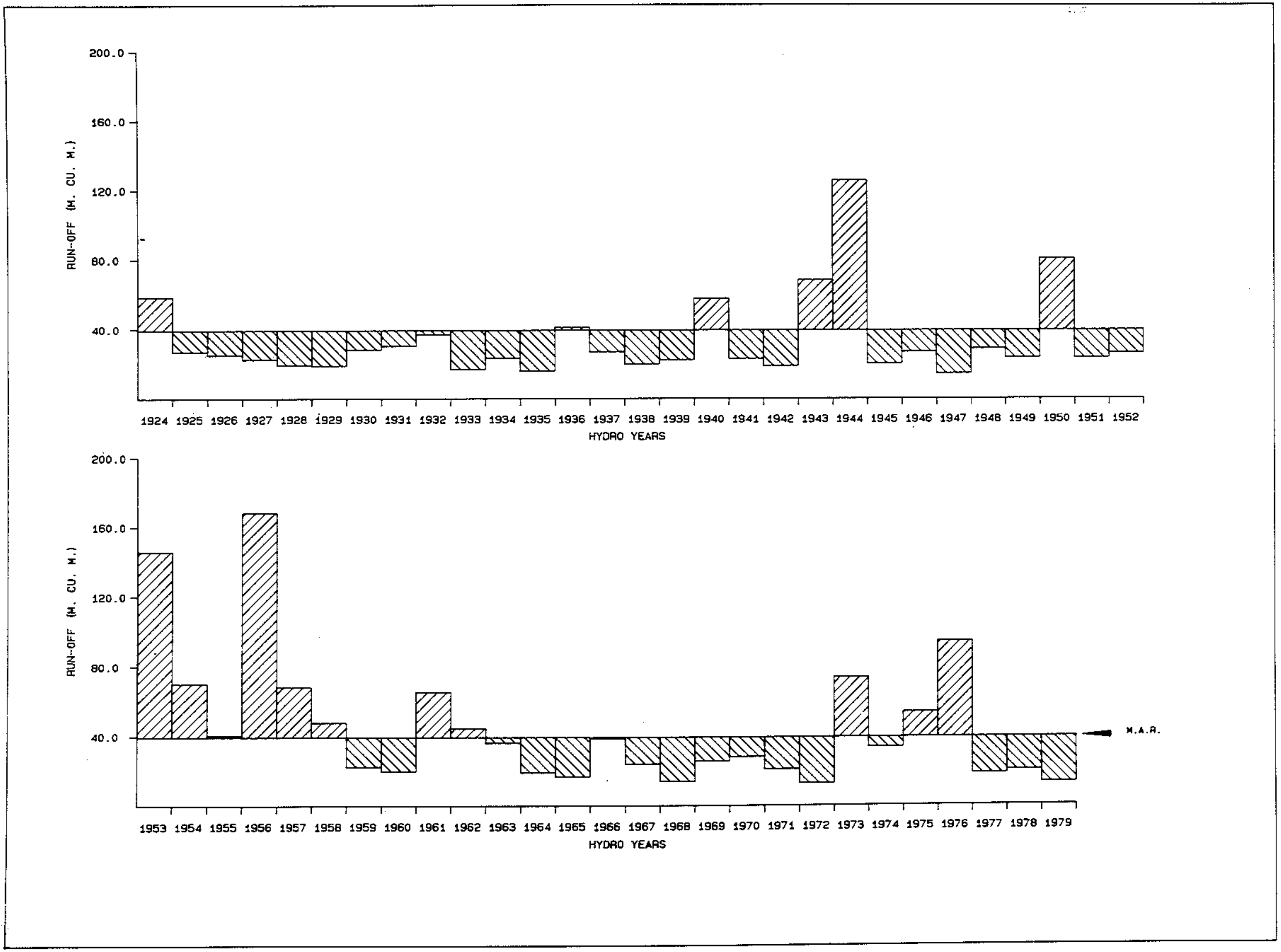
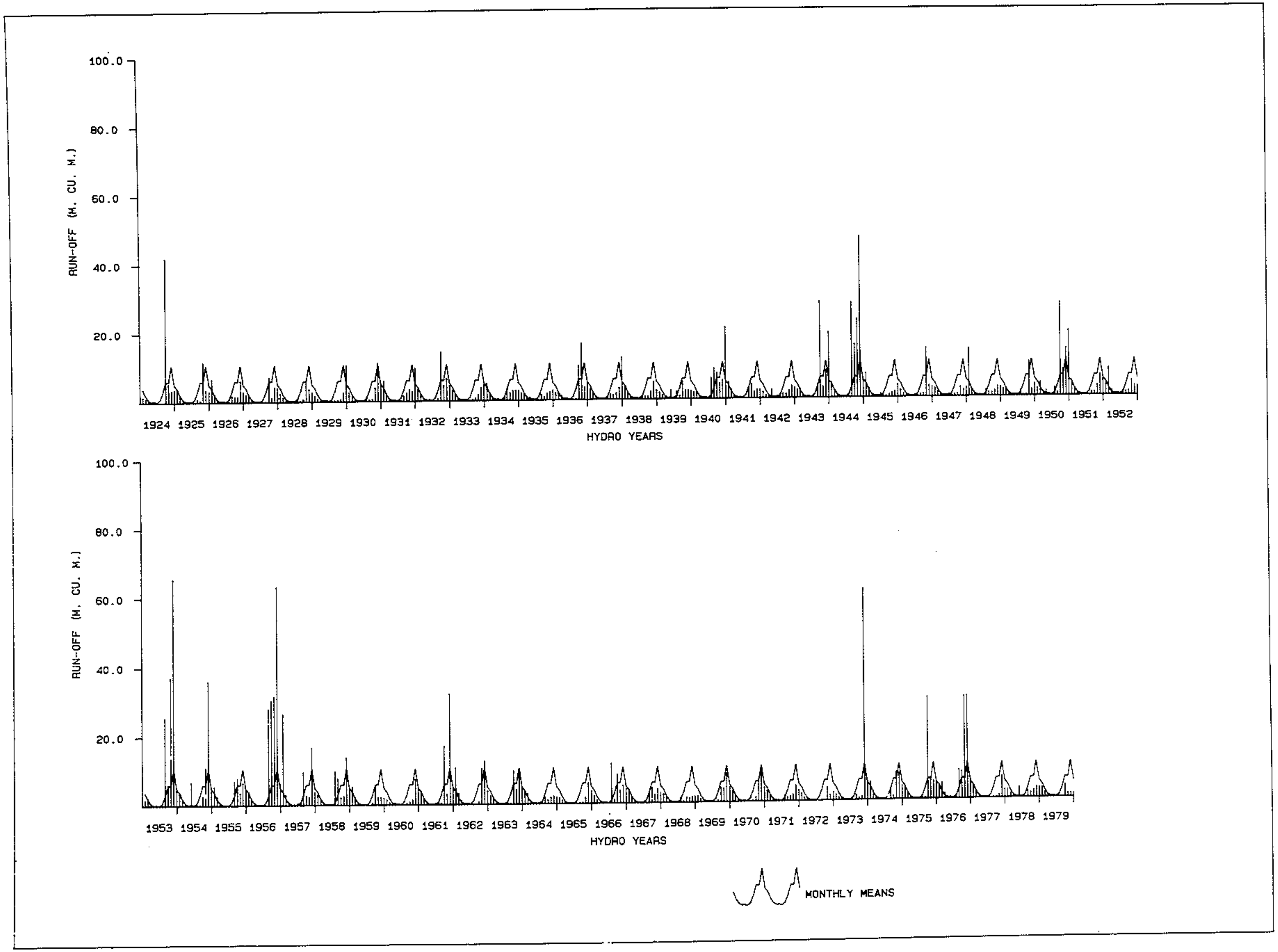


FIG. 7 : Simulated monthly run-off for the Kleinrivier catchment, 1924-1979 (Crowther, 1987)



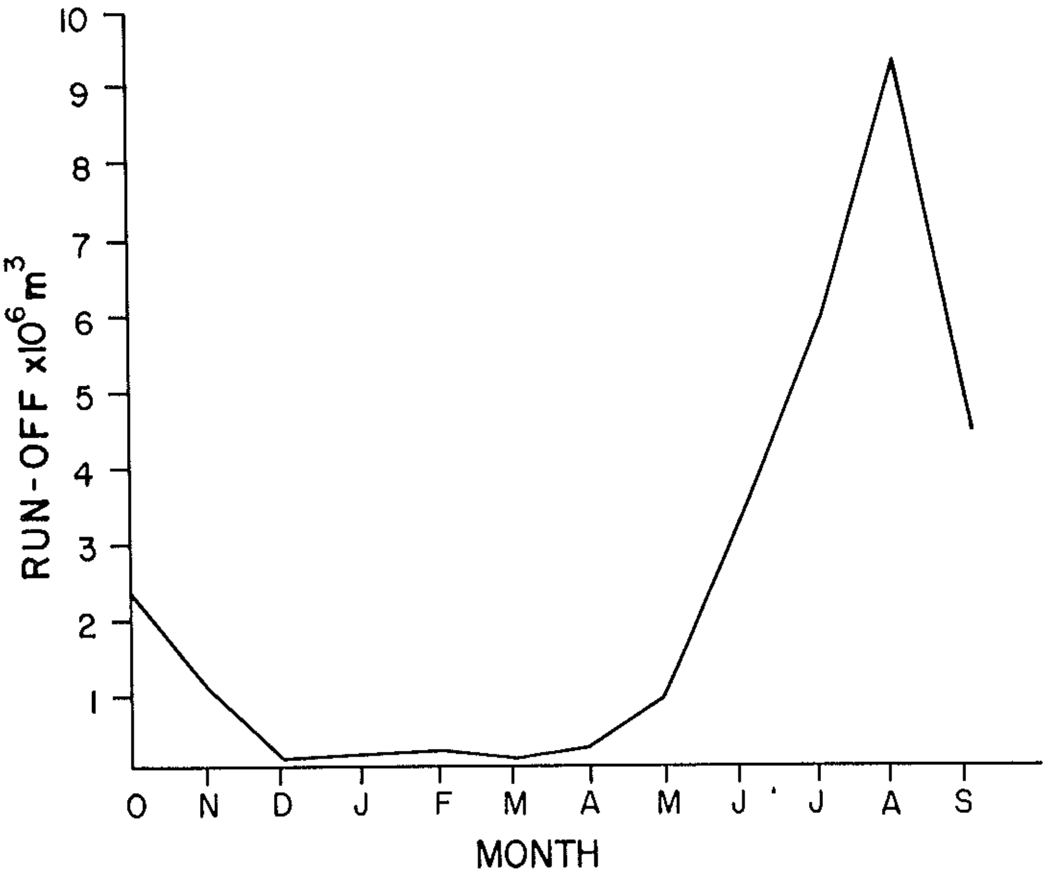


FIG. 8: Mean monthly run-off 1970 - 1980 (from Waldron, 1986)

The extreme variability in run-off (over the period 1924-1979 it ranged from 31,9 percent to 428,9 percent of the MAR) should be noted when drawing up management proposals for the Kleinriviersvlei (Figures 6 and 7).

Figure 8 shows that the mean monthly run-off is highest in August, although annual peaks may occur from June to September in any particular year. Lowest run-off occurs between December and March, when the flow is often less than the resolution of the gauging station (<0,001 x $10^6 m^3$ per month), although the river seldom dries up altogether.

3.1.2 Land Ownership/Uses

The entire catchment falls within the jurisdiction of the Overberg Regional Services Council and, apart from the municipal areas of Hermanus and Stanford or Forestry areas, is entirely privately owned. The CDNEC Section Conservation Forestry controls the coastal zone and dune fields south-east of the estuary (Walker Bay Forest Reserve). Approximately 40 percent of the catchment area is used for wheat farming, often alternated with pasturage for sheep and cattle, while a further 30 percent is used for irrigated crops, mainly potatoes, onions, beetroot and sweet potatoes. The remaining more mountainous areas are covered by fynbos, which supports a flower picking industry supplying the local and export markets (S van Rooyen, pers. comm.).

3.1.3 Obstructions

There are no state controlled dams in the Kleinrivier catchment, although many earth farm dams on smaller tributaries collect water for cattle and, to a lesser extent, for irrigation.

Almost the whole river, including its tributaries as far as Caledon, is heavily infested with the alien wattles *Acacia saligna, A. longifolia* and *A. mearnsii*. There are also very dense stands of the indigenous river sedge, *Prionium serratum* (Palmiet). These plants substantially reduce river run-off (S van Rooyen, pers. comm.) and may account for the fact that, on average, the annual river run-off is only 8,74 percent of the annual precipitation. This can be contrasted with the nearby Palmiet River, which also drains agricultural areas but has a run-off of 40,6 percent of its MAP (Pitman *et al*, 1981). Unfortunately the gauging station was only installed in 1963, after the infestation by alien vegetation was already established, and comparative run-off data are therefore not available. Other problems caused by the alien infestation are the damming of flood water resulting in flooding of roads and properties, and increased evaporative loss leading to reduced flow and raised salinities. Van Rooyen (pers. comm.) has measured salinities in the river of as high as eight parts per thousand.

3.1.4 Siltation

Despite extensive farming, erosion does not constitute a problem in the catchment. Most silt enters the river from the Bokkeveld shales but, since the banks are well stabilized by alien vegetation and Palmiet, the silt load is not high. However, a disturbing practice of destroying the river bank vegetation exists among grain farmers. This vegetation provides roosting and nesting sites for seed-eating birds which sporadically cause considerable damage to local grain crops (King *et al*., 1989). This method of controlling granivorous birds should be assessed against the cost of repairing damage resulting from increased bank erosion. Rather than causing widespread damage to the river bank vegetation, which plays a vital role in the functioning of the river, (such as the uptake of nutrients that would otherwise enter the vlei), measures should be directed at controlling these localised destructive irruptions when they occur.

The present sediment yield of the catchment as a whole is a moderate 100-150 tonnes per square kilometre per annum (Noble and Hemens, 1978). This represents a total yield of 135 900 tonnes per annum for the entire catchment area (Crowther, 1987).

3.2 <u>Estuary</u>

3.2.1 Estuary Characteristics

The Kleinrivier Estuary is cited by Noble and Hemens (1978) as an example of a blind estuary, i.e. one comprising a closed standing water body formed by the seasonal closure of the mouth by a low sandbar. This results in the characteristic change from a tidal, salinity-stratified estuary to a non-tidal, freshwater-dominated system after closure.

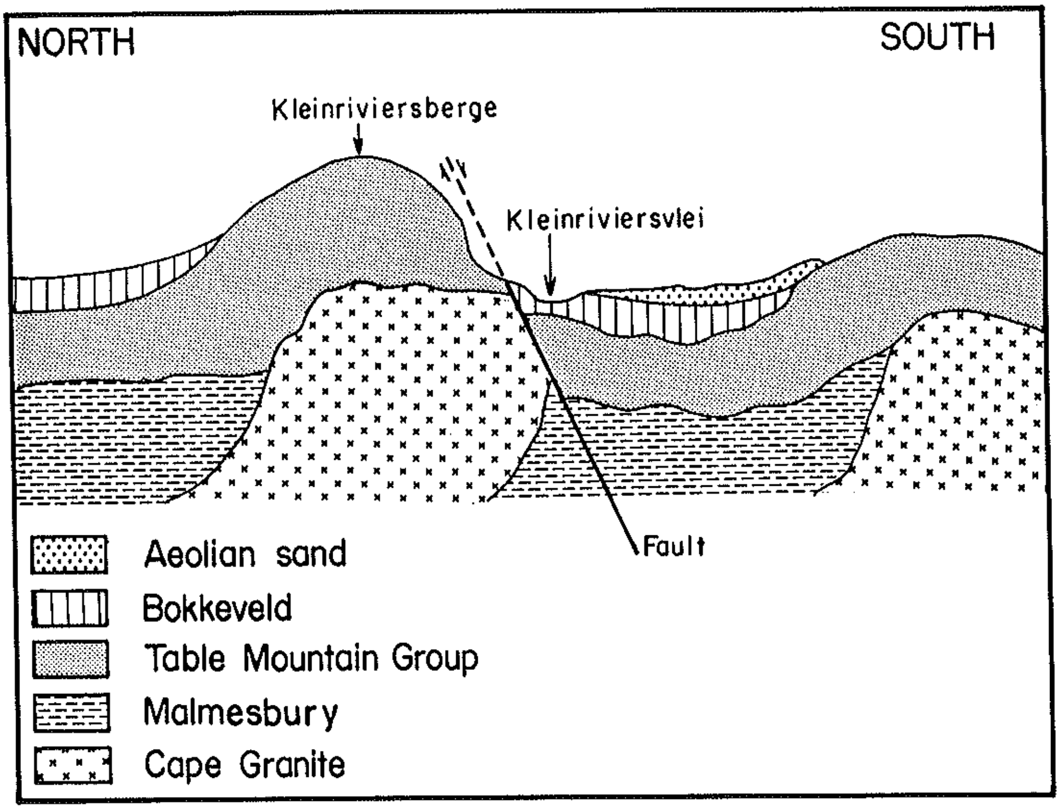


FIG. 9: Section through Kleinriviersvlei showing the geological structure which gave rise to its formation (from Taljaard, 1949). N.B. Geology not representative of present knowledge.

Formation

The Stanford Basin was formed by a combination of folding and faulting, and contains the estuary, which lies in the syncline south of the Kleinriviersberge arch (Figure 9). The rising post-Pleistocene sea-level progressively drowned the river valley upstream, while river-borne sediments were not sufficient to fill the basin. At the same time, a flood-tidal delta was formed by marine sediments which dammed the mouth of the river, forming the estuary. The subsequent marine regression of the last 14 000 years to the modern mean sea-level has left a wide sandbar in the lower reaches through which the river has carved a tortuous channel to the sea. This channel is closed at low lagoon water levels by a sand berm at its mouth.

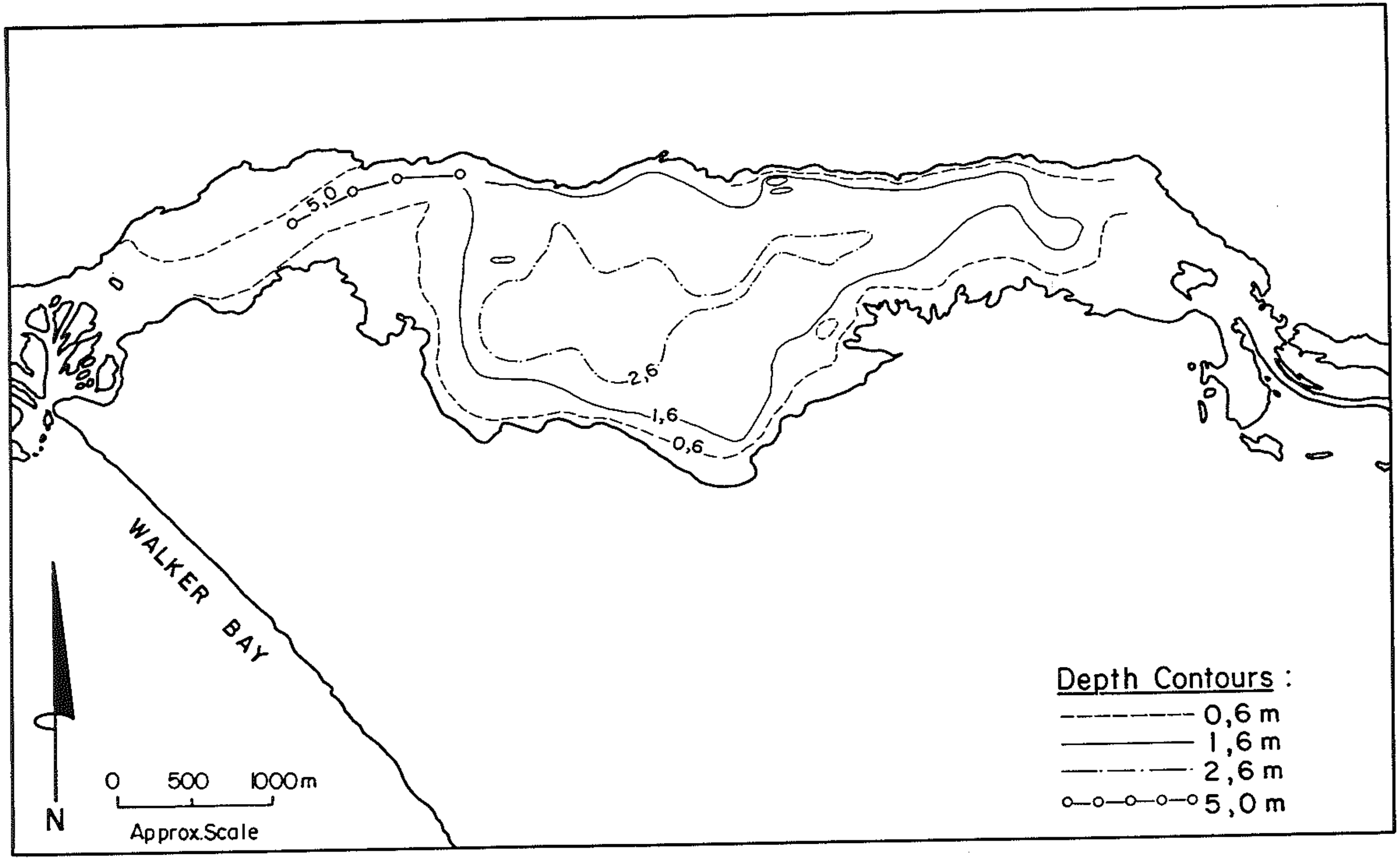


FIG. 10 : Bathymetry of Kleinriviersvlei (Fortuin, in litt.)

	Water Level		
	Highest (84-09-09)	Middle (MSL)	Lowest (83-02-12)
Height (m)	3,83	2,19	1,66
Area (km^2)	11,28	5,60	4,27
Volume ($10^6 m^3$)	24,41	8,87	4,08
Shoreline length (km)	26,83	18,38	17,46
Max depth (m)	4,63	2,99	2,49
Max open water length (km)	7,45	6,60	5,20
Max open water breadth (km)	2,00	1,85	1,75

TABLE 1: Extremes of water levels of the Kleinriviersvlei as recorded by the Department of Water Affairs. 'Middle' approximates to MSL. 'Highest' was recorded on 9 September 1984 and 'Lowest' on 12 February 1983. (After Waldron, 1986).

Area

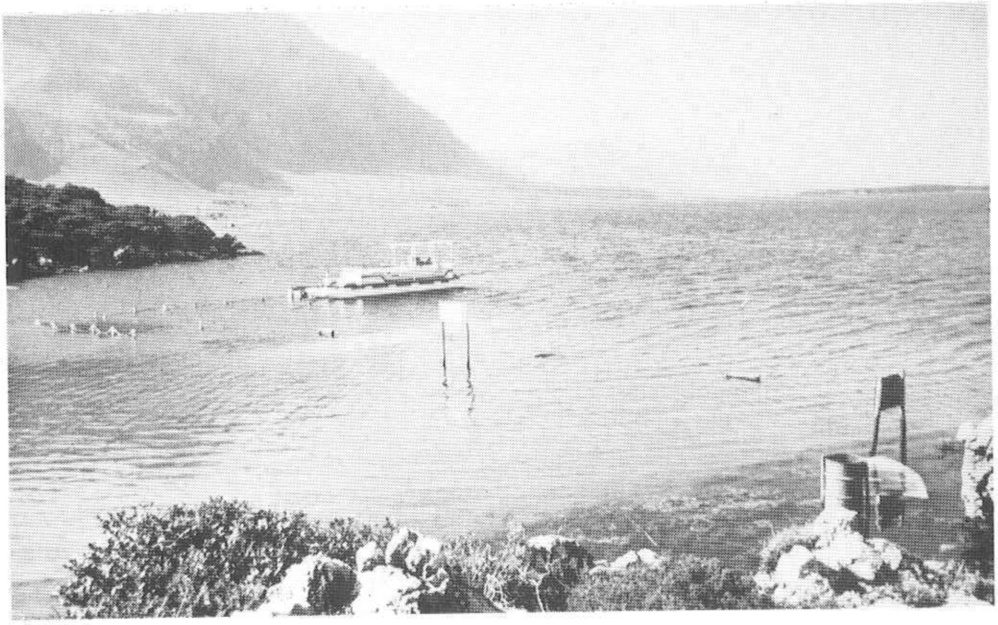
Duvenage (1983) states that Kleinriviersvlei is approximately 10km long and 2km across at its widest point, having a total area of 1 280ha and a water area of 918ha. Since high quality colour aerial photographs were not available at the time of Duvenage's study these measurements were taken from the 1:50 000 topographic map 3419AD Stanford. The water area quoted compares favourably with the figures given by Waldron (1986) (Table 1).

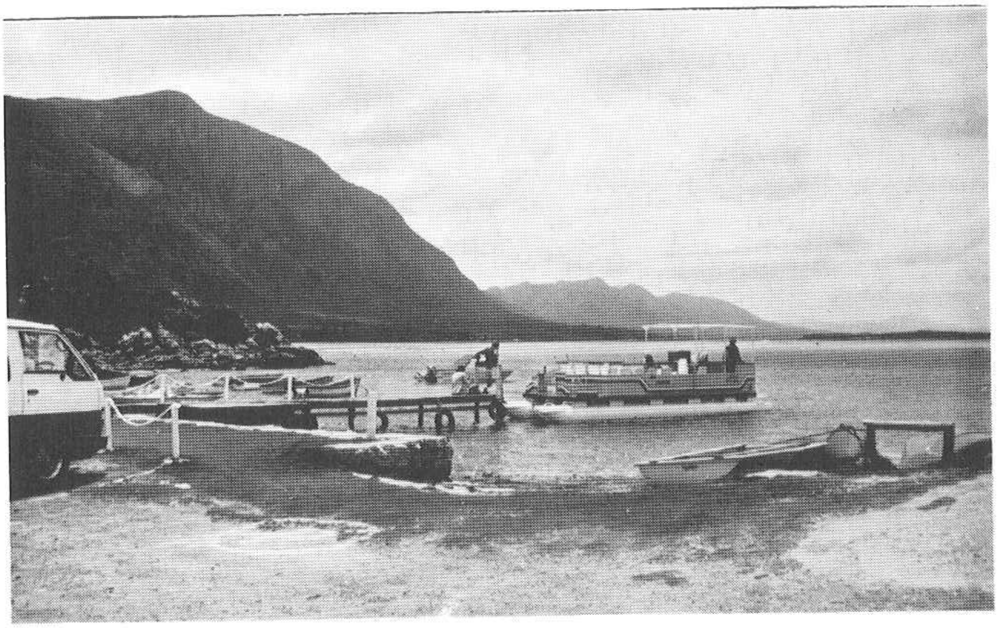
Depth

Bathymetric surveys of the vlei were carried out in 1951 (Truter and partner, 1954) and by CSIR in 1985 (Fortuin, in prep.) Maximum depth is approximately 5m (below MSL) in the subtidal channel (Figure 10). The deepest part of the lagoon is near the northern shore, where the bottom slopes steeply. From this deeper section, the bottom rises gently to the southern shore.

