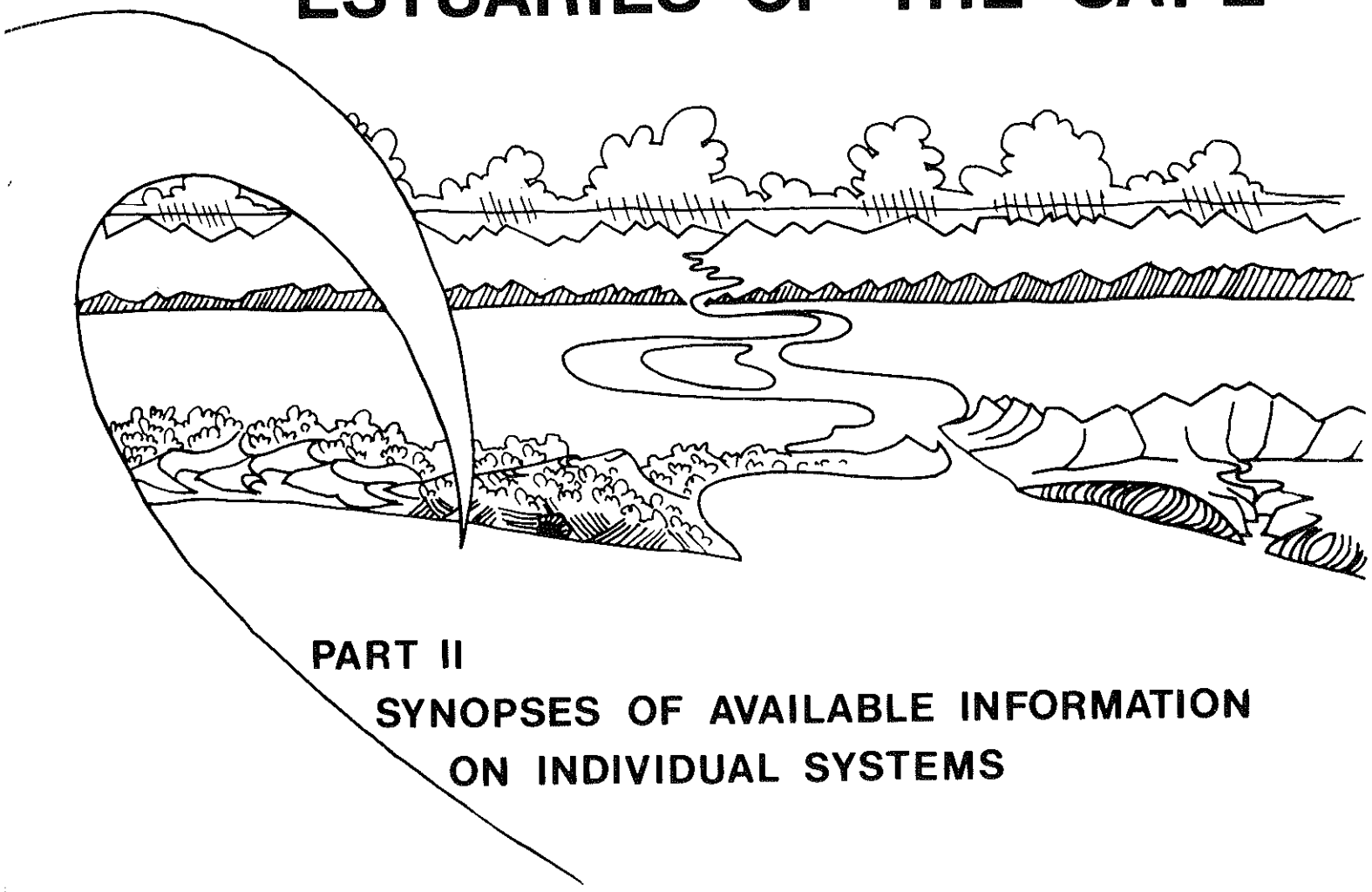
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 32

VERLORENVLEI (CW 13)

CSIR RESEARCH REPORT 431

Stellenbosch, South Africa
December 1986

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
A E F HEYDORN and P D MORANT
National Research Institute for Oceanology, CSIR, Stellenbosch

FRONTISPIECE: VERLORENVLEI – ALT. 450 m, ECRU 79-04-17

REPORT NO. 32: VERLORENVLEI (CW 13)

BY: S A SINCLAIR*, S B LANE** AND J R GRINDLEY***

*DEPARTMENT OF NATURE CONSERVATION, FORESTRY FACULTY,
UNIVERSITY OF STELLENBOSCH
**CHIEF DIRECTORATE OF ENVIRONMENTAL CONSERVATION, DEPARTMENT
OF ENVIRONMENT AFFAIRS, CAPE TOWN
***DEPARTMENT OF ENVIRONMENTAL AND GEOGRAPHICAL SCIENCE,
UNIVERSITY OF CAPE TOWN

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

CSIR RESEARCH REPORT 431

Stellenbosch, South Africa
December 1986

ISBN 0 7988 1812 3
ISBN 0 7988 1813 1
ISBN 0 7988 3503 6

Published in 1986 by:

National Research Institute for Oceanology
Council for Scientific and Industrial Research
P O Box 320, Stellenbosch, 7600

Printed by:

Associated Printing & Publishing Co. (Pty) Ltd, Cape Town

When citing this document in a bibliography, the reference should be as follows:

SINCLAIR, S A, LANE, S B and GRINDLEY, J R (1986). Estuaries of the Cape : Part II: Synopses of available information on individual systems. Rep. no. 32 Verlorenvlei (CW 13). Heydorn, A E F and Morant, P D (eds.). Stellenbosch, *CSIR Research Rep.* 431.