Waldron (1986) presents morphometric data for Kleinriviersvlei at three water levels (Table 1). The highest of these (3,8 m) was recorded by the Department of Water Affairs water level recorder (at the Yacht Club) on 9 September 1984. The middle level approximates to MSL, i.e. it represents the situation shortly after breaching of the berm at the mouth, while the lowest level (1,6 m) was recorded on 12 February 1983 after the water level behind the closed mouth berm had fallen as a result of evaporation uncompensated by river inflow. It is of interest to note that the lowest water volume of the system is only 17 percent of its highest volume and 46 percent of the volume when the surface is at sea-level.

When the mouth is open the lagoon is under tidal influence, showing a fortnightly rise and fall in water level following spring and neap tides. Spring lows are not apparent in the estuary, since the interval between spring highs and lows (6 hours) does not allow time for the estuary to drain sufficiently before the onset of the following high tide. The tidal range varies considerably, depending on the depth at the mouth. The estuary has to reach a level of 2,6 - 2,9m above MSL before it opens naturally (Mr M van Rooyen, Dep. Town Clerk, Hermanus, pers. comm.) (CSIR, 1988).





<u>FIG. 11</u>: The mouth of Kleinriviersvlei
(a) High water level on 87-07-29 just prior to artificial breaching.
(b) Water level when mouth is open i.e. under tidal influence on 86-12-09.

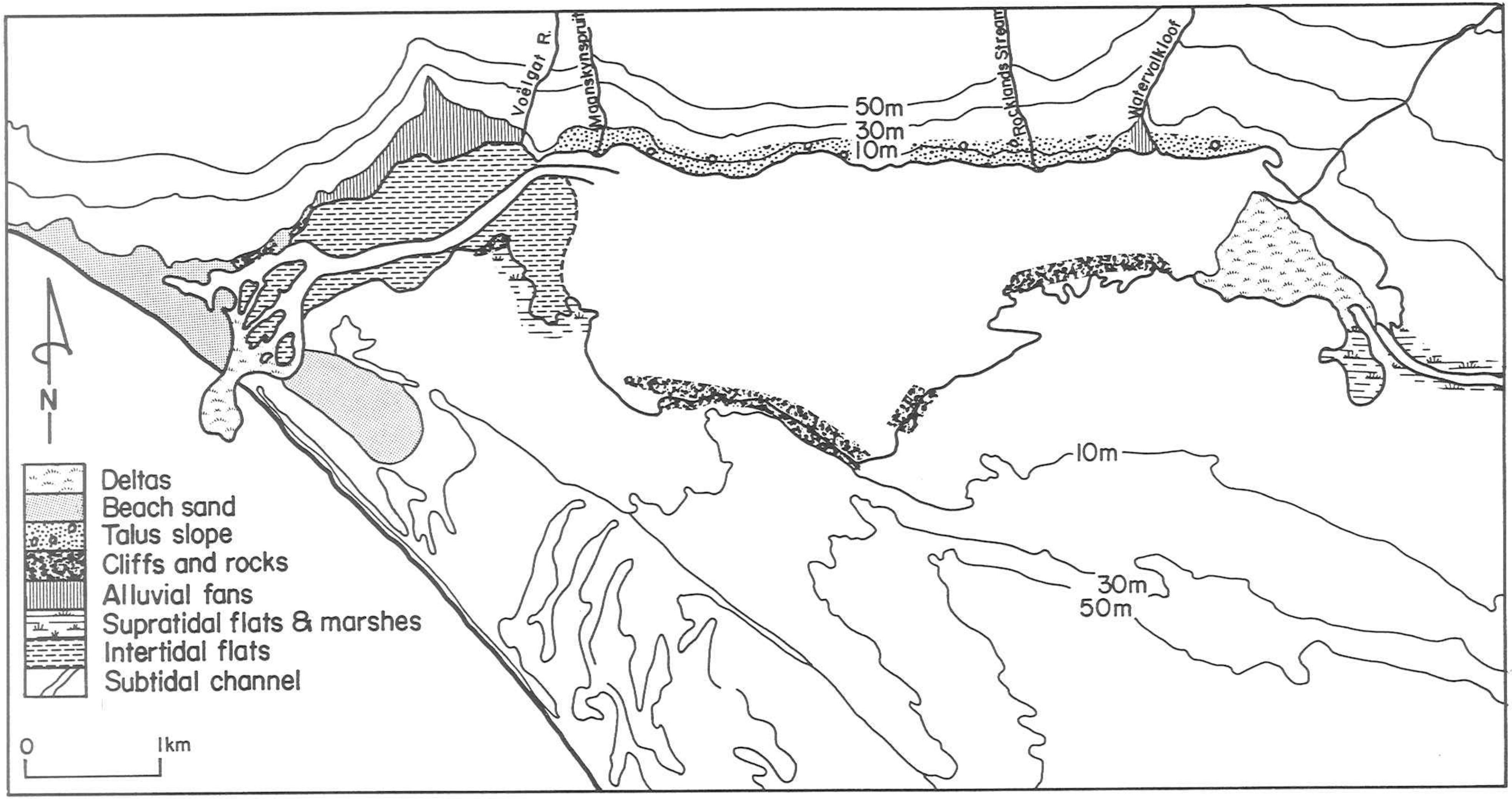


FIG.12 : Physiographic units of Kleinriviersvlei (after Sloman, 1983).

Geomorphology

The only information on the geomorphology of Kleinriviersvlei is that given by Sloman (1983). The estuary is bounded to the north by the Kleinriviersberge composed of rock of the Table Mountain Group, while its southern shore is composed of coastal limestones (calcretes). Fringing the southern shore of the estuary, lithified dunes covered by a calcrete cap are found. The calcrete ends abruptly in a subterranean "cliff", and is replaced on the seaward side by modern sands. These aeolianites progress in a general west to east direction in dunes of up to 30m high at intervals of 300-500m. Stabilization of the dunes (Walsh, 1968) with *Acacia cyclops* (Rooikrantz) and indigenous dune vegetation during the past 40 years has prevented any further movement of the dunes.

Immediately east of the estuary mouth a vegetated dune has been created artificially by the Department of Forestry (Walsh, 1968). This forms a littoral dune line which lies parallel to the dominant wind directions (SE and NW) and consequently does not move. The effect of these manipulations on mouth dynamics is discussed in Section 3.2.2.

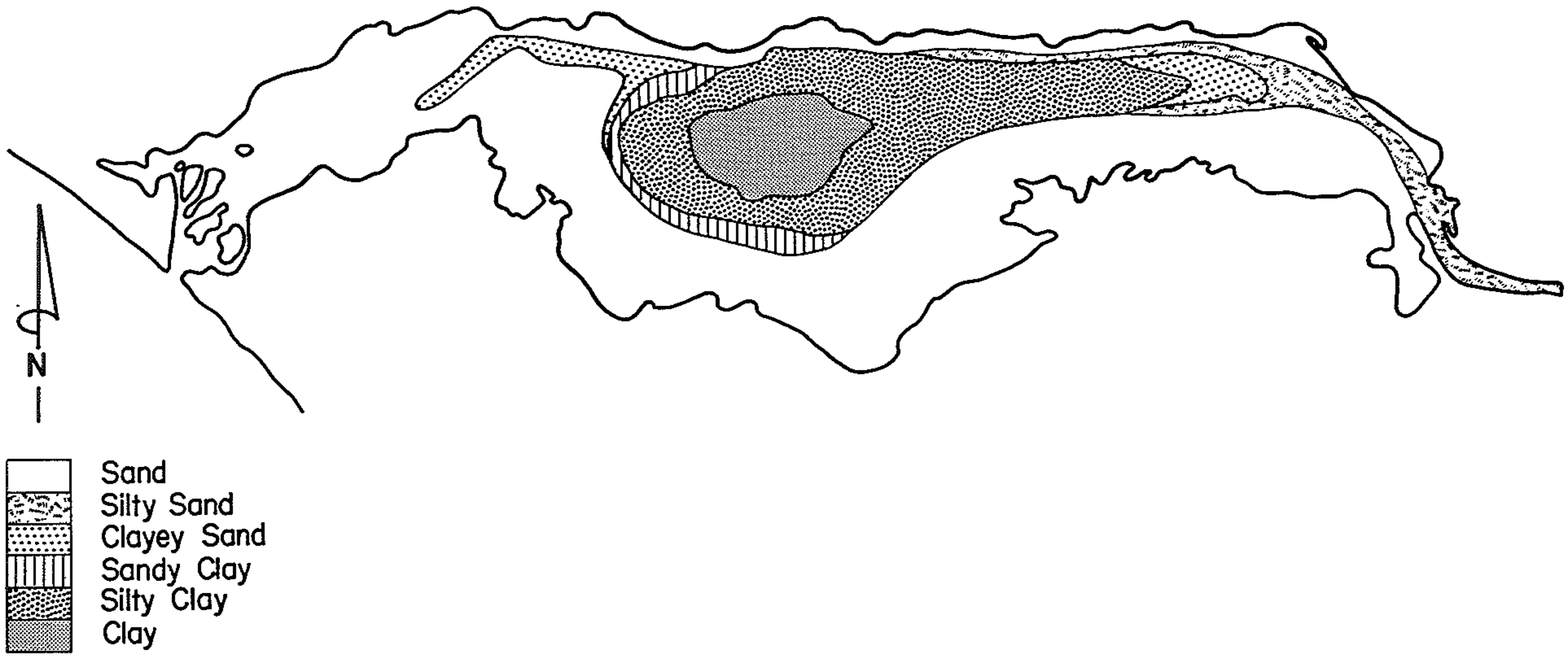
A number of alluvial fan deltas occur along the northern shore, where rivers discharge their sediment load from the mountains into the estuary (Figure 12). The largest of these deltas is formed by the Voëlgat River, which enters the estuary west of Kettle Point. The alluvial fan deltas introduce poorly-sorted sediments along the northern margin of the vlei, with coarse sands and gravels deposited nearshore and fines deeper into the estuary.

A talus slope occurs along the northern shore of Kleinriviersvlei, derived from mechanical and chemical weathering of the Kleinriviersberge. Nearer the lagoon the rock fragments have been rounded by wave action and form boulder-strewn beaches in places.

Sedimentology

A detailed account of the sedimentology of Kleinriviersvlei and its estuary has been completed by Sloman (1983). Most of the sediments in Kleinriviersvlei are derived from three sources: the river, the sea and from bank erosion. The sediment of the estuary west of Maanskynbaai consists mainly of sand, silt and clay fractions, with minor horizons of gravel. In the lagoon the sediments consist mainly of the fine sand fraction which dominates its lower reaches and shore zones (Figure 13). On the northern shore, sediments are coarser, becoming finer grained with increasing depth. On the southern side, however, the nearshore sediments are finer than those in slightly deeper water (1m-1,5m), whereafter they likewise become finer with increasing depth. Fining occurs during sediment re-working by waves along the shore, with subsequent transport and deportation of finer grains into the deeper, wave-free basin (Figure 14). On the shallow southern side, however, rocky ridges perpendicular to the shore reduce current strength, thereby restricting the export of fines from this area.

FIG.13 : Distribution of sediments in Kleinriviersvlei (after Sloman, 1983)



The sediments of the flood-delta area (where the above-mentioned processes do not occur) are dominated by a fine sand fraction, and etiology while very fine sands are found in the channels traversing the area. When water levels are low, the wind may winnow fine sands from exposed areas, leaving a medium sand fraction. Minor (<two percent) contributions of gravel are found in the alluvial fan deltas, in the very shallow areas along the northern shore (derived from the talus slope), and in an extensive shallow area along the southern shore (probably derived from weathering of the calcrete ridges). Further surveys are required to determine the depositional history of the sediments as well as the effects of currents on sedimentation.

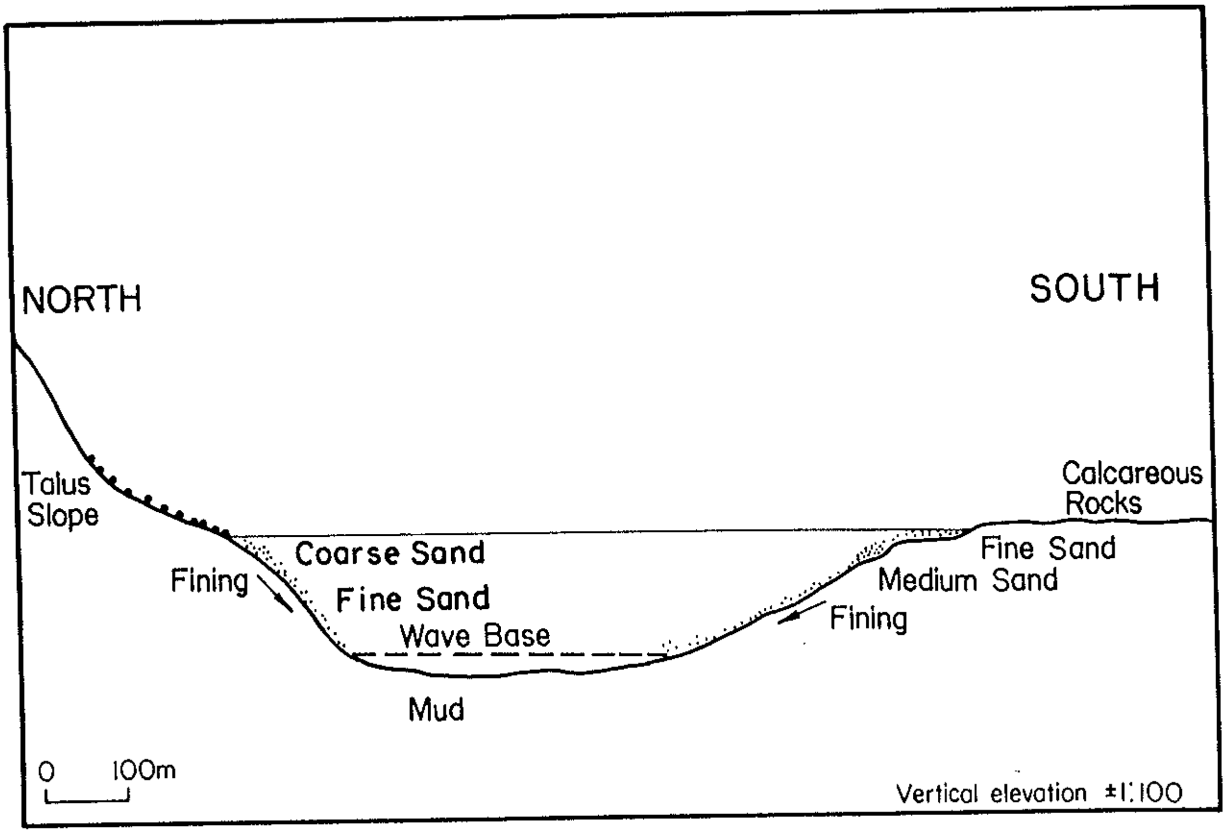


FIG. 14: Cross-section: Sediment distribution in relation to bathymetry (after Sloman, 1983).

3.2.2 Mouth Dynamics

(This section was contributed by L Barwell, EMA, CSIR)

Waves and Longshore Sediment Transport

Waves approaching a coastline at an oblique angle cause nearshore currents, of which the longshore component is the most important for moving sediment into an estuary through its mouth, when open.

The mouth of the Klein Estuary is located within Walker Bay, which is fairly exposed to deep sea swells approaching from the S/SW sector. These swells prevail throughout the year producing a dominant north-westerly - setting longshore current opposite the mouth. During winter, however, swells from the

NW/W sectors may predominate resulting in a south-easterly - setting longshore current. In general, longshore currents and sediment movement in Walker Bay are well balanced with respect to their NW and SE components (J Schoonees, CSIR, pers. comm.). However, at times (after the mouth has been breached), additional wave refraction takes place over an offshore bar in the vicinity of the estuary mouth, usually leading to a movement of sediment from the north-west in a predominantly south-easterly direction (I van Heerden, CSIR, pers. comm.)

The longshore currents move sediment into the open vlei mouth, building sandbanks and eventually blocking the mouth completely as in 1987. The effect of the longshore sediment movement can be seen in the growth of sandbanks similar to those marked A and B in Figure 25.

Sediment Input

In general the water level within a closed estuary varies in response to the volume of fresh water input and, to a lesser degree, to the amount of evaporation and seepage. Under normal conditions the water level reaches a maximum towards the end of the wettest winter months, causing the mouth to breach naturally. Thereafter, approximately two to three months of rain and river run-off can be expected before summer. During such a natural breaching a maximum amount of sediment is flushed from the mouth area while the follow-up freshwater run-off ensures continued flushing of sediment. Subsequent low river flow results in the influx of marine sediment and closing of the mouth due to the domination of coastal currents and longshore sediment movement. The net result is that sufficient sediment is seasonally flushed out of the estuary to ensure that a natural balance is maintained. A change in any of the contributing factors, e.g. premature artificial mouth breaching, may upset this balance and lead to an increase in estuarine sedimentation, as seen at Kleinriviersvlei.

Sedimentation in the mouth area of Kleinriviersvlei has been increasing over the last few decades (Figure 15). This can be ascribed primarily to the net influx of marine sediments due to frequent artificial breachings of the mouth at very low estuarine water levels and at inappropriate times within the hydrological cycle.

Mouth Breaching

Although natural breachings are currently considered to be optimal for the system, the mouth has been artificially breached on many occasions since the turn of the century (Appendix VII). A report by CSIR (1988) discusses the history of mouth breachings and correlates their occurrence with available hydrological and historical data.

In order to assist environmental managers in deciding whether and when to open the mouth, the following procedure was suggested (CSIR, 1988):

* Lagoon water levels within the catchment area together with available river flow and rainfall data, should be recorded on a weekly basis by a responsible body.

* By comparing these data with past trends on a monthly basis, a conclusion should be reached as to whether or not a normal rainfall pattern is developing.

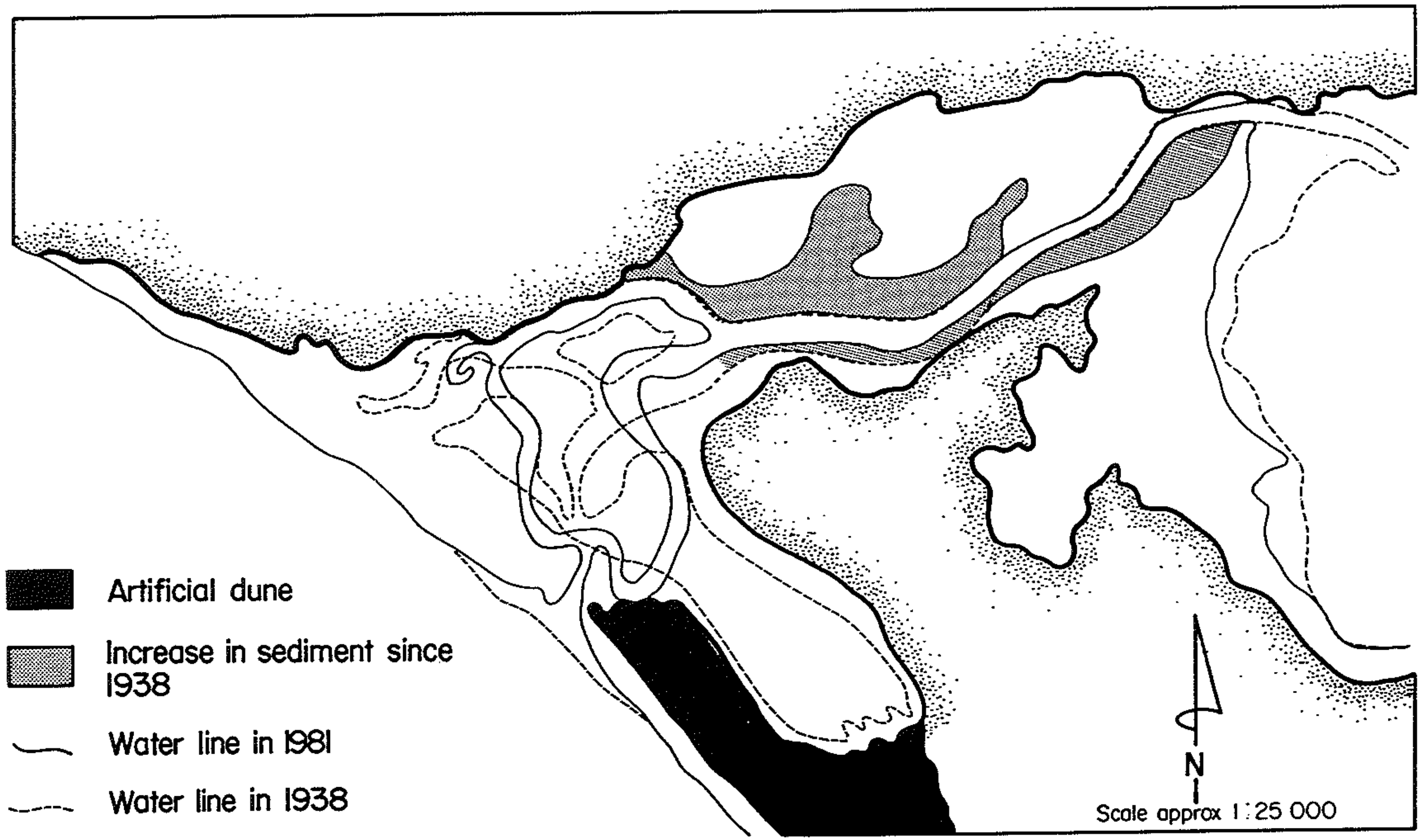


FIG.15 : Sediment accretion in the estuarine channel from 1938 to 1981 (after Waldron, 1986)

* If a normal pattern is developing and the water level in the lagoon is reasonably high (but at least at the recommended minimum level), a decision regarding breaching should be made not later than July each year. This is to ensure that, if the mouth is opened towards the end of July (at the latest), there is sufficient follow-up freshwater flow to allow optimal functioning of the mouth.

* If an abnormally wet pattern is developing, with high run-off during April, May and June, a decision to breach the mouth *before* the end of July should be made.

* If an abnormally dry pattern is developing, with little rain and run-off before the end of July, the mouth should *not* be breached, even should late spring rains cause the lagoon level to rise. However, should such rains result in the water rising to 'dangerous' levels, making breaching unavoidable, it is of the utmost importance that the mouth be opened at the *recommended position and time of month*, as discussed below.

Should it become necessary to breach the mouth of Kleinriviersvlei artificially, the following procedure is recommended:

* The mouth should be opened at a point between 50 m and 150 m north-west of existing beacon PA100 (Figure 18) which is situated on the south-eastern side of the sand berm. It is imperative that the recommended method be followed and the mouth breached exactly 2 hrs before spring low tide (not earlier or later) as described in CSIR, 1988.

* A minimum lagoon water level of +2,1m MSL should be reached prior to breaching. Although a water level equal to the natural height of the sandberm is considered to be optimal for the proper functioning of the estuary mouth, a large number of man-made structures (houses and boat-houses) are situated below this level. A balance should be reached between endangering private property and maintaining as high a water level as possible.

These recommended guidelines were accepted by the CDNEC during 1989 (J Neethling, CDNEC, pers. comm.). A reference mark showing the recommended breaching level of +2,1 m (MSL) has been established close to the jetty at Prawn Flats.

The fact that a controlled breaching policy for the mouth of Kleinriviersvlei is to be implemented implies that it will be breached at the same position whenever necessary. This should result in a low point in the sand berm being maintained at the recommended breaching position which in time, could become the natural breaching point of the Kleinriviersvlei.

Wind and Aeolian Transport

The movement of sand by wind plays an important role in the fine balance that normally exists in most coastal ecosystems. Sand blowing into the estuary not only contributes to the general sedimentation process but may also accumulate at the mouth, when closed, producing an unnaturally high sand berm. For this reason it is very important to determine the prevailing wind conditions and resultant direction of wind-blown sand movement in the study area.

Long-term statistics obtained from voluntary observations made by passing merchant shipping, (the so-called VOS data), were correlated with data recorded *in situ* during the period June 1985 to December 1986. A strong bimodal wind regime with ESE/SE and NW/WNW orientations exists (Figure 16). Wind from the SE sector occurs for 32 percent of the time while wind blowing from the NW sector prevails for 28 percent of the time.

The coastline at the estuary mouth has a NW/SE orientation, resulting in a movement of wind-blown sand up and down the Walker Bay coastline with a slight net movement towards the NW. This aeolian sand movement has little effect on the function of the river mouth but, artificial stabilization of the sandspit at the SE side of the mouth has created a trap for sand blown into this vegetated area. The resulting gradual build-up of the sandspit adjacent to this area could make artificial breaching in this location more difficult. Research by CSIR into the role of wind-blown sand and the effects of the surrounding topography and stabilized dunefield is continuing.

The VOS data were analysed and an aeolian creep diagram (Figure 17) for the Kleinrivier area was produced (Swart, 1986). These diagrams indicate how wind-blown sand would approach the centre of an imaginary circle on the ground from different directions. From the "all year" diagram the annual potential aeolian sand transport rate (cubic metres per year per kilometre perpendicular to the wind) can be calculated for various wind directions.

Calculations indicate that a net aeolian sand movement towards the south-east takes place during winter. During summer the dominant south-easterly winds cause sand to move to the north-west and during autumn and spring sand movement is well balanced between the ESE and WNW sectors. A yearly average net movement towards the ESE sector as a result of the high velocity winds from the WNW sector is suggested.

The development of the large dunefield (now partly artificially stabilized) on the eastern shore of Kleinriviersvlei provides an indication of the long-term aeolian sand movement in the area and corroborates the predictions of the creep diagrams (Figure 17).

Bathymetry

The sandy coastline at the mouth results in the formation of a double spit when the mouth of Kleinriviersvlei is open i.e. both sides of the mouth are sandy. The mouth is therefore classified as being of type B: double sandspit, free to meander along the length of the mouth area (Heydorn and Tinley, 1980).

Tachymetric surveys of the mouth of the Kleinriviersvlei were carried out in 1986, 1987 and 1988 (Van der Merwe, 1988), while cross-sections of the sand berm were surveyed subsequently. Contour maps for the 1986 and 1987 surveys (Figures 18 and 19) and comparative cross-sections of the sand berm and lower estuary are available (Figures 20 and 21). At the time of the most recent survey (89-03-08) the mouth was open and the main channel located at a point some 750m west of beacon PA 100 (Figure 18). Figures 18 and 19 show the positions of the main channel in September 1986 and March 1987.

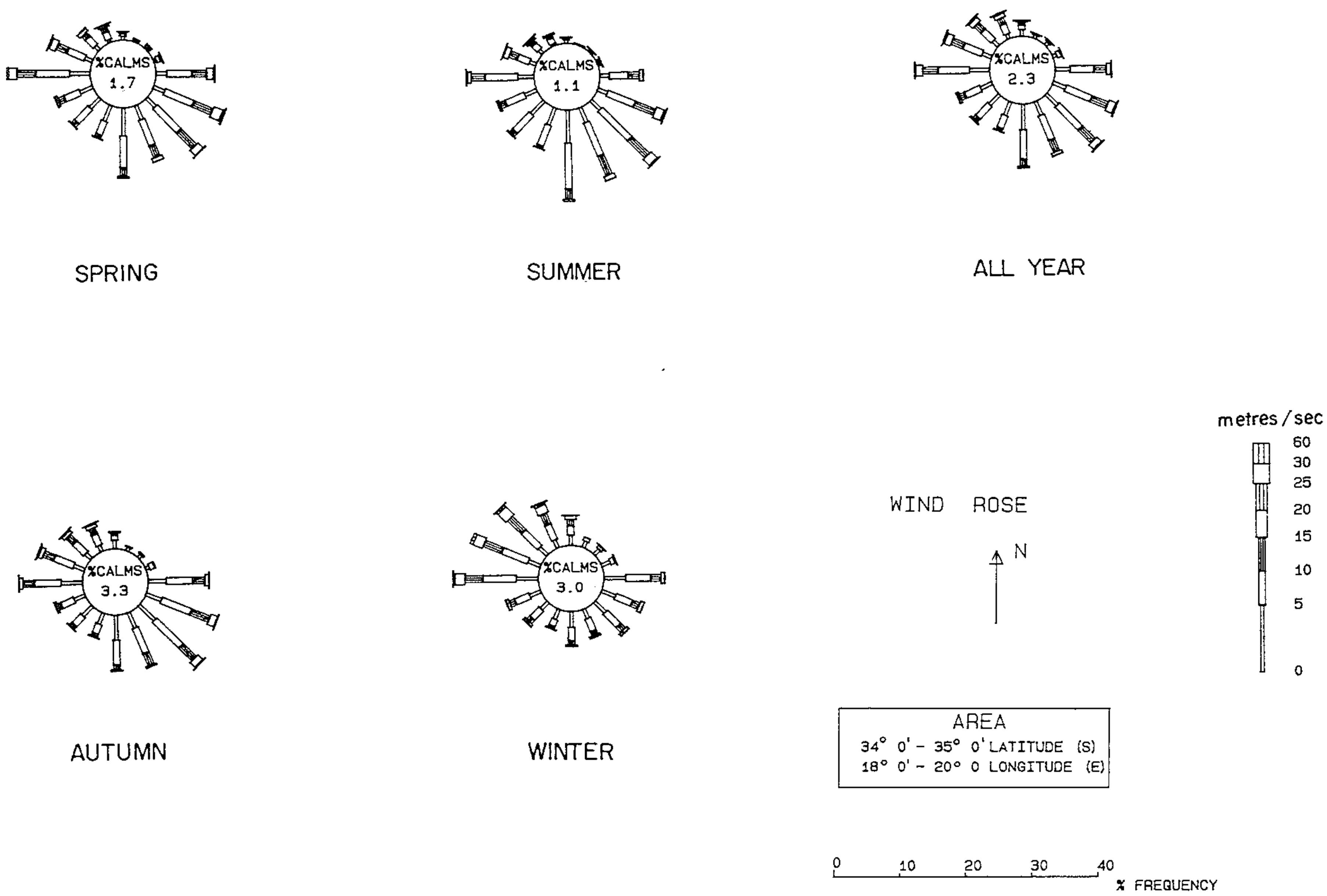
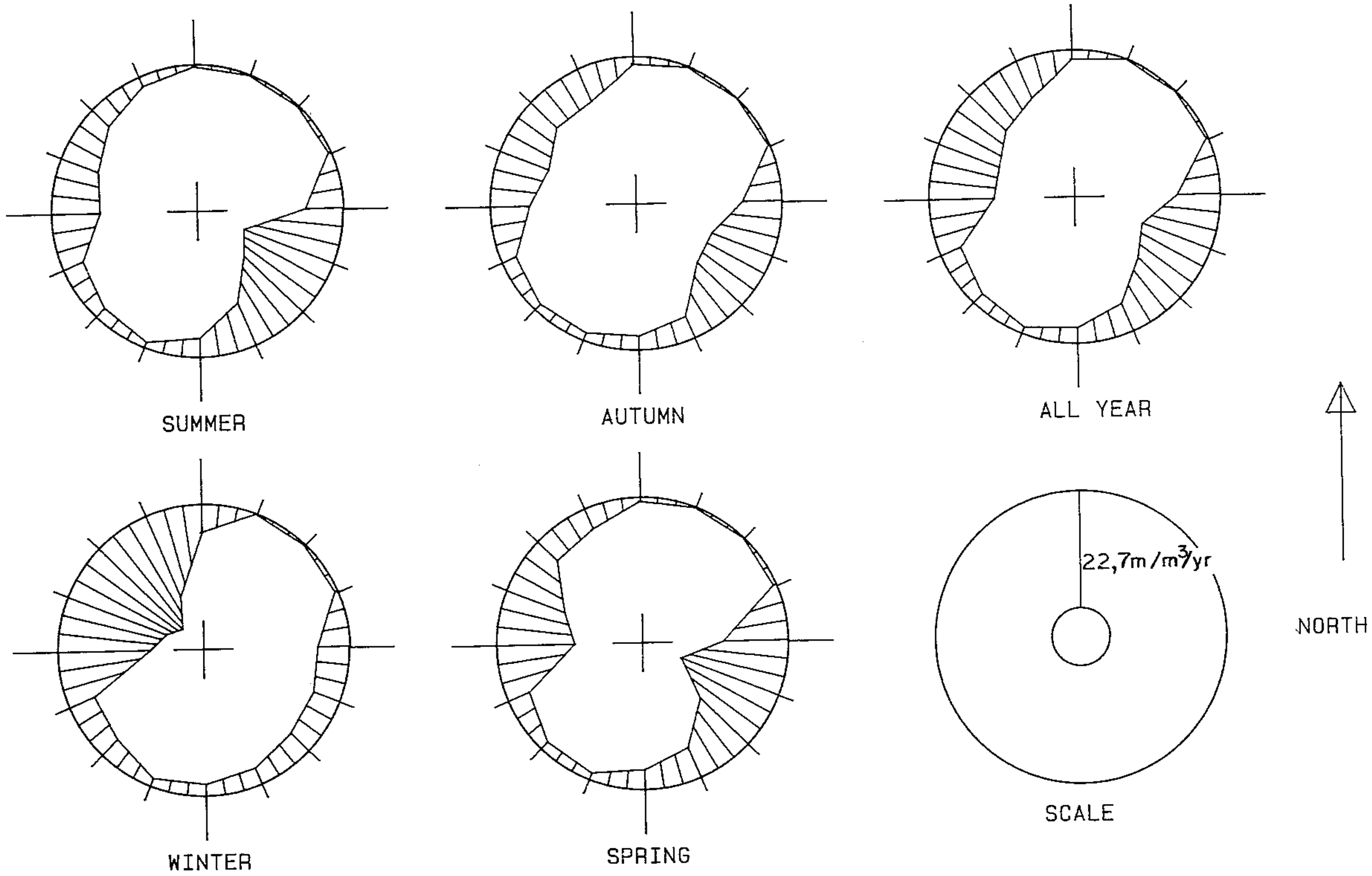


FIG. 16 : Seasonal wind roses (VOS) for the Kleinrivier area.



<u>FIG. 17</u> : Aeolian creep diagram for the Kleinrivier.

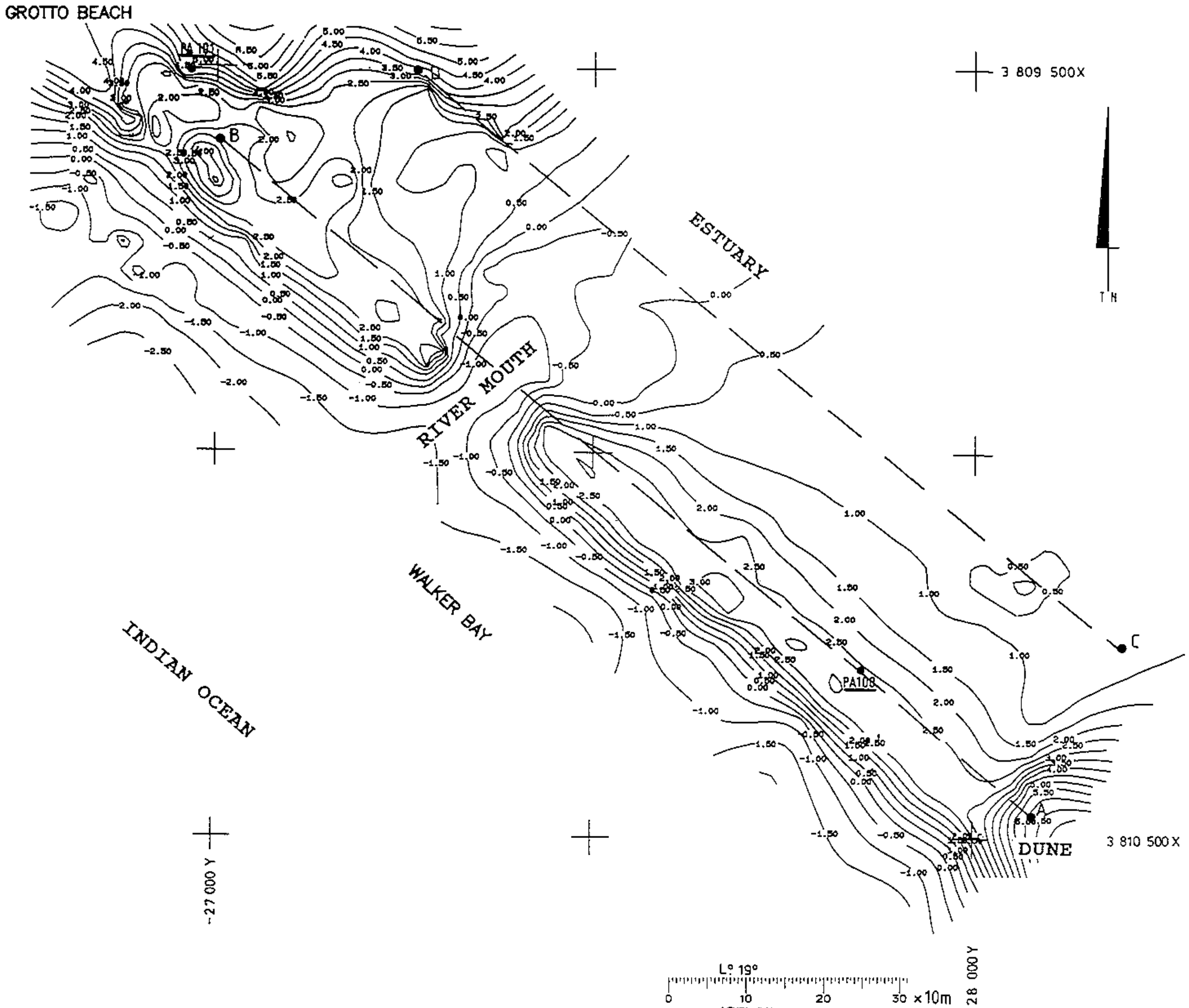


FIG.18 : Contour map of the Klein Estuary, 2 September, 1986

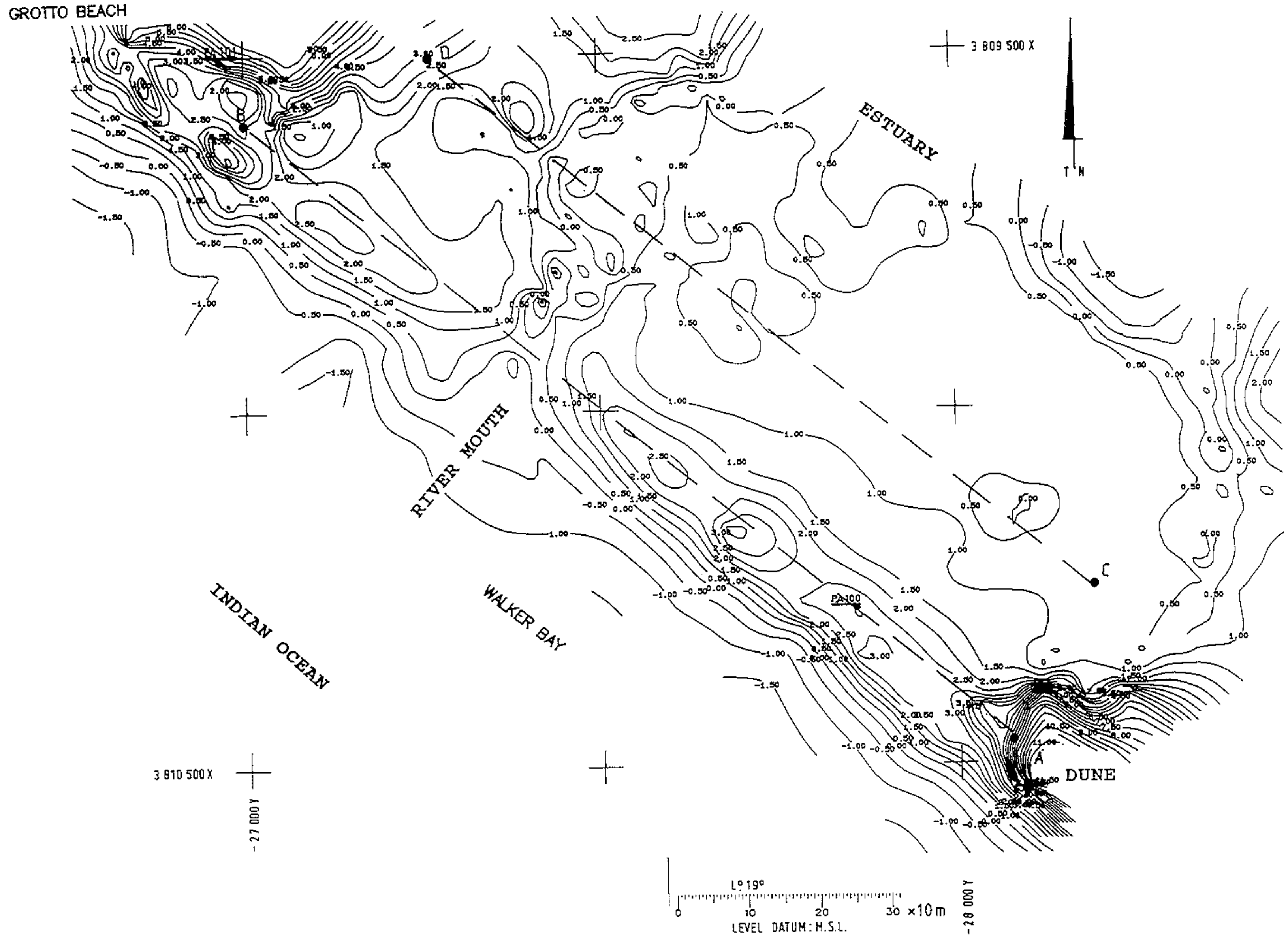


FIG.19 : Contour map of the Klein Estuary, 24 March 1987

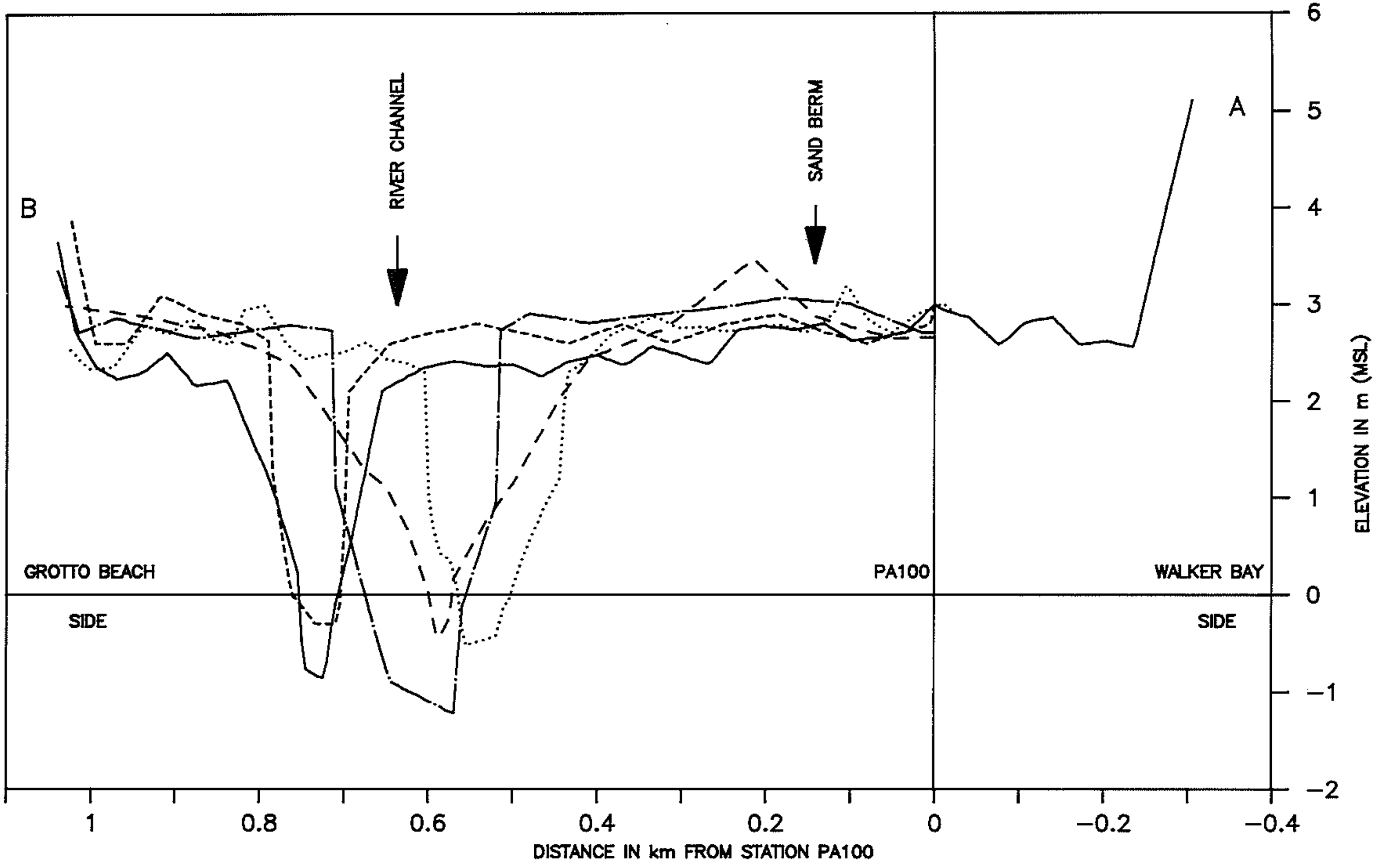


FIG.20: Cross−sections of the sandspit at line A−B
(See Figure 18)

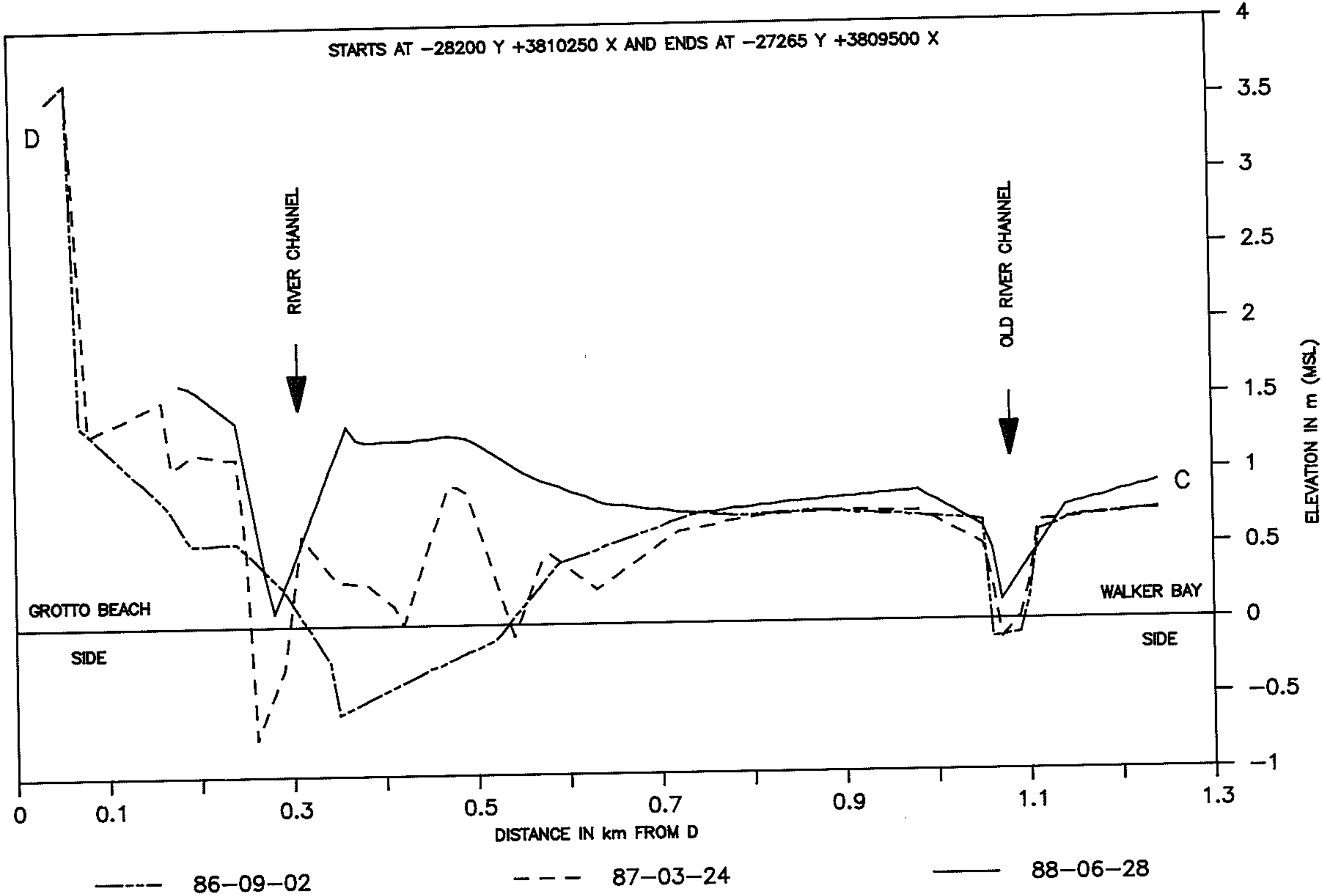


FIG.21: Cross-sections 250m upstream of sandspit at line C-D
(See Figure 19)

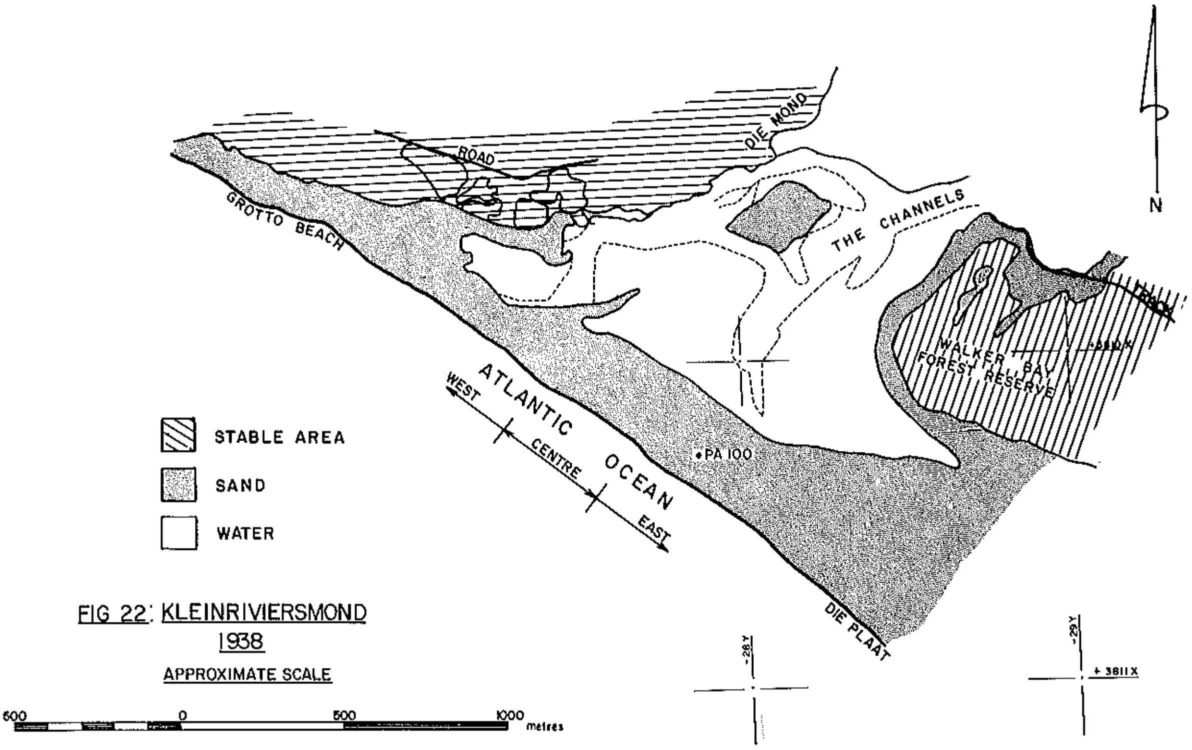


FIG 22: KLEINRIVIERSMOND
1938
APPROXIMATE SCALE

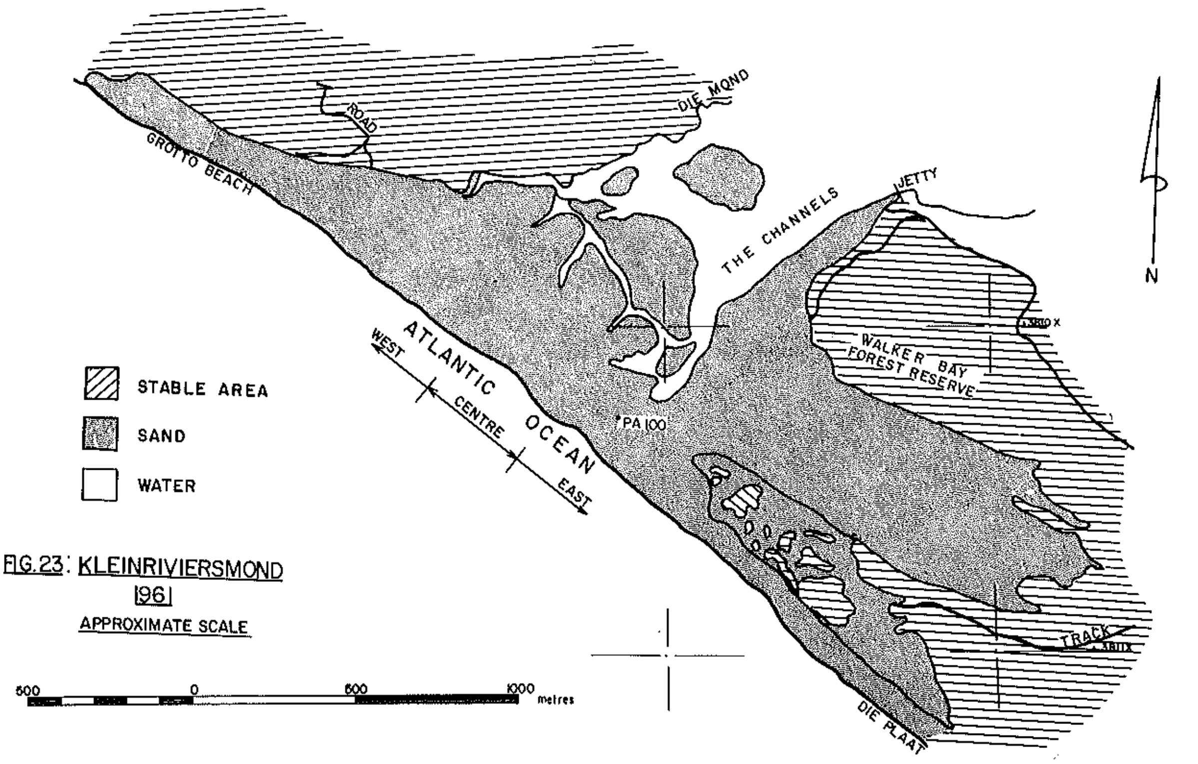


FIG.23: KLEINRIVIERSMOND
1961
APPROXIMATE SCALE

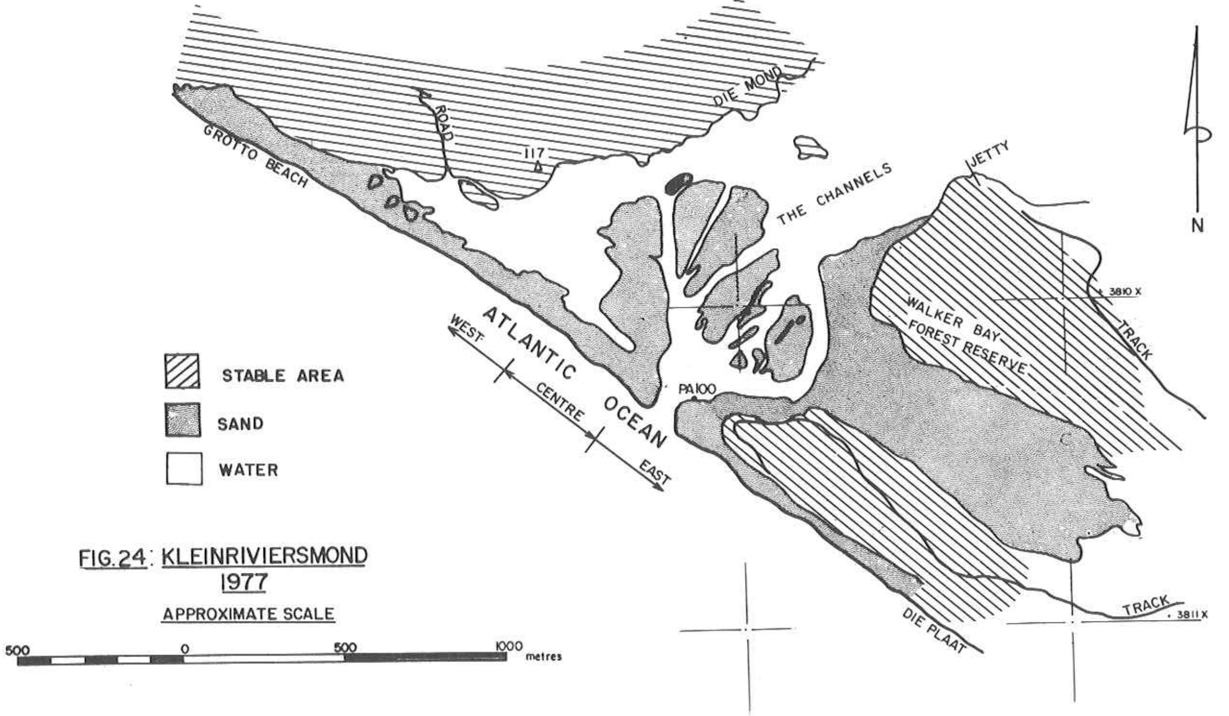


FIG.24: KLEINRIVIERSMOND 1977

APPROXIMATE SCALE

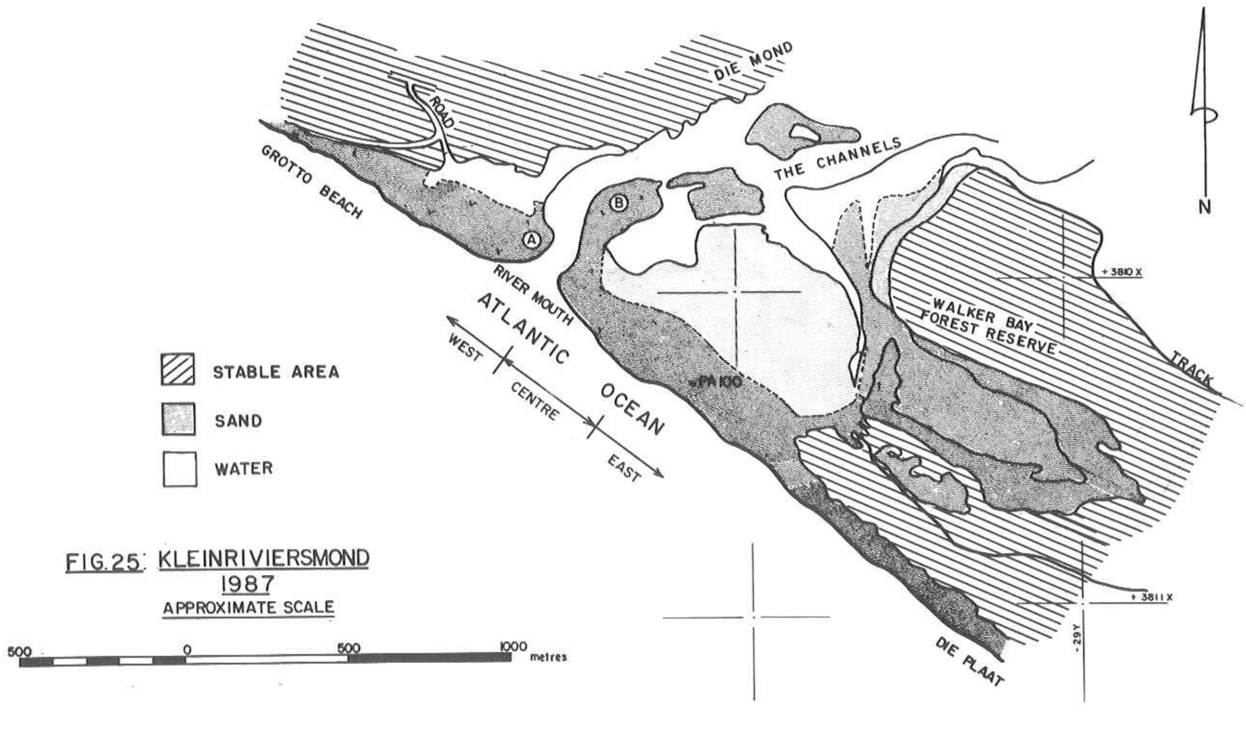


FIG.25: KLEINRIVIERSMOND 1987

APPROXIMATE SCALE

In Figure 21 cross-sections at a point some 250m upstream of the sand berm are shown. Accumulations of up to 1,8m of marine sand can be seen in places here. Although these can be ascribed chiefly to shifting sandbanks, some contribution is possibly made by a net increase in marine sediment. Regular follow-up surveys should indicate the long-term sedimentation rate of the estuary.

Historical Changes

Tracings of the 1938, 1961, 1977 and 1987 aerial photographs were made with the use of a zoom transfer scope (Figures 22, 23, 24, and 25). As these tracings are all of the same scale (approximately) , comparisons can be made of the actual mouth configuration, position of channels and sandbanks, the extent of stabilized areas and other relevant factors. Co-ordinates were traced from the 1977 orthophotomaps (3419AD16 and 17) produced by the Director General of Surveys, Mowbray, Cape Town. Co-ordinates for beacon PA100, situated on the sandberm in the river mouth, were determined by the CSIR, (1988).

In both 1938 (Figure 22) and 1961 (Figure 23) deeper channels were present on the western and eastern sides of the mouth, with sandbanks in the centre. In 1977, the mouth was open on the eastern side, just west of beacon PA100 (Figure 24). Fairly deep channels draining the western and eastern sides of the estuary existed at that time.

By superimposing the high-water marks visible on the available aerial photographs, it can be deduced that the area around the mouth of Kleinriviersvlei is in a state of equilibrium as no long-term changes in the coastline are detectable.

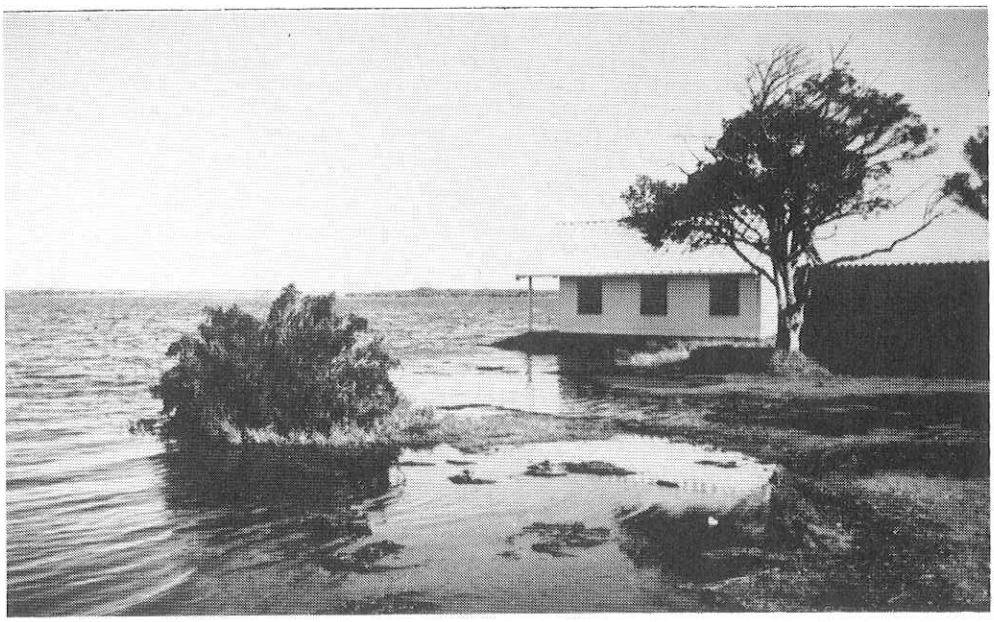


FIG. 26: Flooded house at Maanskynbaai (87-07-29).

3.2.3 Land ownership

The land around Kleinriviersvlei falls under diverse ownership, including : Hermanus Municipality, Hermanus Yacht Club, CDNEC Conservation Forestry, development companies and private individuals. The municipality owns the area on the northern shore between the mouth and Maanskynspruit, and allows lease-holders to erect non-permanent structures on its property at Maanskynbaai and Die Mond. Unfortunately, this proviso has been disregarded by certain individuals and some of these buildings are subjected to flooding at high water levels (Figure 26). On the southern shore, the area between the mouth and Groot Sanddraai (Walker Bay Forest Reserve) is managed by the CDNEC Conservation Forestry, who has an old forestry station (Lê-Bos) on this property. The remaining lagoon shoreline is owned by property development companies and private individuals, many of whom have built holiday houses. The 1st Kenilworth (Cape Town) Scout Troop lease an area between Die Mond and Prawn Flats for use as a permanent Scout camp.

FIG. 27: 'Lagoon Edge' development east of Maanskynbaai (89-08-06).

The northern shore is extensively developed beyond Maanskynbaai with many holiday houses and housing development schemes (Figure 27). The area between Prawn Flats and Maanskynbaai was bequeathed to the Municipality on condition that it would not be developed (M van Rooyen, Deputy Town Clerk, Hermanus, pers. comm.). A section of this area adjoining Prawn Flats is currently used as a municipal dump for garden refuse and building rubble, and has been the subject of complaints from local residents. The shoreline to the east of the Lagoon Edge housing development and along the river as far as Stanford, is less developed and is characterised by small-holdings, some carrying subsistence crops. In contrast to the northern shore, the southern shore is undeveloped. An attempt has been made at developing a holiday resort between Wortelgat and Groot Sanddraai, and has proceeded as far as the bulldozing of roads in the thick alien vegetation. Plans for the development of 45 housing units, one boat house and two jetties have been approved.

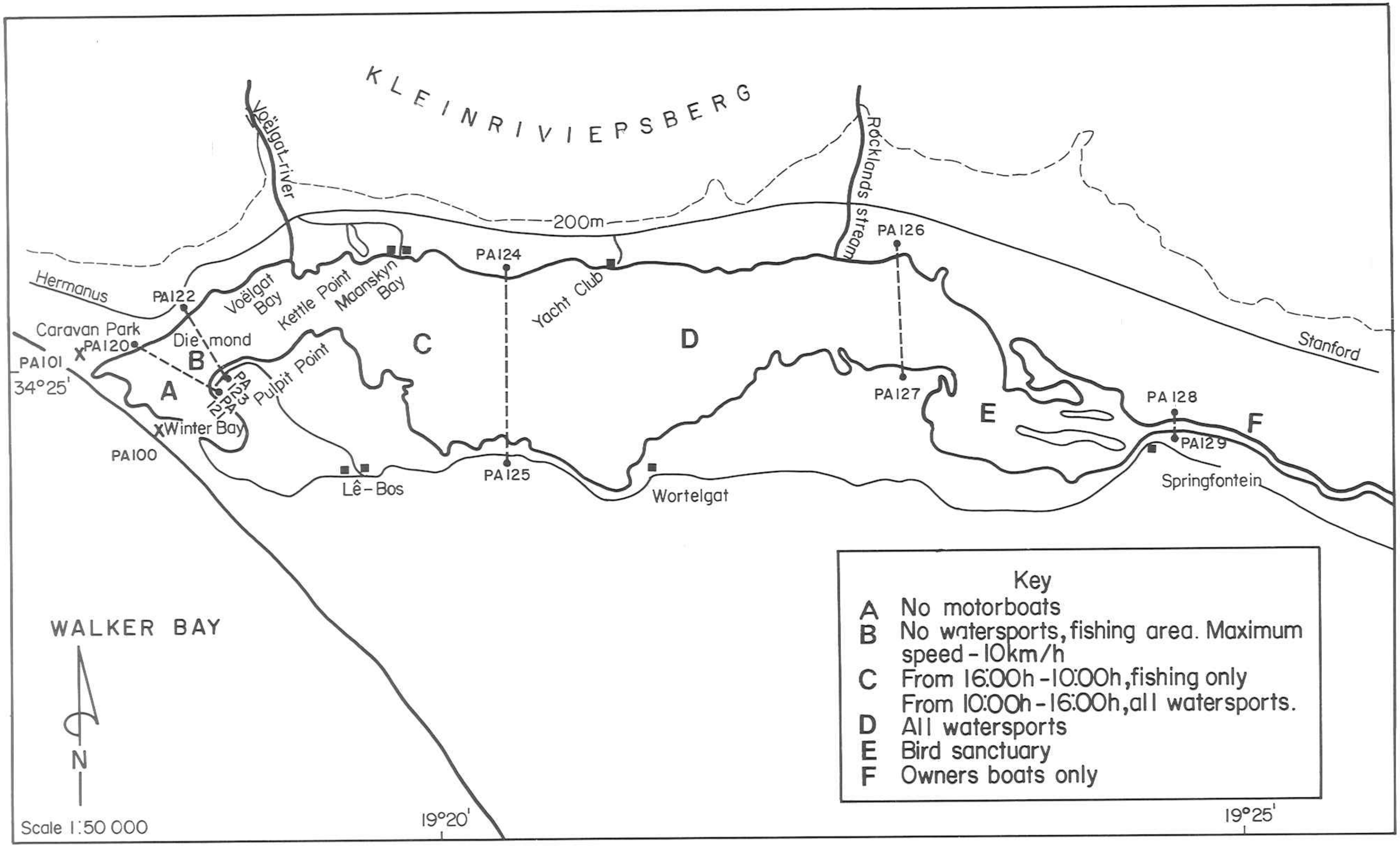


FIG.28 Zoning for aquatic recreation activities (Proclamation 389 of 1977) (after Waldron, 1986)

3.2.4 Uses

Kleinriviersvlei is extensively utilized for recreational activities such as angling, boating and boardsailing as well as being a popular area for bird watching, especially in the upper reaches. Proclamation 389 of 1977 by the Administrator of the Cape Province delineates areas in the vlei for certain purposes (Figure 28), including an area at the head of the estuary which is designated as a bird sanctuary. Here, no boating is allowed except by riparian owners with valid permits. Control of recreation on the vlei is the responsibility of the Hermanus Municipality. The public have access to the vlei at Die Plaat, Prawn Flats and Maanskynbaai only (all under municipal control) and, if members, at the Hermanus Yacht Club. Two slipways at Prawn Flats are available for public use at no charge. Despite this limited public access, the vlei is used extensively for all manner of watersports, and this probably constitutes its most important function.

3.2.5 Obstructions

There are no large constructions spanning the estuary at any point within its tidal regime. There are, however, at least 30 jetties in various states of use or disrepair, and four "harbours" of concrete or sandfill along the northern shore. According to the senior CDNEC law-enforcement officer, few of these have been erected legally. Although some jetties are of sound construction, many obstruct current flow, with subsequent settling of sediment load and infilling of channels. Another problem is the input of sediment into the estuary from sandfill jetties as a result of wave damage, or after the collapse of ill-constructed retaining walls (Figure 29).

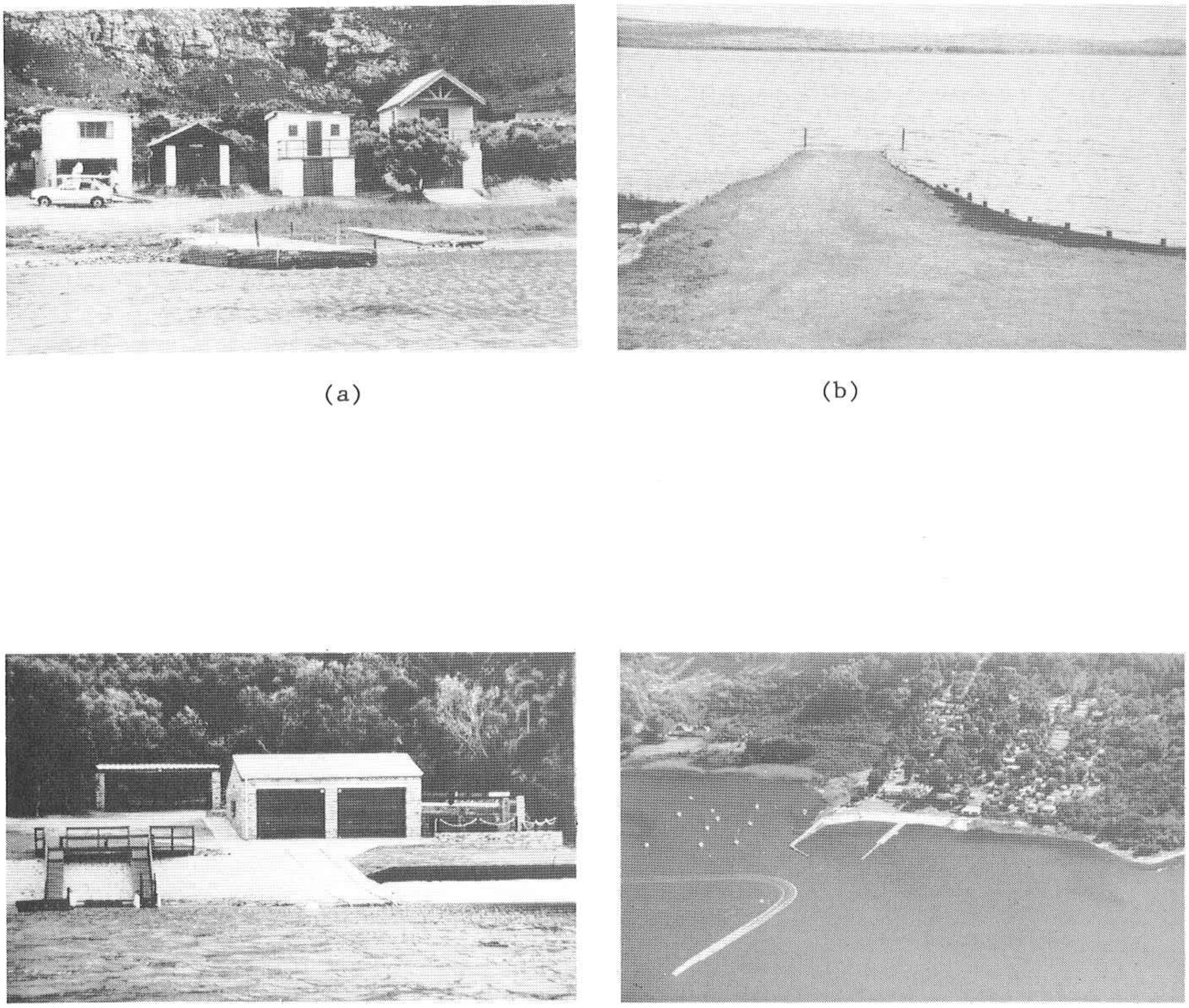
A problem has been posed by a series of concrete blocks which were placed in the main channel between Kettle Point and Die Mond. These blocks, at the time of emplacement, carried wooden poles which projected above the water surface to serve as a guide to boaters following the channel. Unfortunately, the poles have since rotted away at the waterline and now pose a serious threat to motorboats and water-skiers at low water levels. Furthermore, some of the blocks have altered current flow in the deep channel passing in front of the slipways at Prawn Flats, which is now in danger of becoming silted up.

3.2.6 Physico-chemical Characteristics

Until very recently, records of physico-chemical characteristics of the estuary were limited to those given by Scott *et al.* (1952) and by Truter and partner (1954, salinity only). Coetzee and Pool (1986), however, completed a detailed survey of temperature, salinity, oxygenation, acidity and turbidity in the vlei. Readings were taken at 0,5m depth intervals at three stations in the lagoon (lower, middle and upper reaches). Their work provides the primary source for this section.

Temperature

Temperatures in most of the lagoon vary between 12°C and 25°C (Figure 30) but reach 11°C at the surface near the head of the estuary, due to the inflow of cold river water. In summer, while the mouth is open and water levels low, temperatures rise rapidly, but drop steeply again with winter inflow.



(a) (b) (c) (d)

FIG. 29 a-d: Examples of jetties and other structures which may cause obstruction in Kleinriviersvlei. (a) & (b): earthfill jetty prone to collapse and resultant distribution of spoil in the nearshore. (c) Launching ramp and pontoon dock. (d) Yacht club harbour (86-12-09).

Salinity

In broad terms, the salinities depend on the balance between seawater and river inflow and, to a much lesser extent, on evaporation. Salinities vary between 12 and 36 parts per thousand in the lower reaches and between 4 and 35 parts per thousand in the upper reaches, i.e. the lagoon never becomes hypersaline. Scott *et al.* (1952), however, measured salinities of between 37,14 and 39,99 parts per thousand near Die Mond in the summer of 1949 when the mouth was closed. Generally, salinities decrease in winter, when the mouth is closed and there is increased river inflow, whereas they increase in summer as a result of the combined effects of seawater input when the mouth is open, evaporation while closed, and minimal fluvial input. Overwash by waves during spring tides may enhance the salinity somewhat, but this has not been investigated. When the mouth is closed, the vlei is usually well mixed, both vertically and horizontally, mainly as a result of wind mixing. During periods of strong river inflow, however, horizontal salinity variations as large as 18 parts per thousand (7-25^{o}/oo) have been recorded.

From salinity changes in the lagoon, Truter and partner (1954) have calculated that seepage of seawater through the dunefield is minimal or non-existent and has no effect on the salinity of the lagoon.

Scott *et al.* (1952) record an interesting anomaly in the presence of saline water at Stanford, which occurs when water levels are high enough for strong north-westerly winds to generate upstream flowing currents from the estuary.

Oxygen tension

Dissolved oxygen varies between 51 and 125 percent of saturation, with little horizontal or vertical variation. Regular strong winds over the vlei generate sufficient turbulence to maintain a well mixed, oxygenated water column.

pH

The highest and lowest pH measurements recorded in the lagoon by Coetzee and Pool (1986) were 8,5 and 7,1 respectively, which suggests that the vlei never becomes acidic, despite considerable inflow of acidic, humic-stained fresh water from the Kleinrivier (pH 6,1) and from streams along the northern shore (pH 5,0). The lowest readings were obtained in May 1984 and coincided with maximum fresh water input. The constant alkalinity is ascribed to the buffering properties of seawater in the lagoon (Scott *et al.*, 1952), which suggest that the vlei may become acidic in times of floods, when all the seawater is flushed from the estuary. Such a situation would exist only as long as riverine input exceeds marine input, however

Turbidity

Secchi disc readings taken by Coetzee and Pool (1986) show large fluctuations in turbidity, depending on wind-generated wave amplitude, water depth and the nature of the underlying substratum. Maximum secchi disc readings were recorded at the head of the lagoon. In general, turbidity increases when the mouth is open because the bottom sediments are more easily disturbed when the water in the lagoon is shallow.

3.2.7 Nutrients and Pollution

No detailed longterm study of the nutrients in the vlei has been made. In 1986 the Hermanus Municipality embarked on a monthly survey of estuarine coliforms, which are indicators of human faecal contamination, in view of the possibility of seepage from septic tanks along the northern shore. The discharge of treated effluent from a sewage treatment plant above the vlei has recently been considered by the Municipality. To assess the impact of such effluent on the vlei, a short survey of nutrients was undertaken by CSIR and UCT.

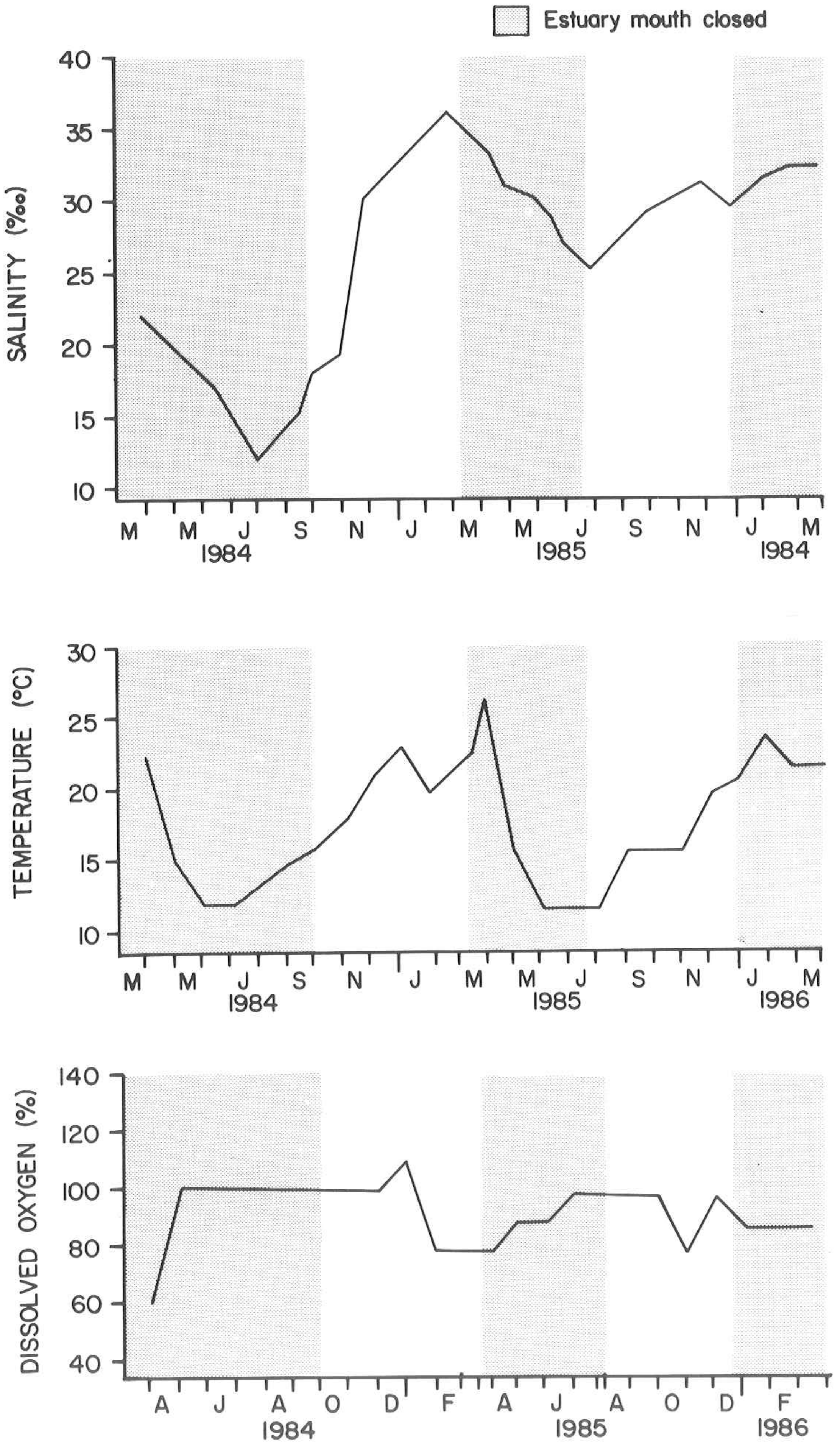


FIG.30: Physico-chemical data (Waldron, 1986)

Proposed Hermanus East Sewage Treatment Works

The connection of houses in Hermanus East/Voëlklip to a mains sewerage system has led to the requirement for a sewage treatment plant in the vicinity. A number of sites for this have been investigated, the most suitable being located above the R43 road to Stanford immediately east of Maanskynskopspruit. The problem of the economic, yet environmentally acceptable, disposal of the treated effluent then arose. The cheapest, and immediately obvious solution would be to discharge the effluent, treated to General Standard, (as specified in Government Notice 991 of 18 May 1984) into Kleinriviersvlei. However, the risk of eutrophication and the potential health hazard requires careful assessment.

The plant is expected to treat 1000 cubic metres of raw sewage per day, rising to a maximum of 2000 cubic metres per day, and to produce an effluent with "an oxygen adsorbed (or PV) value less than 10 mg/litre, total nitrogen content around 2 or 3 mg/litre, and an orthophosphate content of 1 mg/litre as P" (Ninham Shand, *in litt.*, 1988). Expressed in terms of nutrient loading, the annual nitrogen input from the sewage works would initially be about 0,7 to 1,0 tonnes, rising as high as 2,0 tonnes eventually (in other words, equal to about half the existing nitrogen loading from the river). The orthophosphate phosphorus input (which in sewage effluent is almost equal to the total phosphorus input) would start in the region of 0,4 tonnes per year and eventually reach 0,7 tonnes per year (roughly equal to the average annual orthophosphate load from the river).

The Department of Water Affairs (DWA) stipulated that an environmental study should be undertaken prior to the granting of a permit for the discharge of effluent into Kleinriviersvlei. The DWA recommended that the Hermanus Municipality engage the services of Dr J King of the Department of Zoology, University of Cape Town, and CSIR, Stellenbosch. The following section is based on the resultant two reports (King *et al.*, 1989 and CSIR, 1989).

Water quality in the river is reasonable, although it can become slightly saline: Conductivity ranges from 7 to 280mS.m^{-1} (milliSiemens per metre) which approximates to a salinity range of 0,05 to 1,80 parts per thousand. It is normally about 100mS.m^{-1} (0,6 parts per thousand). The main salt appears to be sodium chloride. Phosphate and nitrate concentrations are not excessive: phosphate is normally *ca.* 0,05 mg/litre and nitrate *ca.* 0,2 mg/litre (data supplied by Department of Water Affairs for Station G4M06 from 1968 to 1988).

Of the chemical constituents, the most important ones are nitrogen and phosphorus, which are major plant nutrients; and of these, the least mobile and hence the most likely to accumulate in a system is phosphorus. Fertilizers, nitrogen and phosphorus, are likely to leach from farmland and enter the river/lagoon, where they would encourage the growth of aquatic plants. Concentrations of phosphorus in the river water are likely to be about 0,02 mg/litre, which gives an estimated 0,8 tonnes of phosphate (expressed as soluble phosphorus) entering the lagoon annually in the river water. Note that the total phosphorus load could be up to three times higher than this because of the presence of other forms of phosphorus (Grobler and Silberbauer, 1984). If the concentration of dissolved nitrogen is taken to be 0,1 mg per litre (Department of Water Affairs data for gauging station G4M06), then the annual nitrogen load from the river is approximately 4 tonnes.

CENTRESPREAD : Vegetation mapping units of Kleinriviersvlei

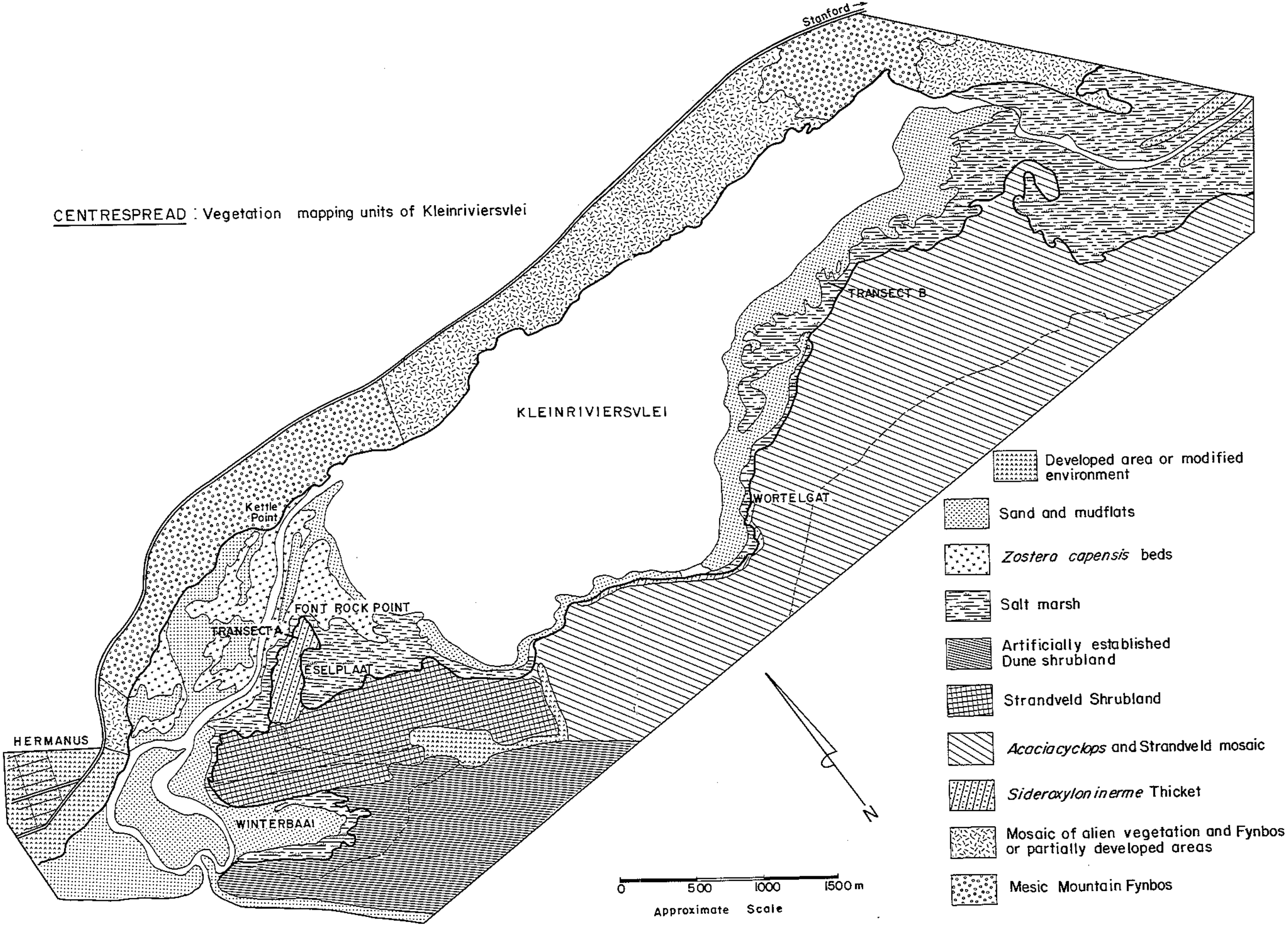


TABLE 2: Physico-chemical data for Kleinriviersvlei

DATE & TIME	POSITION	TIDE	SAMPLE NUMBER	SAL $^{o}/_{oo}$	TEMP ^{o}C	DO mg/l	NO3-N µmol/l	NO2-N µmol/l	NH3-N µmol/l	PO4-P µmol/l	Si µmol/l	TOTAL PIGMENT (CHLOROPHYLL) µg/l
17/2/89	De Mond caravan park:											
15h00	Surface	High	3	37	15.4	8.2	22.0	0.6	8.9	2.6	21.6	0.35
17/2/89	Off yacht club:											
11h15	Surface	High	1	38	22.0		1.3	0.3	6.7	1.0	29.8	0.62
11h15	Bottom (2.5 m)	High	2	38	22.0	7.6	1.5	0.4	10.5	1.0	27.1	0.51
18/2/89	De Mond caravan park:											
8h30	Surface	Low	4	34	14.5	8.1	11.9	0.6	11.8	2.4	20.3	0.86
18/2/89	Off Prawn Flats jetty											
9h10	Surface	Low	5	35	17.1	7.3	11.1	0.4	11.1	2.3	21.6	1.55
18/2/89	Water Ways:											
10h00	Surface	Low		36	?	7.1						
10h00	Middle (1 m)	Low	7	36	?	6.6	2.0	0.4	6.1	0.8	31.1	0.55
10h00	Bottom (2.5 m)	Low	6	36	?	6.6	2.8	0.6	3.8	0.9	31.1	0.98

Where the river enters the lagoon a natural sand bar covered with mud occurs which reduces the input of fresh water to the lagoon to a trickle during the summer months when river flow is low. A small weir upstream of the R43 road bridge at Stanford likewise restricts the upstream flow of saline waters, so that the system is effectively divided into an upstream, freshwater river (salinity < one part per thousand); a lower, wider and deeper river channel with fresh or almost fresh water when flow is high, and saline water at other times; and a lagoon which varies in water quality and salinity depending on whether the river is flowing or the mouth is open to the sea.

The only nutrient survey of Kleinriviersvlei to date is that undertaken by the UCT and CSIR teams during the environmental study required by the DWA (King *et al.*, 1989 and CSIR, 1989). The results are presented in Table 2. The survey showed that the dissolved oxygen values were relatively high with saturation values ranging from 80-100 percent. This indicates that the organic loading is low. Higher nitrate values were obtained near the mouth (De Mond Caravan Park and Prawn Flats jetty) than in the upper reaches of the estuary. Nutrient rich upwelled seawater, brought to the surface by the strong south-easterly winds immediately prior to the survey, is the most likely source of this nitrate. Nitrate concentrations were relatively low in the upper reaches of Kleinriviersvlei. The dissolved ammonia values are anomalous since they were slightly higher than is normal for well-oxygenated waters. There is no obvious explanation for these elevated levels. The higher dissolved reactive phosphate values obtained at the mouth than were obtained in the upper reaches probably reflect input of upwelled seawater. Dissolved reactive silicate values were slightly higher than typical marine values (7μmol/l) but still within normal limits for estuarine waters.

Total pigment (chlorophyll) concentrations were very low (R A Carter, EMA, CSIR, pers. comm.). The values are comparable with those obtained in the Kafferkuils and Duiwenhoks estuaries (Carter and Brownlie, 1989). Many factors could be responsible for the low pigment concentrations such as limited light penetration and limited supply of nutrients. Overall the Kleinriviersvlei appeared to be, at the time of the UCT/CSIR survey, in a healthy condition. In the light of this study, it was recommended that treated sewage should not be discharged into the Kleinriviersvlei. Other, more environmentally favourable options are currently being investigated by the Hermanus Municipality. At the time of going to press no decision had yet been reached on the destination of the treated effluent.

Municipal refuse disposal site

A further possible source of pollution is the municipal rubbish dump adjacent to Prawn Flats (Figure 31). Although the dump is for builders' rubble and garden refuse only, considerable quantities of domestic garbage are also dumped on the site. There have also been complaints that paper and plastic is blown into the lagoon from the dump, while its siting has an adverse aesthetic impact. No clear indication could be obtained from the municipality regarding their future plans for the dump. Serious consideration should be given to the resiting of the dump and rehabilitation of the present site.

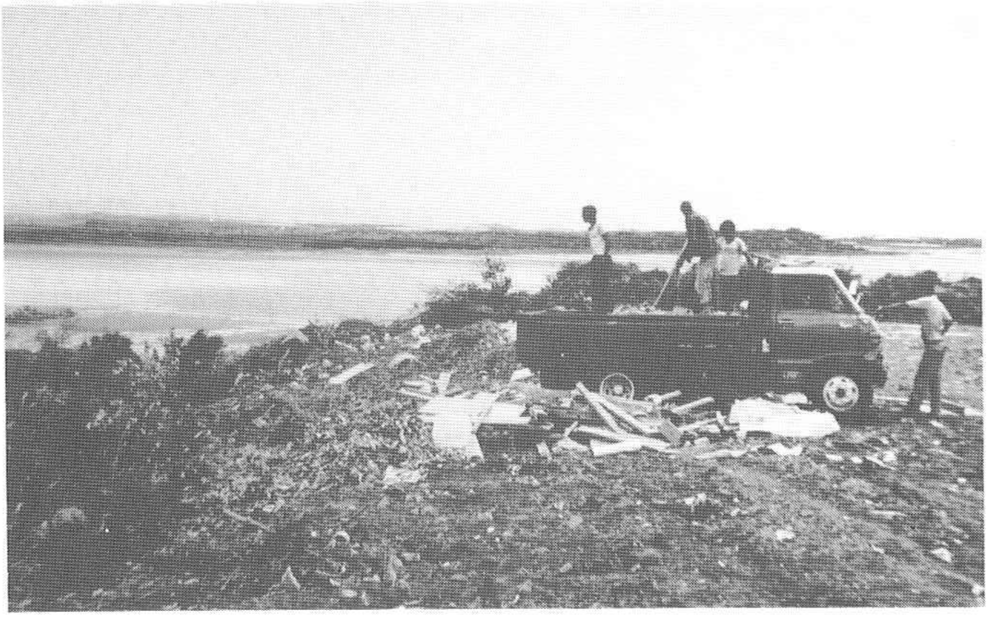


FIG. 31: Unsightly Municipal rubbish dump adjacent to Prawn Flats (86-12-09).

4. BIOTIC CHARACTERISTICS

4.1 Flora

This section was contributed by MER Burns, CPMA, CSIR

4.1.1 Phytoplankton

The status of phytoplankton in Kleinriviersvlei has not been determined in detail and no descriptive literature on the subject has been published to date. Scott *et al.* (1952) do, however, refer to discolouration of the sand surface in parts of the estuary as a result of large numbers of diatoms. Grindley, 1957 and 1965 listed the following genera of diatoms:

Triceratium, Skeletonema, Coscinodiscus, Rhizosolenia, Nitzschia, Bacillaria and *Chaetoceros.*

4.1.2 Algae

In addition to the diatomaceous, planktonic algae, filamentous algal species of the genera *Ectocarpus, Polysiphonia, Rhodochorton, Cladophora* and *Rhizoclonium* are also common epiphytes on *Zostera capensis* and *Ruppia maritima*, particularly in the middle reaches of the lagoon where silty and clay substrata prevail (Scott *et al.*, 1952; Day, 1981). Large floating masses of *Enteromorpha bulbosa* occur within the lower reaches and are often left stranded on the shoreline when water levels fall.

Macroscopic algae are not common and the only species recorded from Kleinriversvlei include one *Ulva* sp. and *Porphyra capensis*, both of which tend to attach to stones and jetty pilings close to the mouth. Water turbidity, sediment deposition and decreased wave action are the major limiting factors affecti

4.1.3 Aquatic vegetation.

The two most common aquatic species are *Zostera capensis* and *Ruppia maritima*. Salinity gradients and water depth appear to determine their distribution and relative dominance. While *Ruppia* favours the shallow, less saline areas of the middle and upper reaches of the estuary, *Zostera* occurs in the deeper, more saline water of the middle and lower reaches. (Centrespread)

Certain species, such as *Cotula myriophylloides* and *Paspalum vaginatum* could be described as being either aquatic or semi-aquatic, but the latter description is perhaps more accurate since they (together with a number of other species) tend to be emergent or only periodically inundated.

4.1.4 Terrestrial and semi-aquatic vegetation.

Terrestrial vegetation

Acocks (1975) has classified the terrestrial vegetation to the north of the estuary as Macchia (veld type no. 69) and that to the south as Coastal Macchia (veld type no. 47). Differentiation between these two vegetation types is also made by Moll *et al.* (1984) who describe them as Mesic Mountain Fynbos and South Coast Strandveld respectively. Both have been extensively altered by the impact of agriculture, property development and severe infestation by alien plant species.

The six vegetation mapping units which have been used to define the generalised distribution of the Fynbos and Strandveld communities, as well as the coastal dune vegetation are discussed below (Centrespread). An abbreviated list of some of the more prominent component species is provided in Appendix I and may be supplemented with the checklist of the Coastal Herbarium of the Fernkloof Nature Reserve at Hermanus, which contains more than 800 species.

Fynbos

The Fynbos vegetation along the northern shore of the estuary occupies the relatively steep talus slopes and the alluvial fan deposits at the foot of the Kleinriviersberge, on soils derived from weathered Table Mountain Group sandstones. It appears to be similar in many respects to the "Seepage Fynbos" described by Boucher and McDonald (1982) for the Cape Hangklip area, particularly on the alluvial fans, where a tall dense community has developed under high water table conditions. Some of the typical species include: *Osmitopsis asteriscoides*, *Carpacoce spermacocea*, *Erica perspicua*, *Neesenbeckia punctoria*, *Cliffortia ferruginea*, *Psoralea pinnata* and *Berzelia lanuginosa*.

Alien plant species which have invaded the natural communities to the extent of becoming locally dominant include: *Pinus pinaster*, *Acacia mearnsii*, *Acacia saligna*, *Leptospermum laevigatum* and various *Eucalyptus* species.

A few small patches of thicket which are not indicated on the Centrespread also occur amongst the rocky outcrops on the northern shore at Kettle Point. These areas have apparently acted as fire refuges for a number of woody species, including: *Olea europaea*, *Euclea racemosa*, *Chionanthus foveolata*, *Rhus glauca* and *Sideroxylon inerme*.

Strandveld

The soils of the coastal plain to the south of Kleinriviersvlei differ significantly from those of the northern shore and consequently support an entirely different type of vegetation. The most extensive community is the Strandveld shrubland which occupies the sandy expanses of calcium-rich Pleistocene deposits. Where this shrubland has not been completely invaded by *Acacia cyclops*, a structural mosaic of dense shrub patches of up to two metres in height, interspersed between a shorter and more open type of vegetation has developed. The total plant cover varies between 60 and 70 percent, except where *A. cyclops* forms dense, almost monospecific stands with a 100 per cent plant cover. Some of the more conspicuous species include: *Metalasia muricata*, *Euclea racemosa*, *Rhus glauca*, *Pterocelastrus tricuspidatus*, *Olea exasperata*, *Chrysanthemoides monilifera*, *Colpoon compressum*, *Psoralea fruticans* and *Restio eleocharis*.

Rehabilitation of the Strandveld vegetation by the active eradication of *A. cyclops* has been most successful and is being carried out on CDNEC Conservation Forestry land. Similar measures are, however, not being applied to the Strandveld communities on privately-owned land and the common property boundary has therefore been used to indicate this differentiation on the vegetation map.

A narrow discontinuous band of thicket, which is dominated by *Sideroxylon inerme*, occupies the low calcrete cliffs around the perimeter of the estuary between Font Rock Point and Wortelgat. The species diversity within this community is typically low, with *S. inerme* (milkwood) representing the only significant contributor to the canopy layer, which is approximately four metres in height. Other sub-canopy members include: *Chionanthus foveolata*, *Euclea racemosa*, *Rhus glauca* and a *Protasparagus* sp. *Acacia cyclops* has become established in openings and around the fringes of the thicket, where fires have assisted it in competing with the natural ecotonal species.

Dune shrubland

The tongue of dune vegetation which has become established to the south-east of the estuary mouth between the beach and the Winterbaai saltmarsh, contains both pioneer and typical open dune shrubland species. To the east of Winterbaai, the dune shrubland gradually merges into Strandveld which contains noticeably more woody elements. The important dune colonizer species include *Arctotheca populifolia*, *Tetragonia decumbens* and *Agropyron distichum*, which have a combined ground cover of less than 10 percent. The open dune shrubland which is less than one metre in height, has a ground cover of approximately 20 percent and comprises species such as *Senecio elegans*, *Chironia baccifera*, *Myrica cordifolia*, *Psoralea fruticans*, *Carpobrotus acinaciformis*, *Chrysanthemoides monilifera* and *Metalasia muricata*. Typical dune slack species include *Juncus acutus*, *Conyza scabrida* and *Plantago carnosa*.

Semi-aquatic vegetation

The semi-aquatic communities are best developed along the southern shore of the vlei, where mudflats and shallows are more common than on the steeper, northern shore. Large areas of saltmarsh occur at Winter Bay, Eselplaat and in the silted upper reaches of the vlei, particularly on the delta mudflats where the Kleinrivier enters the lagoon. The principal species are similar in all three areas as well as along the remaining perimeter of the vlei, where saltmarsh vegetation occurs. Zonation patterns are evident within the communities with changes in species composition occurring in response to gradients created by the degree of inundation and decreasing salinities from the mouth towards the head of the vlei.

Species which are characteristic of the lower, moist zone include *Sarcocornia natalensis*, *Salicornia meyerana* and *Triglochin bulbosum* in the more saline reaches and *Paspalum vaginatum*, *Scirpus maritimus* and *Scirpus triqueter* in the less saline, upper reaches. *Stenotaphrum secundatum* occupies the drier, upper saltmarsh zone together with species such as *Orpheum frutescens*, *Sarcocornia pillansiae* and *Chondropetalum tectorum*, while the intermediate zone comprises species such as *Limonium scabrum*, *Sporobolus virginicus*, *Juncus kraussii*, *Plantago carnosa* and *Samolus porosus*.

Phragmites australis also occurs as a semi-aquatic species in narrow belts of reedswamp in the upper, less saline reaches of the vlei, particularly along the banks of the Klein River inlet channel. Its freshwater requirements restrict it to small, isolated patches elsewhere along the shore of the vlei, at stream or seepage inflow points, some of which are indicated on the Centrespread.

The results of a zonation and biomass study carried out by Du Plessis (1988) along two transects in the lower and upper reaches of the vlei in August 1988 are presented in Figures 32 and 33 and Table 3. The origin co-ordinates of transects A and B, that were used in the study, are (-29 570,8 Y) (+3 809 426,5 X) and (-34 194,4 Y) (3 809 737,3 X) respectively (Centrespread). The transect orientations were perpendicular to the shoreline.

The vertical zonation of species along Transect A is shown in Table 3 to be characterized by the dominance of *Sporobolus virginicus* at the highest elevation followed by *Stenotaphrum secundatum*, *Limonium* sp., *Salicornia meyeriana* and *Sarcocornia natalensis* as dominants at progressively lower elevations. Along Transect B, *Stenotaphrum secundatum* represents the dominant species at the highest elevation, followed by *Juncus kraussii*, *Chondropetalum tectorum* and *Salicornia meyeriana* as dominants at the lower elevations. Similar phytosociological trends are evident along both transects which indicates that the salt marsh environments at the two sampling sites were not significantly different.

The results of the biomass study, presented in Figure 33 indicate that at the time of the survey there was a significant increasing trend in above ground dry weight biomass with decreasing elevation. As there is a relationship between biomass and salt marsh production (Pierce, 1983; Christie, 1981) it is likely that the communities situated at lower elevations may contribute significantly towards the carbon budget within Kleinriviersvlei.

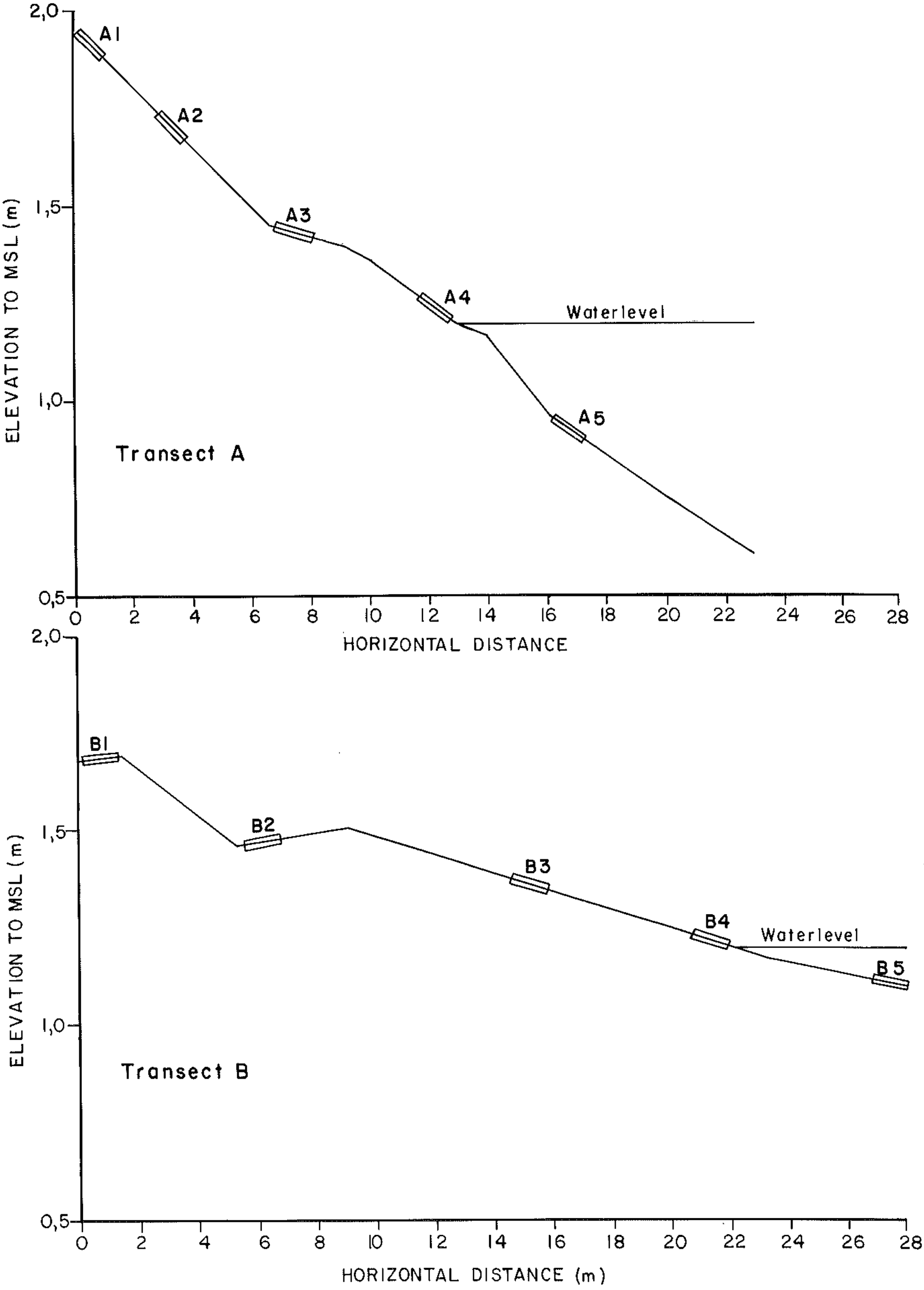
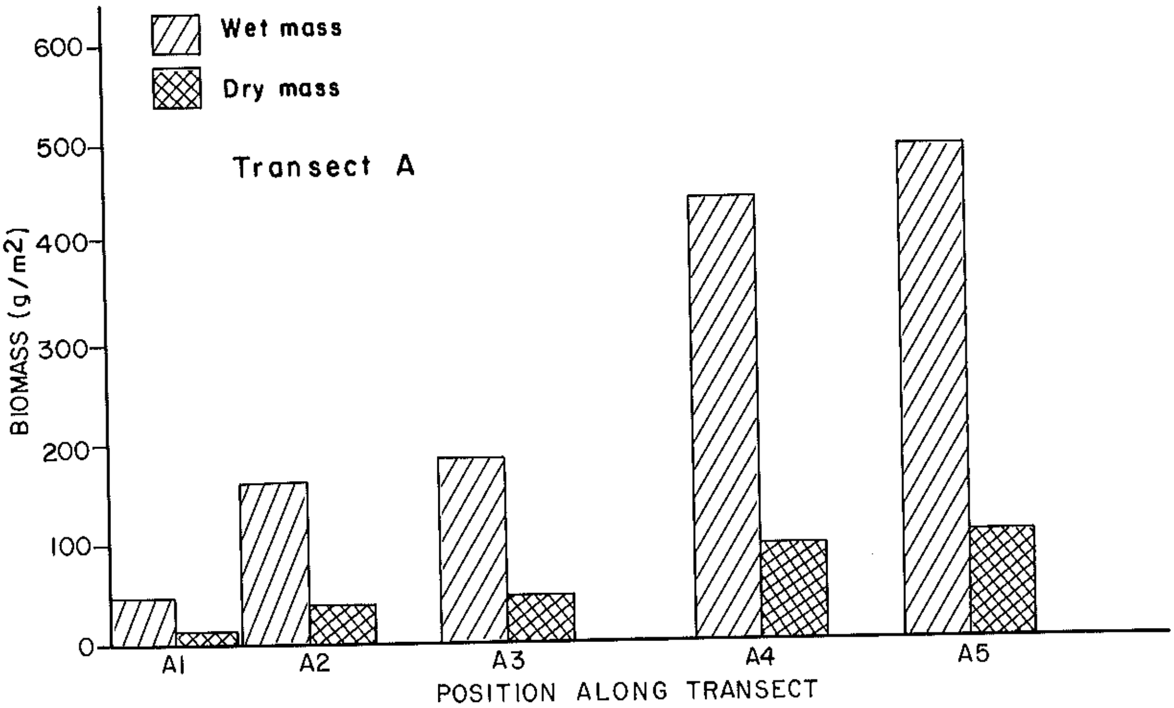
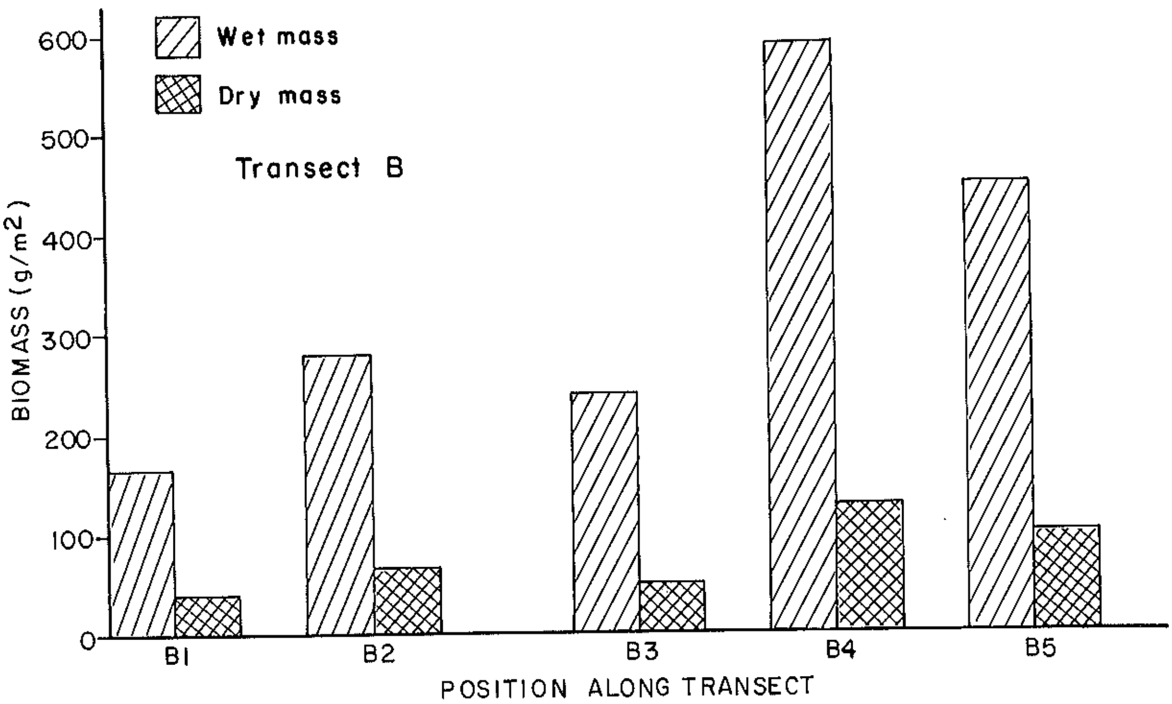


FIG. 32 : Vegetation transect profiles used in the salt zonation study. (after du Plessis, 1988).





<u>FIG. 33</u> : Biomass estimates of the salt marsh communities established along transects A and B (after du Plessis, 1988).

TABLE 3: Saltmarsh plant distribution at two transects (du Plessis, 1988) (see Centrespread for positions)

Transect A

Species	Percentage Cover at Sampling Points				
	A1	A2	A3	A4	A5
Sporobolus virginicus	35	15	7,5		20
Stenotaphrum secundatum	3	25	2		
Limonium sp.		1	12	2	
Plantago carnosa			7,5	6	
Salicornia meyerana			1	65	
Falkia repens			4	4	
Samolus porosus				1,5	1
Triglochin cf. *bulbosum*				0,5	
Sarcocornia natalensis					25
Juncus kraussii					15

Transect B

Species	Percentage Cover at Sampling Points				
	B1	B2	B3	B4	B5
Stenotaphrum secundatum	62,5	10	2		
Sporobolus virginicus	10,5	7	1	1	
Plantago sp.	0,5				
Cotula filifolia	0,5				
Disphyma crassifolium	0,5	3	3		
Triglochin cf. *bulbosum*	1	4			
Cotula coronopifolia		1,5			
Spergularia media		0,5			
Falkia repens		0,5	1	0,5	
Juncus kraussii		18,5	4	1	1,5
Salicornia meyeriana		8,5	1,5	23,5	45
Chondropetalum tectorum			30,5		
Plantago carnosa			0,5	0,5	0,5
Limonium sp.				3	1,5
Samolus porosus					1

4.2 Fauna

4.2.1 Zooplankton.

Grindley (1957 and 1965) found the following zooplanktonic organisms in Kleinriviersvlei:

PROTOZOA

Foraminifera	*Rotalia* sp.
Dinoflagellates	*Noctiluca scintillans*

COELENTERATA

Hydroid medusae
Rhizostoid medusae
Muggiaea

NEMATODA

Nematode species indet.

POLYCHAETA

Polychaete larvae

OSTRACODA

Ostracoda species indet.

COPEPODA

Cyclops spp indet.
Centropages brachiatus
Copepod nauplii
Halicyclops spp.
Harpacticus gracilis
Harpacticoids indet.
Oithona nana
Oithona similis
Paracalanus crassirostris
Paracalanus parvus
Paracartia africana
Paracartia longipatella
Pseudodiaptomus hessei

CIRRIPEDIA

Cypris larvae
Nauplius larvae

TANAIDACEA

Apseudes digitalis
Leptochelia savignyi

MYSIDACEA

Gastrosaccus brevifissura
Gastrosaccus gordonae
Mesopodopsis africanus
Mesopodopsis slabberi
Leptomysis tattersalli
Rhopalopthalamus terranatalis

CUMACEA

Iphinoe capensis

ISOPODA

Eurydice longicornis
Exosphaeroma hylocoetes
Haliophasma sp

AMPHIPODA

Hyale sp.
Melita zeylanica
Paramoera capensis
Photis sp.

DECAPODA

Hymenosoma orbiculare
Megalopa larvae
Zoea larvae
Mysis larvae
Palaemon pacificus

OSTEICHTHYES

Fish eggs
Fish larvae

4.2.2. Invertebrate Macrofauna

The detailed survey of Scott *et al.* (1952) is the only study of the benthic macrofauna of Kleinriviersvlei to date. It is difficult, in the absence of modern data, to assess how the present biota of Kleinriviersvlei differs from that described by Scott *et al.* (1952). Characteristic zonal communities rather than exact species abundance and distributions will therefore be emphasized, since the former is probably more resistant to change. Some major changes are readily discernible, however, and less obvious changes in species composition, abundance and distribution may therefore be anticipated. The obvious changes will be discussed below.

Scott *et al.* (1952) divided the Kleinriviersvlei system into three major zones, viz., the canal-like stretch below Stanford; the junction between the canal and the lagoon and thirdly, the lagoon itself (including the estuarine mouth region).

The canal-like stretch is usually brackish, with a maximum salinity of eight parts per thousand, and here they found a gradual replacement of freshwater species by estuarine forms was found. Estuarine copepods and amphipods, as well as the bivalve, *Arcuatula capensis*, first appeared just below Stanford, but the community was still dominated by freshwater insects. Permanent residents were *Ischnura senegalensis* and *Cloeon* sp., which can withstand salinities of up to eight parts per thousand, while other insect larvae appeared sporadically. The bulk of the community, however, comprised estuarine species eg. the isopod, *Melita zeylanica* and the mussel, *Arcuatula capensis*.

The junction between the river-canal and the lagoon, at the head of the subaerial delta, supported the most varied fauna. Here, in response to fluctuations in salinity, the community alternated between that typical of the canal-like stretch and one characteristic of an estuarine lagoon.

The most striking characteristic of the lagoon fauna was its lack of seasonal variation, as evidenced by the year-long consistency of species abundance and community structure. A similar lack of variation was noted by De Decker and Bally (1985) in the nearby Bot River Estuary. The major variable component was the marine one, which was dependent on the extent of tidal influence in the lagoon. There were no freshwater species below the riverine delta.

The lagoon area was divided into three distinct zones, viz., shore, weedbed and bottom. The shore community component was a mixture of terrestrial insects and marine littoral invertebrates feeding on cast-up vegetation (*Ruppia*, *Zostera* and *Enteromorpha*). Most of the species in this community, with the exception of *Oxystele* spp., *Siphonaria* sp. and *Littorina knysnaensis*, were absent at high water levels in winter, probably as a result of sensitivity to low salinities.

The weedbed community had a much reduced marine component, but was densely populated by:

amphipods	- *Melita zeylanica*
	Corophium triaenonyx
isopods	- *Exosphaeroma hylecoetes*
mysids	- *Rhopalophthalmus egregius* Hansen
snails	- *Assiminea* sp.
mussels	- *Arcuatula capensis*.

These species were evenly distributed in weedbeds throughout the lagoon, and, excluding the mysid and snail, closely resemble those of the *Ruppia* community of the Bot River estuary (De Decker and Bally, 1985).

Palaemon pacificus is a migrant shrimp which spent most of the day in the weedbeds, but formed part of the lagoon plankton at night. In the weedbeds at the foot of the lagoon, the crab, *Hymenosoma orbiculare* and the molluscs, *Natica* sp. and *Haminea alfredensis* became more abundant.

The bottom fauna was divided into three communities based on the major sediment fraction of their respective distributions. The dominant species in each community were as follows:

mud - tanaiids - *Leptochelia savignyi*
- isopods - *Paramunna* sp.

gravel - amphipods - *Parorchestia rectipalma*

sand - amphipods - *Grandidierella lutosa*
- spionids - *Prionospio pernana* and *Capitella* sp.
- sandprawn - *Callianassa kraussi*

Common to all three subdivisions were the following species:-

isopods - *Cyathura carinata*
- *Exosphaeroma hylecoetes*

amphipods - *Corophium triaenonyx*
- *Melita zeylanica*
- *Talorchestia ancheidos*

mysid - *Rhopalophthalmus egregius* Hansen

crab - *Hymenosoma orbiculare* (in shallows)

The sand prawn, *Callianassa kraussi*, was found on sandy substrata throughout the lagoon, and in the total absence of *Upogebia africana* (the mud prawn), uncharacteristically colonized more muddy areas.

A number of larger animals were associated with sandy bottoms, but colonized mainly the lower reaches of the estuary. These included many popular bait species such as pencil bait (*Solen capensis*), bloodworm (*Arenicola loveni*) and sandprawn (*Callianassa kraussi*), as well as many other stenohaline temporary residents. It is in this community that the most obvious change since the 1952 survey by Scott *et al.* is discernible, since it has been devastated in the mouth area, probably as a result of the combined effects of excess sedimentation, compaction of sand by vehicles and easy bait collection.

Scott *et al.* (1952) identified a total of 128 species in the Kleinrivier Estuary. This compares with a total of 23 in the Bot River Estuary (De Decker and Bally, 1985), an estuary which is only breached every few years, and a total of 319 species in the Knysna estuary (Day, 1967), a permanently open estuary. It appears that annual breachings allow more chance for recruitment of benthos, but that prolonged closure, with complete mixing of the estuary, prevents the establishment of permanent distinct communities of the complexity found in open estuaries.

4.2.3. Fish

The only reliable information available on the fish fauna of the estuary is contained in the paper by Scott *et al.* (1952) and in the study of the biology of the white stumpnose, *Rhabdosargus globiceps* by Talbot (1955). Since there is little doubt that major changes have occurred in the fish population since then (I Williams, ex-Commodore, Hermanus Yacht Club, pers. comm.),the species list will be given here for historical interest only (Appendix II).

During December 1983 and January 1984, a "mass mortality" of *Liza richardsonii* occurred in the estuary (Grindley, *in litt.*, 1984). After approximately 2 000 dead fish were counted (*Die Burger* 84-01-17), the CDNEC decided to breach the mouth at the western end on 84-01-14 to "freshen" the estuary. Grindley (*in litt.*, 1984) measured salinities in the vlei on 84-01-01, which were all above 14 parts per thousand, well within the limits tolerable to *L. richardsonii* (Bennett, 1985). Furthermore, strong winds over the vlei, the absence of dead fish of any other species and healthy plant life discounted oxygen depletion of the water column as a possible cause for the fish-kill. Besides the fact that all the fish were of one species, a further interesting aspect was that the fish were of one size class only (mean of 247 ±15mm, n=23; Grindley, *in litt.*, 1984). Investigations by ECRU and CDNEC failed to reveal any obvious cause for the fish-kill, and it remains unexplained.

4.2.4. Amphibians and Reptiles

The amphibian and reptile records (Appendix III), were compiled by A L de Villiers of the CDNEC for the grid squares 3419AC Hermanus and 3419AD Stanford. Due to the lack of specimen records from these loci, species one would *expect* to find in this area have also been included, with the proviso that their distribution ranges and habitat preferences coincided with this area, and that there were confirmed distribution records in neighbouring loci. Some of the species listed are not directly associated with the vlei, but are restricted to its upper catchment.

The list of lizards is made up entirely of "likely to occur" species, largely due to the lack of information on lizard distribution and the poor state of lizard taxonomy. The listed amphibians and reptiles are based on the following sources: Poynton (1964), Greig and Burdett (1976), Greig *et al.* (1979), Broadley (1983), Branch (1988) and the herpetological records of the CDNEC.

Three of the species are endemic to the south-west Cape and are listed in the South African Red Data Book - Reptiles and Amphibians (Branch, 1988). They are *Xenopus gilli* (Cape platanna) and *Microbatrachella capensis* (micro frog) in the "endangered" category and *Capensibuto rosei* (Cape mountain toad) in the "restricted" category. Although *X. gilli* and *M. capensis* have not yet been recorded in the vicinity of Kleinriviersvlei, populations of both of these species occur to the west of the estuary in the Kleinmond area and near Pearly Beach situated approximately 30 km east of the estuary. Likewise *C. rosei* has not yet been recorded in the vicinity of Kleinriviersvlei but specimens have been collected in the mountains above Hermanus.

4.2.5. Birds

The abundant avifauna of Kleinriviersvlei was first described by Ashton (1945), who, in a period of two weeks, recorded 84 species. A list of birds recorded by the Cape Bird Club (as part of their Atlas Project), for the locus 3419AD, was revised by Dr. Langley Roberts of Onrus, to include only those species present at the vlei, and is given in Appendix IV. A total of 217 species was recorded, of which ten are listed in the South African Red Data Book - Birds (Brooke, 1984), as either vulnerable, rare or indeterminate (Appendix V). Of these ten, three species (Martial Eagle, Stanley's Bustard and Caspian Tern), have declining populations in South Africa.

Five species, which were included in the 1976 South African Red Data Book (Siegfried *et al.*, 1976), and occur at the estuary, have now been identified as species requiring monitoring and protection to ensure that they do not return to "Red Data" categories. These are the Crowned Cormorant, Booted Eagle, African Fish Eagle, Black Harrier, and the Osprey (Brooke, 1984).

In a study of coastal waders of the south-western Cape, Summers *et al.* (1977) considered the estuary to be the third-most important wetland in the Western Cape (after Langebaan Lagoon and the Berg River estuary). These workers counted 5 057 Palaearctic migrant and 348 resident waders (a total of 5 406 waders). This represents approximately 4,5 percent of the total estimated coastal wader population of the south-western Cape. More recently, Ryan *et al.* (1988), who counted a total of 9 983 waders in January 1981 in the vlei, regarded the estuary as one of the ten most important wetlands of the south-western Cape coast, again emphasising the need for conservation of the estuary as a wader habitat, as indicated by Cooper *et al.* (1976) and Summers (1977). The presence of the ten "Red Data" category and five "monitor" species lends further weight to the importance of this view.

4.2.6. Mammals

A list of mammals occurring (or likely to occur) in the locus 3419AC was compiled by P H Lloyd of the CDNEC from Stuart *et al.* (1980), Stuart (1981) and their own records (Appendix VI). Of these, ten are listed in the South African Red Data Book - Terrestrial Mammals (Smithers, 1986) as vulnerable, rare or indeterminate.

5. SYNTHESIS AND RECOMMENDATIONS

Present state of the system

The Kleinrivier Estuary is a blind estuary with a low sandbar at its mouth which forms a lagoon or coastal lake approximately 10km long and 2km wide at its widest point, and an area of 1 280ha. Artificial breachings of the sandbar have occurred almost every year for more than 100 years, but this practice has now been modified in favour of controlled breaching at a minimum prescribed water level (CSIR, 1988) (Figure 34 and PLATE III). In a review of the status of South African estuaries (Heydorn, 1986) the condition of the Kleinrivier Estuary was assessed as "fair", and was placed in a category defined as suitable for development along environmentally acceptable guidelines. The "fair" categorization indicates that some degree of ecological disturbance has taken place in the catchment or environs of the estuary. More specifically, farming in the catchment and floodplain and manipulation of the mouth were highlighted. This assessment appears to be accurate in the light of the extensive agricultural development of the catchment, the obstruction of riverine flow by alien vegetation and Palmiet (*Prionium serratum*), property development along the northern shore, widespread infestation of the surrounding Strandveld by alien vegetation, and more than a century of artificial mouth breaching.

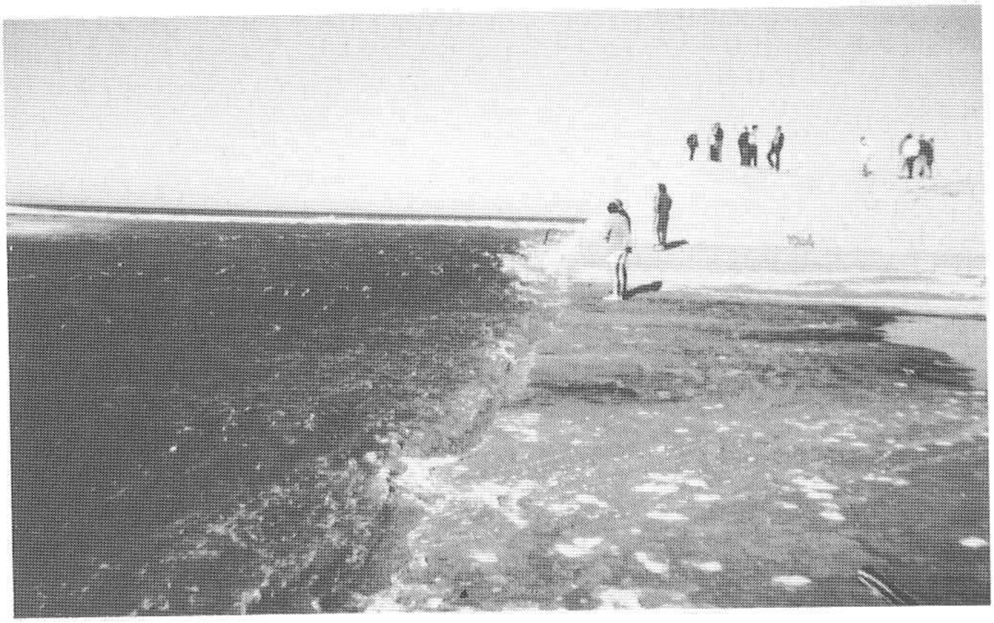


FIG. 34: Artificial breaching of Kleinriviersvlei on 82-09-05.

There are no industrial or other major sources of pollution feeding into the vlei and all other physico-chemical criteria are within normal limits. Regular contact with the sea ensures that the estuary does not become hypersaline, while high levels of dissolved oxygen are maintained by the strong winds blowing over the shallow basin. All these factors are important in the maintenance of as complex an ecosystem as found in this estuary, exemplified by features such as the fairly high invertebrate species richness, its importance as a wader wetland and its popularity for angling. Only carefully guided planning and development can successfully maintain or improve the present state of the estuary.

Present state of knowledge

Despite its importance as a wetland and its ideal setting and potential as a study area for estuarine processes, the Kleinrivier Estuary has attracted relatively little research. Some earlier work described its invertebrate populations (Scott *et al.*, 1952), but until this decade, little else of note has been studied at the estuary. More recently, detailed studies of its geomorphology and sedimentology (Sloman, 1983, Fortuin, in prep.) and the physico-chemical characteristics (Coetzee and Pool, 1986) of its water have been completed.

Controversy has always surrounded the issue of artificial, as against natural, breachings of the sandbar. A detailed survey of the sediment dynamics of the mouth area has been completed and proposals for the management of the mouth have been advanced (CSIR, 1988) and accepted by CDNEC (J Neethling, pers. comm.).

Angling is one of the most popular attractions of the estuary, yet no comprehensive study of its fish fauna has been undertaken to date. Talbot (1955) made passing reference to the fish fauna in his study of the white stumpnose in Kleinriviersvlei. The status of the fish fauna is not only of academic interest, but has an important bearing on the question of artificial versus natural breachings of the mouth, as in the case of the Bot River estuary (Branch *et al.*, 1985).

As a result of this lack of recent, comprehensive studies on the estuary, its dynamics and vulnerabilities are not yet fully understood. Detailed knowledge of the interactions between the multiple components of the ecosystem is necessary if the estuary is to be developed in a way which will allow its continued healthy functioning. More studies are urgently required on all aspects of the estuary and its surrounds (including property development), but especially in those areas mentioned above.

Problems: present and foreseeable.

Despite having a relatively small catchment (906 km^2), the Kleinrivier discharges into one of the largest estuaries of the south-west Cape coast. This "size discrepancy" may be ascribed to the local geomorphology, i.e. a drowned fault through which the river drains to the sea. Due to the poor erosive action of the Kleinrivier with its low run-off (eight percent of the annual precipitation), the estuary is not in the immediate danger of being filled by river-borne sediment, as in the case of the nearby Onrus Estuary (Heinecken and Damstra, 1983). On the other hand, the reduced flushing power of a small river buffered by a large lagoon, renders the estuary particularly sensitive to any mismanagement of its mouth. This constitutes the major problem of, and threat to, the system. Chronic mismanagement is evident from the accretion of marine sediments in the mouth area, which may choke channels, slipways and jetties, and possibly reduce the recruitment of fish from the sea. The flooding of low-lying properties at high water levels, is a related problem, but in most instances, eg at Maanskynbaai and Stanford, it is due to development below the estuarine floodline. Complaints from these landowners should therefore not take precedence over other issues in policies regarding the management of water levels.

Poor control of the construction of jetties is apparent from the excessive number of these obstructions (more than 20) along the northern shore (Figure 29). Not only are many of these structures dilapidated and unsightly, but they may alter flow regimes and contribute tonnes of sediment to the estuary when their retaining walls collapse. Both these effects may exacerbate the sedimentation problem of the estuary.

Abundant growth of the aquatic weed, *Ruppia maritima*, has been the source of many complaints in the past, since it interferes with all manner of water activities. In the past, the problem was solved by breaching the mouth, since high salinity water kills the plants. If, however, artificial breachings are to occur less frequently, the lagoon water may remain fresh (less saline) for longer periods before high water levels breach the mouth naturally. Extensive weed growth may then again become problematical. A similar problem exists at Zandvlei, near Muizenberg in the Cape Peninsula, where a mechanical weedcutter is used to remove the plants (Morant and Grindley, 1982). Since the *Ruppia* only grows around the periphery of the estuary, at depths of less than 1,5m (Scott *et al.*, 1952), while leaving the central, deeper areas clear, a similar solution could be used in certain problem areas eg in front of slipways, jetties etc. This should only become necessary in those few years during which water levels remain too low to breach the mouth naturally.

Other problems encountered are:

- unauthorized artificial breaching of the mouth by members of the public apparently just for the thrill of it.
- the possibility of treated effluent from a sewage plant being discharged into the estuary.
- dense infestation of privately owned land along the southern shore by alien shrubs (*Acacia cyclops*), which may spread into and destroy the remaining coastal Strandveld in this area.
- the municipal dumping site between Prawn Flats and Maanskynbaai is an eyesore and a source of windblown litter which finds its way into the estuary.
- subsurface poles which are the remains of "navigation" marks set into concrete blocks in the channel between the lagoon and the mouth constitute a serious hazard to boats.
- blatant disregard of the zoning regulations and speed limits on the estuary by motor boats.

Recommendations.

Management of the Kleinriviersvlei, based on comprehensive knowledge of all its aspects is essential if a realistic balance is to be found between its development as a holiday and retirement resort and the continued functioning of the estuary as a rich, viable ecosystem. It is important to keep in mind that the attraction of the estuary is heavily dependent on its healthy, natural functioning, and that this may easily be damaged by short-sighted management decisions. This report not only provides a synthesis of information available to date, but also attempts to elucidate those areas in which knowledge is insufficient to permit the formulation of sound management policies. With such information at hand, it should be possible to develop the Kleinrivier Estuary successfully, without compromising its ecological processes.

Present compilation of a Structure Plan for the Kleinriviervlei area.

It is encouraging to learn that the Overberg Regional Services Council, in conjunction with the Hermanus Municipality, is having a comprehensive Structure Plan drawn up for the Kleinriviervlei area by a firm of Consulting Town Planners. The area to be included in this study includes the properties adjoining both sides of the Kleinriviervlei and the Kleinrivier up to the road bridge at Stanford.

The objective of this Structure Plan is, *inter alia*, to provide a clear framework for future development in the form of guidelines for the management of the total system. Although a Structure Plan does not grant any rights pertaining to land use, nor does it take any rights away, it outlines the importance for comprehensive forward planning and provides guidelines for harmonious development so as to resolve any potential conflict between urbanization, recreation and conservation.

In terms of Structure Planning legislation (Land Planning Ordinance 15 of 1985), a Structure Plan has to be revised every 10 years on the basis of full public participation. The Structure Plan is, therefore, a dynamic document which is, in effect, an agenda for future decision-making.

In addition, this Structure Plan should be seen as complementary to and supportive of the Council for the Environment's endeavors to implement effective conservation measures and ensure adequate protection of the functioning of existing dynamic ecological processes within the Kleinriviersvlei area.

In principle therefore, the most important recommendations are, firstly that a single authority representing or consulting all relevant parties should control the estuary, and secondly, that this controlling body avails itself of as much information as possible upon which to base its decisions. If information is lacking on any aspect, steps should be taken to obtain it through competent investigators. Kleinriviersvlei is ideally suited and situated as a study area for projects and theses at tertiary education level. This has proved to be an excellent method of obtaining detailed knowledge of a system, as exemplified by the work at the nearby Bot River estuary (Branch *at al.*, 1985). At least two minor theses have already been completed at the Kleinrivier Estuary and make major contributions to this synthesis.

More specifically, detailed long term studies are urgently required on the sediment dynamics of the mouth area, on lagoonal nutrients, on all aspects of the fish fauna, on changes that have occurred to the benthic fauna since the study of Scott *et al.* (1952) and on the spread and control of alien vegetation. In the catchment, the effects of the obstructing vegetation in the riverbed and further water obstruction must be assessed in greater detail.

Development of the environs of Kleinriviersvlei should be controlled strictly and confined to the northern shore. Developments such as the proposed resort southwest of Wortelgat should not be permitted. Consideration should be given to the incorporation of the southern shore into the Walker Bay State Forest to protect, in particular, the milkwood groves between The Cliffs and Wortelgat.

Other, more specific recommendations are:

- The accepted mouth breaching policy should be strictly enforced with heavy penalties for illegal, uncontrolled mouth breaching.
- sewage effluent should not be discharged into the estuary. Alternate sites for the disposal of treated effluent should be sought eg evaporation ponds located in the dunes of Walker Bay State Forest.
- stricter law enforcement on the estuary, especially with regard to zone demarcation and speed regulations, in the light of the importance of the estuary as a coastal wetland.
- the eradication and control of alien vegetation on private land must be encouraged and assisted.

- greater control must be exercised over the construction of new jetties, sandfill jetties being discouraged, while illegal and derelict jetties must be removed.

- the subsurface poles and the concrete blocks holding them in the main channel between the mouth and the lagoon must be removed, since they constitute a danger to boating.

- all vehicles should be banned from Die Plaat, since by compacting the sand there, they destroy the faunal communities and possibly reduce the amount of sand that is removed during mouth breachings, thereby exacerbating the import of sand into the estuary.

- the unsightly rubbish dump between Prawn Flats and Maanskynbaai must be removed and the site rehabilitated.

Despite major disruptions in its catchment and a long history of manipulation of its mouth, the Kleinrivier Estuary is still in a fairly sound ecological state. The estuary and its environs, however, are becoming increasingly popular as a holiday and retirement resort. Only a comprehensive management plan can guide future development in a way which will preserve the delicate estuarine ecosystem and maintain ecological stability. By having synthesized current information on the estuary and highlighting areas of insufficient knowledge, it is hoped that this report will be of assistance in the drawing up of a cohesive management plan for the Kleinriviersvlei.

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Aerial Photographs

Date	Job No.	Photo Nos.	Scale, 1:	Type	Source
1938	130 38	20363-65	25 000	B&W	Trig. Survey
		20390-97			
		20429,52,57			
1961	461	3738-41	36 000		
		8694,95		B&W	Trig. Survey
		8703,04,14			
1972	295/8	6940-46	8 000	B&W	Dept. Transport
1973	719	1781,1783,1805	40-50 000	B&W	Trig. Survey
1977	282	563-565	4 500	Col.	Univ. of Natal
1979	326	330/3-333/3	10 000	Col.	Univ. of Natal
1979	498/74	139,146,149,150	30 000	B&W	Trig. Survey
1980	349	8,9	20 000	B&W	Univ. of Natal
1980	374	241-243	20 000	B&W	Univ. of Natal
1981	391	328/3-333/3	20 000	Col.	Univ. of Natal
1987	-	377-383	10 000	Col.	EMA/CSIR
1989	-	1 Photo		Col.	EMA/CSIR

8. 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: orginating 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 the 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.

EDDY: 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.

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 saline 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.

ISOBATH: a line joining points of equal depth of a horizon below the surface.

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 to the shore.

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.

MEIOFAUNA: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the benthic macrofauna.

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^{o}, 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.

OLIGOTROPHIC: poor in nutrients and hence having a paucity of living organisms.

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.

PERIPHYTON: plants and animals adhering to parts of rooted aquatic plants.

PHOTOSYNTHESIS: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.

PHYTOPLANKTON: plant component 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 silica. 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.

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.

WAVE HEIGHT (average energy wave height): an index which reflects the distribution of average incident wave energy at inshore sites along the coast presented as a wave height.

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 component of plankton.

References:

DAY, J.H. (ed.)(1981). Estuarine ecology with particular reference to Southern Africa. Cape Town, A.A. Balkema.

SOUTH AFRICAN TIDE TABLES (1980). Retreat C.P. The Hydrographer. South African Navy.

APPENDIX I: Conspicuous plant species comprising the mapped vegetation units at the Kleinrivier Estuary.

Note: The symbols in brackets following each species' name represent adapted Braun-Blanquet Cover-Abundance Classes as follows:

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

Dune Shrubland and slack communities

Agropyron distichum (1); *Tetragonia decumbens* (1); *Arctotheca populifolia* (r); *Metalasia muricata* (2); *Chrysanthemoides monilifera* (1); *Senecio elegans* (+); *Carpobrotus acinaciformis* (+); *Ficinia littoralis* (+); *Thesidium fragile* (r); *Passerina* sp. (+); *Chironia baccifera* (1); *Myrica cordifolia* (1); *Colpoon compressum* (+); *Helichrysum crispum* (+); *Psoralea fruticans* (+); *Erharta villosa* (1); *Heteroptilis suffruticosa* (+); *Conysa scabrida* (r); *Plantago carnosa* (+); *Juncus acutus* (+).

Dune Scrub and Strandveld

Psoralea fruticans (3); *Rhus glauca* (1); *Pterocelastrus tricuspidatus* (1); *Carpobrotus acinaciformis* (+); *Rhus crenata* (+); *Olea exasperata* (2); *Chrysanthemoides monilifera* (1); *Passerina* sp. (+); *Colpoon compressum* (+); *Protasparagus* sp. (+); *Myrsine africana* (r); *Euclea racemosa* (+); *Metalasia muricata* (+); *Nylandtia spinosa* (+); *Zygophyllum flexuosum* (+); *Cassine peragua* (+); *Sideroxylon inerme* (+); *Tetragonia fruticosa* (+); *Acacia cyclops* (3); *Chionanthus foveolata* (r); *Restio eleocharis*.

Sideroxylon inerme Thicket

Sideroxylon inerme (4); *Cassine peragua* (r); *Chionanthus foveolata* (+); *Euclea racemosa* (+); *Rhus glauca* (+); *Acacia cyclops* (1).

Salt Marsh (species abundance has not been determined)

Stenotaphrum secundatum; Sporobolus virginicus; Juncus kraussii; Orpheum frutescens; Spergularia media; Sarcocornia natalensis; Salicornia meyeriana; Plantago carnosa; Limonium scabrum; Samolus porosus; Disphyma crassfolium; Sarcocornia pillansiae; Scirpus triqueter; Scirpus maritimus; Paspalum vaginatum; Triglochin striatum; Juncellus laevigatus; Falkia repens; Chondropetalum tectorum; Cotula filifolia; Triglochin bulbosum; Cotula coronopifolia; Juncus acutus; Plantago carnosa.

Fynbos

(See checklist of the Coastal Herbarium at the Fernkloof Nature Reserve, Hermanus)

APPENDIX II: Fishes recorded at Kleinriviersvlei by Scott *et al.* (1952) and Talbot (1955)

Freshwater fishes

Indigenous:

Sandelia capensis	Cape kurper
Galaxius zebratus	Cape galaxias

Alien:

Micropterus salmoides	Large-mouth black bass
Micropterus punctulatus	Spotted bass

Estuarine and marine fishes

Gilchristella aestuarius	Estuarine roundherring
Galeichthyes feliceps	White seacatfish
Heteromycteris capensis	Cape sole
Solea bleekeri	Blackhand sole
Syngnathus acus	Longsnout pipefish
Lichia amia	Leervis
Pomadasys olivaceum	Piggy
Pomatomus saltatrix	Elf
Rhabdosargus holubi	Cape Stumpnose
Rhabdosargus globiceps	White stumpnose
Diplodus sargus	Blacktail (Dassie)
Diplodus cervinus	Zebra (wildeperd)
Lithognathus lithognathus	White steenbras
Mugil cephalus	Flathead mullet
Liza richardsonii	Southern mullet
Atherina breviceps	Cape silverside
Caffrogobius nudiceps	Bareheaded goby
Psammogobius knysnaensis	Knysna sandgoby
Clinus superciliosus	Super klipfish
Ophisurus serpens	Sand snake-eel
Argyrosomus hololepidotus	Kob
Atractoscion aequidens	Geelbek
Trigla sp.	Gurnard
Sarpa salpa	Strepie
Spondyliosoma emarginatum	Steentjie
Chelidonichthys capensis	Cape gurnard
Amblyrhynchotes honckenii	Evileye blaasop
Rhinobatos sp.	Sandshark
Rhinobatos annulatus	Lesser guitarfish

APPENDIX III: List of Amphibians and Reptiles which have been recorded or are likely to occur for the grid squares 3419 AC and AD (A L de Villiers, CDNEC, *in litt.*)

RDB - Red Data Book (Branch, 1988)
L - Likely to occur
X - Specimen record

APPENDIX III: (Continued)

FROGS	3419 AC	3419 AD	
Xenopus laevis (Common platanna)	X	L	
Xenopus gilli (Cape platanna) RDB: endangered	X	L	Branch (1988), CDNEC
Heleophryne purcelli (Cape ghost frog)	L	X	Branch (1988), CDNEC
Bufo angusticeps (Sand toad)	L	L	
Capensibufo rosei (Cape mountain toad) RDB: restricted	L	X	Branch (1988), CDNEC
Bufo rangeri (Raucous toad)	X	L	Poynton (1964), CDNEC
Bufo pardalis (Leopard toad)	X	L	Poynton (1964), CDNEC
Breviceps rosei (Sand rain frog)	L	L	
Breviceps montanus (Cape mountain rain frog)	L	X	Poynton (1964), CDNEC
Tomopterna delalandii (Cape sand frog)	L	L	
Rana fuscigula (Cape river frog)	L	X	CDNEC
Strongylopus grayii (Spotted grass frog)	X	X	Poynton (1964), CDNEC
Strongylopus bonaespi (Cape grass frog)	X	X	Greig, Boycott & De Villiers (1979)
Microbatrachella capensis (Micro frog) RDB: endangered	X	L	Branch (1988), CDNEC
Cacosternum boettgeri (Common caco)	L	X	CDNEC
Arthroleptella lightfooti (Cape chirping frog)	L	X	CDNEC
Semnodactylus wealii (Rattling kassina)	L	L	
Hyperolius horstockii (Arum frog)	X	L	Poynton (1964), CDNEC
TORTOISES			
Chersina angulata (Angulate tortoise)	X	L	Greig & Burdett (1976)
Homopus areolatus (Padloper tortoise)	X	L	Greig & Burdett (1976)
Pelomedusa subrufa (Water tortoise)	L	L	
SNAKES			
Typhlops lalandei (Pink earth snake)	L	L	
Leptotyphlops nigricans (Black worm snake)	L	L	
Lycodonomorphus rufulus (Brown water snake)	L	L	
Lamprophis aurora (Aurora house snake)	L	L	
Lamprophis inornatus (Olive house snake)	L	L	
Prosymna sundevallii (Southern shovel-snout)	L	L	
Pseudaspis cana (Mole snake)	L	L	
Duberria lutrix (Southern slug-eater)	X	L	Broadley (1983)
Dasypeltis scabra (Common egg-eating snake)	L	L	
Crotaphopeltis hotamboeia (Herald snake)	L	L	
Amphlorhinus multimaculatus (Cape many-spotted snake)	L	L	
Dispholidus typus (Boomslang)	L	L	
Psammophylax rhombeatus (Spotted skaapsteker)	X	X	Broadley (1983)
Psammophis notostictus (Whip snake)	L	L	
Psammophis crucifer (Cross-marked sand snake)	L	X	Broadley (1983)
Aspitelaps lubricus (Coral snake)	L	L	
Elaps lacteus (Spotted dwarf garter snake)	L	L	
Hemachatus haemachatus (Rinkhals)	L	L	
Naja nivea (Cape cobra)	L	L	
Bitis arietans (Puff adder)	L	L	
Bitis atropos (Cape mountain adder)	L	L	
Bitis cornuta (Many-horned adder)	L	X	Broadley (1983)

APPENDIX III: (Continued)

LIZARDS

	AC	AD
Pachydactylus geitje (Ocellated gecko)	L	L
Phyllodactylus porphyreus (Marbled gecko)	L	L
Bradypodion pumilum (Cape dwarf chameleon)	L	L
Agama atra (Rock agama)	L	L
Tropidosaura gularis (Yellow-striped mountain lizard)	L	L
Tropidosaura montana (Green-striped mountain lizard)	L	L
Acontias meleagris (Golden sand lizard)	L	L
Scelotes bipes (Silver sand lizard)	L	L
Mabuya capensis (Common skink)	L	L
Mabuya homalocoephala (Cape speckled skink)	L	L
Chamaesaura anguina (Cape snake lizard)	L	L
Pseudocordylus microlepidotus (Small-scaled girdled lizard)	L	L
Pseudocordylus capensis (Cape small-scaled girdled lizard)	L	L
Cordylus cordylus (Cape girdled lizard)	L	L
Gerrhosaurus flavigularis (Yellow-throated plated lizard)	L	L
Tetradactylus seps (Short-legged seps)	L	L
Tetradactylus tetradactylus (Long-tailed seps)	L	L

APPENDIX IV: List of birds recorded by the Cape Bird Club for the locus 3419AD and revised by Dr L. Roberts of Onrus to include birds recorded at the Klein River estuary only.

New Roberts Number (Maclean, 1985)	Common Name	New Roberts Number (Maclean, 1985)	Common Name
3	Jackass Penguin	56	Cape Cormorant
6	Great Crested Grebe	57	Bank Cormorant
8	Little Grebe	58	Reed Cormorant
12	Blackbrowed Albatros	59	Crowned Cormorant
17	Giant Petrel	60	Darter
21	Pintado Petrel	62	Grey Heron
23	Greatwinged Petrel	63	Blackheaded Heron
24	Softplumaged Petrel	65	Purple Heron
29	Broadbilled Prion	66	Great White Egret
32	Whitechinned Petrel	67	Little Egret
35	Great Shearwater	68	Yellowbilled Egret
37	Sooty Shearwater	71	Cattle Egret
42	Storm Petrel	76	Night Heron
44	Wilson's Storm Petrel	78	Little Bittern
49	White Pelican	81	Hamerkop
53	Cape Gannet	83	White Stork
55	Whitebreasted Cormorant	84	Black Stork

APPENDIX IV: (Continued)

91	Sacred Ibis	249	Threebanded Sandplover
93	Glossy Ibis	254	Grey Plover
94	Hadeda	255	Crowned Plover
95	Spoonbill	258	Blacksmith Plover
96	Greater Flamingo	262	Turnstone
97	Lesser Flamingo	264	Common Sandpiper
101	Whitebacked Duck	266	Wood Sandpiper
102	Egyptian Goose	269	Marsh Sandpiper
103	South African Shelduck	270	Greenshank
104	Yellowbilled Duck	271	Knot
105	Black Duck	272	Curlew Sandpiper
106	Cape Teal	274	Little Stint
108	Redbilled Teal	281	Sanderling
112	Cape Shoveller	284	Ruff
113	Redeyed Pochard	286	Ethiopian Snipe
116	Spurwing Goose	288	Bartailed Godwit
117	Maccoa Duck	289	Curlew
118	Secretary Bird	290	Whimbrel
126	Yellowbilled Kite	294	Avocet
127	Blackshouldered Kite	295	Stilt
131	Black Eagle	297	Cape Dikkop
136	Booted Eagle	298	Water Dikkop
140	Martial Eagle	307	Arctic Skua
148	Fish Eagle	309	Pomarine Skua
149	Buzzard	310	Subantarctic Skua
152	Jackal Buzzard	312	Kelp Gull
155	Redbreasted Sparrowhawk	315	Greyheaded Gull
160	African Goshawk	316	Hartlaub's Gull
165	African Marsh Harrier	322	Caspian Tern
168	Black Harrier	324	Swift Tern
170	Osprey	326	Sandwich Tern
172	Lanner	327	Common Tern
173	Hobby	328	Arctic Tern
181	Rock Kestrel	329	Antarctic Tern
183	Lesser Kestrel	338	Whiskered Tern
190	Greywing Francolin	339	Whitewinged Black Tern
195	Cape Freancolin	348	Feral Pigeon
200	African Quail	349	Rock Pigeon
203	Helmeted Guineafowl	350	Rameron Pigeon
208	Blue crane	352	Redeyed Turtle Dove
210	Water Rail	354	Turtle Dove
213	Black Crake	355	Laughing Dove
217	Redchested Flufftail	356	Namaqua Dove
223	Purple Gallinule	377	Redchested Cuckoo
226	Moorhen	382	Jacobin Cuckoo
228	Redknobbed Coot	385	Klaas's Cuckoo
231	Stanley Bustard	391	Burchell's Coucal
239	Black Korhaan	395	Marsh Owl
242	Painted Snipe	401	Spotted Eagle Owl
244	Black Oystercatcher	405	Fierynecked Nightjar
245	Ringed Plover	412	Black Swift
246	Whitefronted Sandplover	415	Whiterumped Swift
248	Kittlitz's Sandplover	417	Little Swift

APPENDIX IV: (Continued)

418	Alpine Swift	651	Crombec
424	Speckled Mousebird	661	Grassbird
425	Whitebacked Mousebird	664	Fantail Cisticola
428	Pied Kingfisher	666	Cloud Cisticola
429	Giant Kingfisher	669	Greybacked Cisticola
431	Malachite Kingfisher	677	Levaillant's Cisticola
435	Brownhooded Kingfisher	686	Karoo Prinia
451	Hoopoe	689	Spotted Flycatcher
465	Pied Barbet	690	Dusky Flycatcher
474	Greater Honeyguide	698	Fiscal Flycatcher
480	Ground Woodpecker	700	Cape Batis
486	Cardinal Woodpecker	710	Paradise Flycatcher
488	Olive Woodpecker	713	Cape Wagtail
495	Clapper Lark	716	Richard's Pipit
500	Longbilled Lark	717	Nicholson's Pipit
507	Redcapped Lark	718	Plainbacked Pipit
512	Thickbilled Lark	727	Orange Throated Longclaw
516	Greybacked Finchlark	732	Fiscal Shrike
518	European Swallow	736	Southern Boubou
520	Whitethroated Swallow	742	Southern Tchagra
523	Pearlbreasted Swallow	746	Bokmakierie
526	Greater Striped Swallow	757	European Starling
529	Rock Martin	759	Pied Starling
530	House Martin	760	Wattled Starling
532	European Sand Martin	769	Redwinged Starling
533	African Sand Martin	773	Cape Sugarbird
536	Black Sawwing Swallow	775	Malachite Sunbird
538	Black Cuckooshrike	777	Orangebreasted Sunbird
541	Forktailed Drongo	783	Lesser Doublecollared Sunbird
543	European Golden Oriole	796	Cape White-eye
547	Black Crow	801	House Sparrow
548	Pied Crow	803	Cape Sparrow
550	Whitenecked Raven	813	Cape Eeaver
566	Cape Bulbul	824	Red Bishop
572	Sombre Bulbul	827	Cape Widow
577	Olive Thrush	836	Common Waxbill
581	Cape Rockthrush	860	Pintailed Whydah
587	Capped Wheatear	874	Cape Siskin
589	Familiar Chat	872	Cape Canary
596	Stone Chat	877	Bully Canary
601	Cape Robin	878	Yellow Canary
614	Karoo Scrub Robin	879	Whitethroated Canary
631	African Marsh Warbler	880	Protea Canary
635	Cape Reed Warbler	881	Streakyheaded Canary
638	African Sedge Warbler	885	Cape Bunting
645	Barthroated Apalis		

APPENDIX V: List of bird species of vulnerable (V), rare (R), or indeterminate (I) status species occurring at the Kleinrivier Estuary (Brooke, 1984). The population trend is either stable (S) or declining (D).

Species	Conservation status	Population trend
White Pelican	R	S
Black Stork	I	S
White Stork	R	S
Greater Flamingo	I	S
Lesser Flamingo	I	S
Martial Eagle	V	D
Stanley's Bustard	V	D
Caspian Tern	R	D
Antarctic Tern	R	S
House Martin	I	S

APPENDIX VI: List of mammals recorded from or likely to occur in the loci 3419 AC and AD (P H Lloyd, CDNEC, *in litt.*)

*- Species occurring in Hermanus loci (3419 AC & AD)
+- Species occurring in adjacent loci and probably present
Unmarked- Species possibly occurring but not yet recorded from these areas
RDB- Species listed as rare or endangered in the Red Data Book - Terrestrial Mammals (Smithers, 1986)

PRIMATES - Primates
* *Papio ursinus* - Chacma baboon

ARTIODACTYLA - Even-toed ungulates
+*Pelea capreolus* - Grey rhebuck
+*Sylvicapra grimmia* - Grimm's duiker
+*Raphicerus melanotis* - Cape grysbok
Raphicerus campestris - Steenbok
Tragelaphus scriptus - Bushbuck
Taurotragus oryx - Cape eland
Oreotragus oreotragus - Klipspringer

CARNIVORA - Carnivores
RDB +*Panthera pardus* - Leopard
**Felis caracal* - African lynx
+*Felis lybica* - African wildcat
+*Felis serval* - Serval (historical record)

APPENDIX VI: (Continued)

RDB +*Mellivora capensis* - Ratel
Ictonyx striatus - Striped polecat
+*Aonyx capensis* - Cape clawless otter
RDB +*Proteles cristatus* - Aardwolf
+*Vulpes chama* - Cape fox
Otocyon megalotis - Bat-eared fox
Canis mesomelas - Black-backed jackal
Genetta genetta - Small-spotted genet
Genetta tigrina - Large-spotted genet
Herpestes ichneumon - Egyptian or large grey mongoose

Galerella pulverulenta - Cape or small grey mongoose
Cynictis penicillata - Red meerkat
+*Atilax paludinosus* - Marsh mongoose

INSECTIVORA - Insectivores
+*Suncus varilla* - Lesser dwarf shrew
Myosorex varius - Forest shrew
Crocidura flavescens - Greater musk shrew
Crocidura cyanea - Reddish-grey musk shrew
Chrysochloris asiatica - Cape golden mole
Amblysomus hottentotus - Hottentot golden mole
Macroscelides proboscideus - Round-eared elephant shrew
Elephantulus rupestris - Smith's rock elephant shrew

CHIROPTERA - Bats
+*Rousettus aegyptiacus* - Egyptian fruit bat
+*Rhinolophus capensis* - Cape horseshoe bat
+*Rhinolophus clivosus* - Geoffroy's horseshoe bat
Nycteris thebaica - Common or Egyptian slit-faced bat

Miniopterus schreibersii - Schreiber's long-fingered bat
+*Eptesicus melckorum* - Melck's serotine bat
Eptesicus hottentotus - Long-tailed serotine bat
Eptesicus capensis - Cape serotine bat
Myotis tricolor - Temninck's hairy bat
RDB *Myotis lesueuri* - Lesueur's hairy bat
Sauromys petrophilus - Flat-headed free-tailed bat
Tadarida pumila - Little free-tailed bat

RODENTIA - Rodents
Hystrix africaeaustralis - Porcupine
RDB +*Graphiurus ocularis* - Spectacled dormouse
RDB *Tatera afra* - Cape gerbil
+*Rhabdomys pumilio* - Striped mouse
RDB +*Myomyscus verreauxii* - Verreaux's mouse
Rattus rattus - House rat (introduced alien)
Otomys irroratus - Vleirat
Otomys saundersiae - Saunder's vleirat
Mystromys albicaudatus - White-tailed rat
Dendromus melanotis - Grey climbing mouse
Dendromus mesomelas - Brants' climbing mouse

APPENDIX VI: (Continued)

RDB *Steatomys krebsii* - Kreb's fat mouse
Gerbillurus paeba - Hairy-footed gerbil
RDB *Acomys subspinosus* - Cape spiny mouse
Aethomys namaquensis - Namaqua rock mouse
Mus minutoides - Pygmy mouse
Mus musculus (introducaed alien) - House mouse
+*Bathyergus suillus* - Cape dune molerat
+*Cryptomys hottentotus* - Common molerat
+*Georychus capensis* - Cape molerat

TUBULIDENTATA - Antbears
RDB *Orycteropus afer* - Aardvark

HYRACOIDEA - Dassies
Procavia capensis - Rock dassie

LAGAMORPHA - Hares and rabbits
Lepus saxatilis - Scrub hare
Lepus capensis - Cape hare
Pronolagus rupestris - Smith's red (rock) hare

PINNIPEDIA - Seals
**Mirounga leonina* - Southern elephant seal
+*Arctocephalus pusillus* - Cape fur seal

CETACEA - Whales and dolphins
Balaenoptera acutorostrata - Minke whale
Balaenoptera edeni - Bryde's whale
Balaena glacialis australis - Southern right whale
Kogia breviceps - Pygmy sperm whale
Kogia simus - Dwarf sperm whale
Grampus griseus - Risso's dolphin
Delphinus delphis - Common dolphin
Tursiops aduncus - Indian Ocean bottlenosed dolphin
Tursiops truncatus - Atlantic Ocean bottlenosed dolphin
Mesoplodon mirus - True's beaked whale
Globicephala melaena - Long-finned pilot whale
Stenella coeruleoalba - Striped dolphin

APPENDIX VII: Notes on the opening of the Hermanus (Kleinrivier) Lagoon by Mr G E Franks (from Waldron, 1986) N.B. no attempt has been made to edit these notes.

1948: On the "East": This was the year when a family was washed out to sea and two people drowned.

1949: On the East side:

1950: On the East side: This was he year when the writer started fishing on the Lagoon; at that time the out-flow was tremendous at Spring tides and the in-flow so great two anchors were needed to hold a small boat and the fishing was excellent.

1951: On the East side: The above remarks apply. One could see large steenbras standing on their heads feeding in shallow water as the tides came in (Kopstanders).

1952: On the West side: There was then a fairly deep channel leading to the sea on this side and the flow was almost as good as the East side openings and the fishing good but this channel has long since silted up due to "middle" openings.

1953: On the West side: The above remarks apply.

1954: On the West side: "

1955: On the East side: Again excellent out- and in-flow and good fishing, etc.

1956: On the East side: Ditto./ N.B. This opening remained open until March of the following year and the flow was so good that galjoen came in with the tide and were caught in large numbers.

1957: In the Middle: This was the start of the "bad openings" and the and eventual silting up of the West side channel damage to the Lagoon. and Only the surface water could run off and the Lagoon could not drain efficiently neither could large fish get in or out. 1958 The Middle opening was deliberately done with the object of obtaining the earliest possible closing of the mouth so that Jeeps etc could be driven across. One man is believed to have been responsible for this.

1957: In the Middle:Yes. This series of "Middle" openings brought about a rapid fall-off in the flow
1958: In the Middle:Yes. of water and scouring effect, an accumulation of weeds, and an almost
1959: In the Middle:Yes. complete lack of worth catching fish. This went on for the next five
1960: In the Middle:Yes. consecutive years until the angling public rose in protest and formed an
1961: In the Middle:Yes. association and pressure was brought to bear to have the lagoon properly
1962: In the Middle:Yes. opened.

1961: In the Middle:Yes.
1962: In the Middle:Yes.

An association was hurriedly formed and a deputation approached Mr Milton the Forestry Officer, and asked him if he wouldn't open the Lagoon either on the East or West side. This he refused to do. The Association then called a meeting and, after much discussion, approached the Government and various bodies concerned with Conservation, inland waters, etc. etc., and a large meeting was held in situ and it was decided that the Lagoon should be opened for five consecutive years on the East side and the matter brought up for review after that period: unfortunately, as it turned out, this was construed by the protagonists of the West side, that this automatically meant that it would be opened there at the expiry of the five years and this was done and proved disastrous.

1963: The East side: The result of this opening exceeded all expectations and the flow was wonderful and the fishing spectacular.

1964: The East side: This was again a good year as were the following three.

1965: The East side:

1966: The East side:

1967: The East side: This was the last of the "good years" for some time and the flow and fishing excellent and lasting until well into April 1968.

1968: On the West side: Having decided that "the East had its turn" it was opened on the West side in spite of warnings that it would not flow and the net result was that only surface water drained off and no big fish could get in and there was practically no scouring effect to remove weeds and rubbish. Only one large fish was caught and the majority were undersize to minute.

1969: On the West side: On the principle that "it will take time to develop" it was opened again on the West side with very much the same result, although an artificial channel had been pre-dug before the Lagoon filled, and the mouth remained open for four weeks, as against one the previous season!!

1970: On the East side: Pressure having been brought to bear, the Lagoon was once more opened on the East side with again spectacular results as to flow and fishing and most people with any real knowledge of the Lagoon were satisfied.

1971: On the East side: This was again a very good opening with similar results to the previous year.

1972: In the Middle: After a great deal of controversy about the East or West side opening and on the excuse that "no one could make up their minds" it was opened in the Middle once more with the result that enormous damage was done and the <u>West side was finally silted up for good</u>. Only surface water was able to escape and no fish of any size were able to enter with the result that people were catching numerous undersized fish.

1973: No opening: For the first time in living memory the winter rains were so poor that the Lagoon never filled up and could not be opened so the position remained static.

1974: In the Middle: It had been hoped that a lesson would have been learned from the 1972 opening but, in spite of this, it was again opened in the Middle and further damage, silting and weeding-up took place and no large fish could get in nor could they get out.

There the position remains and the power still seems to be in the hands of the one man who has the "say" and, in the writer's opinion, unless something is done soon the Lagoon will be ruined for good.

1975: In the Middle: Comments more or less in line with the 1974 opening. Opened 26.9.75 - closed 6.10.75.

1976: In the Middle: Ditto. Opened 21.6.76 - closed 31.12.76.

1977: In the Middle: Ditto. Opened 28.6.77 - closed 10.10.77.

It is believed that this coming opening is of vital importance if the lagoon is to be saved and the weeds washed away, but it is said that it will either be in the middle again, which will lead to the final ruination of the lagoon as a tourist attraction, or on the West side which cannot work owing to the complete sanding up of that old channel. Apart from every aspect of the opening it is a great pity that every year the lagoon is opened long before it is properly full, with the assistance of bull dozers, etc., at the behest of the Standford farmers whose lagoon-side land becomes flooded, and the initial rush of water which would do much to clear the lagoon of weeds and rotting rubbish, is lost.

It is a great pity that the opening of the lagoon is undertaken by people who have little knowledge and less interest in it, or so it would appear.

1978: East side: Opened 5.9.78 - closed 15.1.79. Strong pressure was made by the anglers interested to open the lagoon this year as near to the sand dune in the East as possible. The Forest Officer, Mr Fourie and Mr Eksteen of the Divisional Council were in complete agreement with the above, and the lagoon was opened on September 5th 1978. The result was a great success. A large portion of the man-made dune was washed away and the channel moved more to the East. Angling was excellent, until illegal netters got busy at night and the fish catches tailed off. However, the lagoon remained open until 15th January 1979 leaving a large area of water and excellent yachting was experienced during the summer. The general feeling is that the lagoon should be left for nature to open it but failing this the next opening should be right next to the sand dune which will eventually lead to the opening being opposite the old and deep channel running in front of Winter Bay towards the Foresters' Jetty and which <u>never silts up</u>.

1979: On the East side: Opened 24.7.79 - closed 22.3.80. As in 1978 it was agreed by the Divisional Council (Rep.) and the Forestry Officer that the openings be made next to the artificial man-made sand dune and this operation was a complete success. Many "old timers" stated that it was many years since such a rush of outgoing water had been seen, taking with it debri of all sorts which had accumulated in the lagoon.

Many metres of the artificial dune were washed away enabling the original Eastern channel to have a more direct route to the sea and so bringing the opening back to the way nature had made it many many years ago. The fact that the mouth remained open for nearly eight months during which excellent angling was experienced, plus first class yachting in the lagoon, more than justified the Easterly opening.

It is understood that the 1980 opening will be in the same position as 1979 which should guarantee another successful operation.

1980: East side: The lagoon remained closed for seven months and on the <u>11th & 16th of March 1980</u> two unsuccessful attempts were made to open it but it appeared that it was not full enough for the volume of water to really get going on its outward rush and it closed on its own on <u>March 22nd 1980</u>. It remained closed until November 18th when another attempt was made to open it, this proved partially successful & it remained open until January 12th 1981 when it closed on its own accord through lack of sufficient rain.

1981: East side:

Between January 13th & February 7th 192 mm of rain fell and the lagoon became fuller than it has been for decades. The result was that Popa Eksteen, the Divisional Council Representative & a couple of labourers were able to open the bar with spades on February 7th. This opening proved to be another 'clean out' of the lagoon, and at the time of writing this record June 14th it is still open and running strongly from spring tide to spring tide. An excellent feature of this last opening is that the 'man made' dune on the East side of the mouth has been scoured away by some 50 or more meters, it means that nature has taken a hand again removing a lot of this dune which has been blocking the main channel ever since the Forestry Dept, consolidated the sand dunes all along the Plaat, too near the sea, some 10-15 years ago. Angling has been good but mostly small to medium sized White Steenbras plus elf and leervis in reasonable quantities. Unfortunately the local conservation officer resigned and plans are being made to replace him. In the meantime illegal trekkers are 'having a ball' and greatly disturbing the fish life.

Just prior to the end of June 1981 very heavy seas and swells were experienced caused by a SW Gale and vast quantities of sand was washed into the mouth of the lagoon with the result that a sand bar was formed and the mouth closed on June 27th. During the following spring tides a large volume of water poured over the sand bar and the level of the lagoon was raised quite a lot. Our rainy season is now upon us and the lagoon should fill rapidly. A new Nature Conservation Officer was appointed at the beginning of July 1981. 85 mm of rain fell during the first 12 days of July and the lagoon is just about full.

OPENINGS

1981: East side:

Owing to excellent rains during July (126 mm) the Divisional Council opened the Lagoon on the 25th July, 1981, and made an excellent job indeed. Further inroads were made by the strong volume of water rushing out on the man made dunes (Forestry Department) and many more metres disappeared. The result is that the original deep channel running across the front of Winter Bay has improved its outlet to the sea. This channel is now more in line with what is was some 50 years ago and is still running strongly in between tidal movements. After nearly nine months the Lagoon mouth closed naturally on April 18th 1982. During this period the Lagoon water was being refreshed every day with tidal sea water, and it remained clean and healthy right through the summer season. There was easy access to Die Mond by holiday makers and the general public. Angling was excellent and full scope was available for yachting.

August 23rd 1982. The Lagoon was closed for four months and was over three-quarters full. Another 50-60 mm of rain would have made it ready for opening again. It is hoped by those who have studied the Lagoon for many years, that an opening will be made on the eastern side again to ensure a repeat of the successful openings during the last four years.

1982: West side:

Alas, in spite of all the most satisfactory openings in the East in recent years, the Department of Nature and Environmental Conservation decided to open the mouth on the west side. This was carried out on September 4th,

1982. The Lagoon had been closed for four months and the latest opening only lasted for one month. A very weak outflow took place and compared to the easterly opening, much weed, bushes etc. were left in the Lagoon. In the eastern openings all this rubbish was usually washed out to sea. Many years ago, successful openings were made from the middle and west sides, but since the sand dunes all along Die Plaat were stabilised too close to the sea some 15 years ago by the Forestry Department, the level of the sand over Die Mond is much higher than it was. This movement of sand from Die Plaat, caused by a westerly drift, has silted up most of the popular fishing spots by covering up the black mussels, worms red bait etc., which most fish feed upon.

The Forestry Department have agreed, through their representative, that when and as the sea erodes the consolidation, re-consolidation will only take place further inland out of reach of the sea. During the late 1930's there were no dunes next to the sea along Die Plaat and the beach was flat all along, past Soupie's Klip and beyond. The Lagoon has now been closed for four months, but due to evaporation, lack of rain and mainly due to the fact that the Lagoon is not tidal, the level has not been so low for many, many years. Certain areas of the water are becoming stale and smelly and there is a general feeling that when the rains come the salinity of the water will be affected, causing fish to die, as in Lake Marina.

It has been observed that now the sand level is so high (near the sea) even spring tides and rough seas very rarely wash over into the Lagoon, as in previous years. This means that very little water overflows from the sea into the Lagoon.

APPENDIX VIII: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: KLEINRIVIERSVLEI

Guide to available information			Acocks	Ashton	Bally	Bennett	Boucher and McDonald	Branch	Branch et al	Broadley	Brooke	Bulpin	Burman	Cape of Good Hope	Carter and Brownlie	Christie	Coetzee and Pool	Cooper	Crowther	CSIR
YEAR (DATE OF INFORMATION)			1975	1945	1985	1985	1982	1985	1988	1983	1984	1980	1970	1977	1989	1981	1986	1976	1987	1988
MANAGEMENT		Historical			*							*	*							
MANAGEMENT		Conservation/Utilization						*												
MANAGEMENT		Management/Planning						*												*
MANAGEMENT		Legislation												*						
MANAGEMENT		Water																		
BIOTIC		Food webs/Ecosystems																		
BIOTIC	Fauna	Mammals																		
BIOTIC	Fauna	Birds		*							*							*		
BIOTIC	Fauna	Reptiles							*	*										
BIOTIC	Fauna	Amphibians							*											
BIOTIC	Fauna	Fish				*														
BIOTIC	Fauna	Molluscs																		
BIOTIC	Fauna	Crustaceans																		
BIOTIC	Fauna	Other aquatic invertebrates																		
BIOTIC	Fauna	Terrestrial invertebrates																		
BIOTIC	Fauna	Zooplankton																		
BIOTIC	Flora	Terrestrial vegetation	*				*													
BIOTIC	Flora	Semi-aquatic vegetation																		
BIOTIC	Flora	Aquatic vegetation																		
BIOTIC	Flora	Algae														*				
BIOTIC	Flora	Phytoplankton													*					
BIOTIC		Microbiology																		
ABIOTIC	Chemistry	Pollution																		
ABIOTIC	Chemistry	Eutrophication																		
ABIOTIC	Chemistry	General Chemistry													*		*			
ABIOTIC		Salinity															*			
ABIOTIC	Physics	Circulation and mixing															*			*
ABIOTIC	Physics	Hydrology / Flood regime																	*	*
ABIOTIC	Physics	Oceanography																		
ABIOTIC	Physics	Climate																		
ABIOTIC	Geology	Sedimentology																		*
ABIOTIC	Geology	Palaeoenvironment																		
ABIOTIC	Geology	Geology																		
ABIOTIC	Physiography	Morphology																		
ABIOTIC	Physiography	Dams/Obstructions																		
ABIOTIC	Physiography	Catchment characteristics																		

Sources of information

APPENDIX VIII: (Cont)

ESTUARY / RIVERMOUTH / LAGOON: KLEINRIVIERSVLEI

Guide to available information

Group	Subgroup	Item	CSIR 1989	Day 1967	Day 1981	De Decker and Bally 1985	Du Plessis 1988	Duvenage 1983	Fortuin in prep.	Greig et al. 1979	Greig and Burdett 1976	Grindley 1957	Grindley 1965	Grobler and Silberbauer 1984	Heinecken and Damstra 1983	Heydorn 1986	Heydorn 1980	Heydorn and Tinley 1989	King et al. 1985	Maclean 1906	Marloth
MANAGEMENT		Historical																			*
		Conservation/Utilization														*					
		Management/Planning													*		*				
		Legislation																			
		Water																			
BIOTIC		Food webs/Ecosystems															*				
	Fauna	Mammals		*	*																
		Birds																	*		
		Reptiles									*										
		Amphibians								*											
		Fish																			
		Molluscs				*															
		Crustaceans				*															
		Other aquatic invertebrates				*						*	*								
		Terrestrial invertebrates										*	*								
		Zooplankton																			
	Flora	Terrestrial vegetation																			
		Semi-aquatic vegetation					*														
		Aquatic vegetation																			
		Algae																			
		Phytoplankton																			
		Microbiology																			
ABIOTIC	Chemistry	Pollution	*															*			
		Eutrophication	*											*				*			
		General Chemistry																			
		Salinity																			
	Physics	Circulation and mixing																			
		Hydrology / Flood regime																			
		Oceanography																			
		Climate																			
	Geology	Sedimentology							*						*						
		Palaeoenvironment																			
		Geology																			
	Physiography	Morphology						*													
		Dams/Obstructions																			
		Catchment characteristics																			

Note: Sources of information (with YEAR (DATE OF INFORMATION)): CSIR 1989; Day 1967; Day 1981; De Decker and Bally 1985; Du Plessis 1988; Duvenage 1983; Fortuin in prep.; Greig et al. 1979; Greig and Burdett 1976; Grindley 1957; Grindley 1965; Grobler and Silberbauer 1984; Heinecken and Damstra 1983; Heydorn 1986; Heydorn 1980; Heydorn and Tinley 1989; King et al. 1985; Maclean 1906; Marloth.

APPENDIX VIII: (Cont)

ESTUARY / RIVERMOUTH / LAGOON: KLEINRIVIERSVLEI

Guide to available information / Sources of information	Midgley and Pitman	Moll et al.	Morant and Grindley	Noble and Hemens	Pierce	Pitman et al.	Poynton	Ryan et al.	Schloms et al.	Scott et al.	Siegfried et al.	Sloman	Smithers	Stuart	Stuart et al.	Summers et al.	Swart	Talbot
YEAR (DATE OF INFORMATION)	1969	1984	1982	1978	1983	1981	1964	1988	1983	1952	1976	1983	1986	1981	1980	1977	1986	1955
MANAGEMENT – Historical																		
MANAGEMENT – Conservation/Utilization																		
MANAGEMENT – Management/Planning			*															
MANAGEMENT – Legislation																		
MANAGEMENT – Water																		
BIOTIC – Food webs/Ecosystems										*								
BIOTIC – Fauna – Mammals													*	*	*			
BIOTIC – Fauna – Birds								*			*					*		
BIOTIC – Fauna – Reptiles																		
BIOTIC – Fauna – Amphibians							*											
BIOTIC – Fauna – Fish																		*
BIOTIC – Fauna – Molluscs										*								
BIOTIC – Fauna – Crustaceans										*								
BIOTIC – Fauna – Other aquatic invertebrates										*								
BIOTIC – Fauna – Terrestrial invertebrates																		
BIOTIC – Fauna – Zooplankton																		
BIOTIC – Flora – Terrestrial vegetation		*																
BIOTIC – Flora – Semi-aquatic vegetation										*								
BIOTIC – Flora – Aquatic vegetation			*		*					*								
BIOTIC – Flora – Algae																		
BIOTIC – Flora – Phytoplankton																		
BIOTIC – Microbiology																		
ABIOTIC – Chemistry – Pollution																		
ABIOTIC – Chemistry – Eutrophication																		
ABIOTIC – Chemistry – General Chemistry																		
ABIOTIC – Salinity																		
ABIOTIC – Physics – Circulation and mixing																		
ABIOTIC – Physics – Hydrology / Flood regime	*			*		*												
ABIOTIC – Physics – Oceanography																		
ABIOTIC – Physics – Climate																		
ABIOTIC – Geology – Sedimentology												*					*	
ABIOTIC – Geology – Palaeoenvironment																		
ABIOTIC – Geology – Geology									*			*						
ABIOTIC – Physiography – Morphology										*								
ABIOTIC – Physiography – Dams/Obstructions																		
ABIOTIC – Physiography – Catchment characteristics						*			*									

APPENDIX VIII: (Cont)

ESTUARY / RIVERMOUTH / LAGOON: KLEINRIVIERSVLEI

Group	Subgroup	Guide to available information	Taljaard	Theron et al.	Tredgold	Truter and Partner	Van der Merwe	Van Heerden	Waldron	Walsh
MANAGEMENT		Historical	*		*				*	
		Conservation/Utilization								
		Management/Planning							*	
		Legislation								
		Water							*	
BIOTIC		Food webs/Ecosystems								
	Fauna	Mammals								
		Birds								
		Reptiles								
		Amphibians								
		Fish								
		Molluscs								
		Crustaceans								
		Other aquatic invertebrates								
		Terrestrial invertebrates								
		Zooplankton								
	Flora	Terrestrial vegetation								
		Semi-aquatic vegetation								
		Aquatic vegetation								
		Algae								
		Phytoplankton								
		Microbiology								
ABIOTIC	Chemistry	Pollution								
		Eutrophication								
		General Chemistry								
		Salinity				*				
	Physics	Circulation and mixing				*			*	
		Hydrology / Flood regime							*	
		Oceanography								
		Climate								
	Geology	Sedimentology		*				*		*
		Palaeoenvironment								*
		Geology								
	Physiography	Morphology					*		*	
		Dams/Obstructions								
		Catchment characteristics								*
YEAR (DATE OF INFORMATION)			1949	1981	1965	1954	1988	1985	1986	1968
Sources of information			Taljaard	Theron et al.	Tredgold	Truter and Partner	Van der Merwe	Van Heerden	Waldron	Walsh

NOTES

PLATE I: Mouth of Kleinrivier Estuary (79-10-16)

PLATE II: The Kleinrivier as it enters the vlei. Note the silt-laden river and the extensive wetlands (89-08-06)

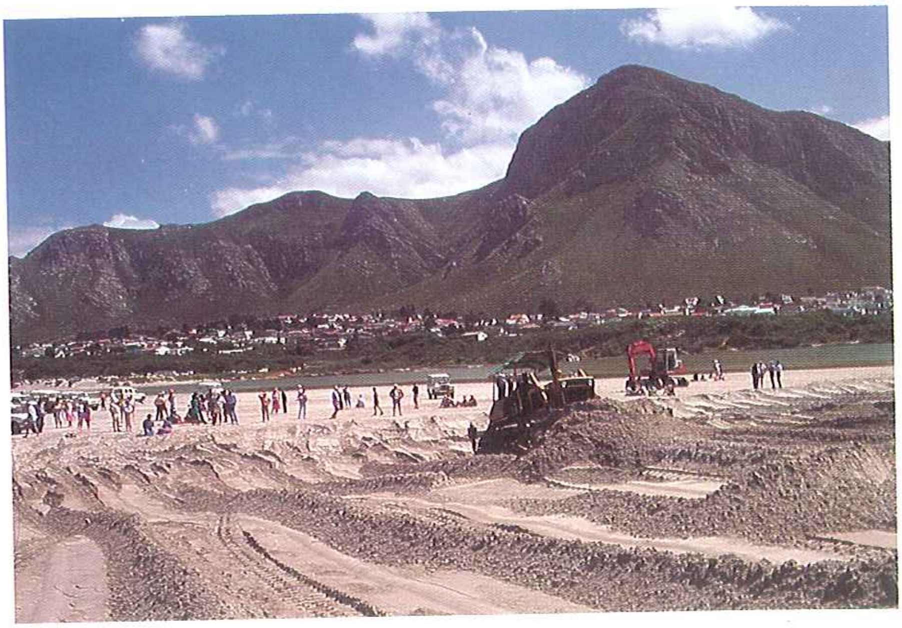

PLATE III: Excavations in preparation for the artificial breaching (88-11-09)