PREFACE

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

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

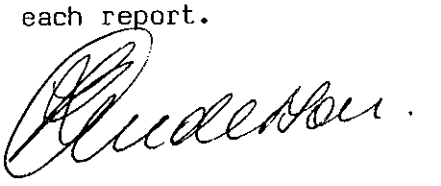
The Unit was established at the request of the Government, and the Department of Environment Affairs contributes substantially to the running costs.

In 1980 the Unit published its first report under the title "Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley, CSIR Research Report 380). As the name of the report implies, it is an overview of the Cape Coast dealing with aspects such as climate, geology, soils, catchments, run-off, vegetation, oceanography, and of course, estuaries. At the specific request of the Government, the report includes preliminary management recommendations.

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

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

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



F P ANDERSON
CHIEF DIRECTOR

National Research Institute for Oceanology, CSIR

CONTENTS

FIGURES

TABLES

APPENDICES

PLATES

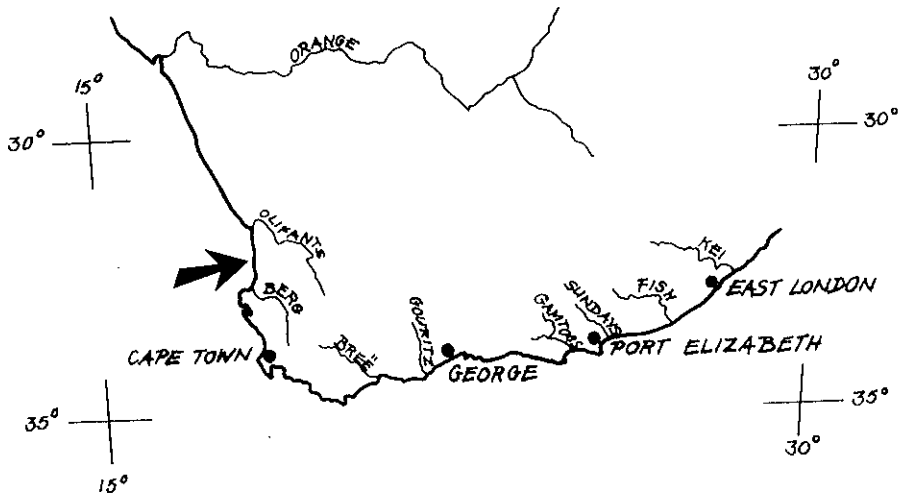
LIST OF REPORTS PUBLISHED BY ECRU - Inside back cover

VERLORENVLEI

1. LOCATION

Position of mouth 32°19′S; 18°21′E.

Verlorenvlei lies along the Atlantic coast of the south-western Cape, 180 km north of Cape Town, between Elandsbaai and Redelinghuys. The vlei is aligned in a northwest/southeast direction, at 45° to the predominantly north/south coastline. It lies between latitudes 32°19′ and 32°23′ south, and longitudes 18°20′ and 18°28′ east. Its catchment lies between 32°15′ and 32°51′ south and 18°20′ and 19°04′ east. Relevant 1:50 000 topographical map sheets are 3218 AD Elandsbaai and 3218 BC Redelinghuys.



1.1 Accessibility

From Cape Town, Verlorenvlei is accessible via Piketberg, Het Kruis, and along an untarred road on the northern bank of the vlei, past Redelinghuys to Elandsbaai at the coast (Figure 1). A more direct route is the N11, running from Milnerton through Velddrif to Dwarskersbos, beyond which the road is not yet tarred. This road runs directly into the Verlorenvlei farm settlement on the southern bank of the vlei. The road then runs westwards along the southern bank, crosses the vlei at a causeway, and links with the north-bank road into Elandsbaai.

Access from the north is via an untarred road, southwards from Lambert's Bay to Leipoldtville, and thence to the northern bank of the vlei at Bonteheuwel farm, to where the road links with the north-bank road from Het Kruis. An alternative route runs from Clanwilliam to Het Kruis, and then along the north-bank road to Elandsbaai.

From the causeway that crosses the vlei near the coast, an untarred road runs along the southern bank and around Baboon Point also known as Cape Deseada (Africa Pilot, 1977). This untarred road provides access to the crayfish factories at the Point, and previously extended southwards to Velddrif, but has been closed to the public since the construction of the Sishen/Saldanha railway line.

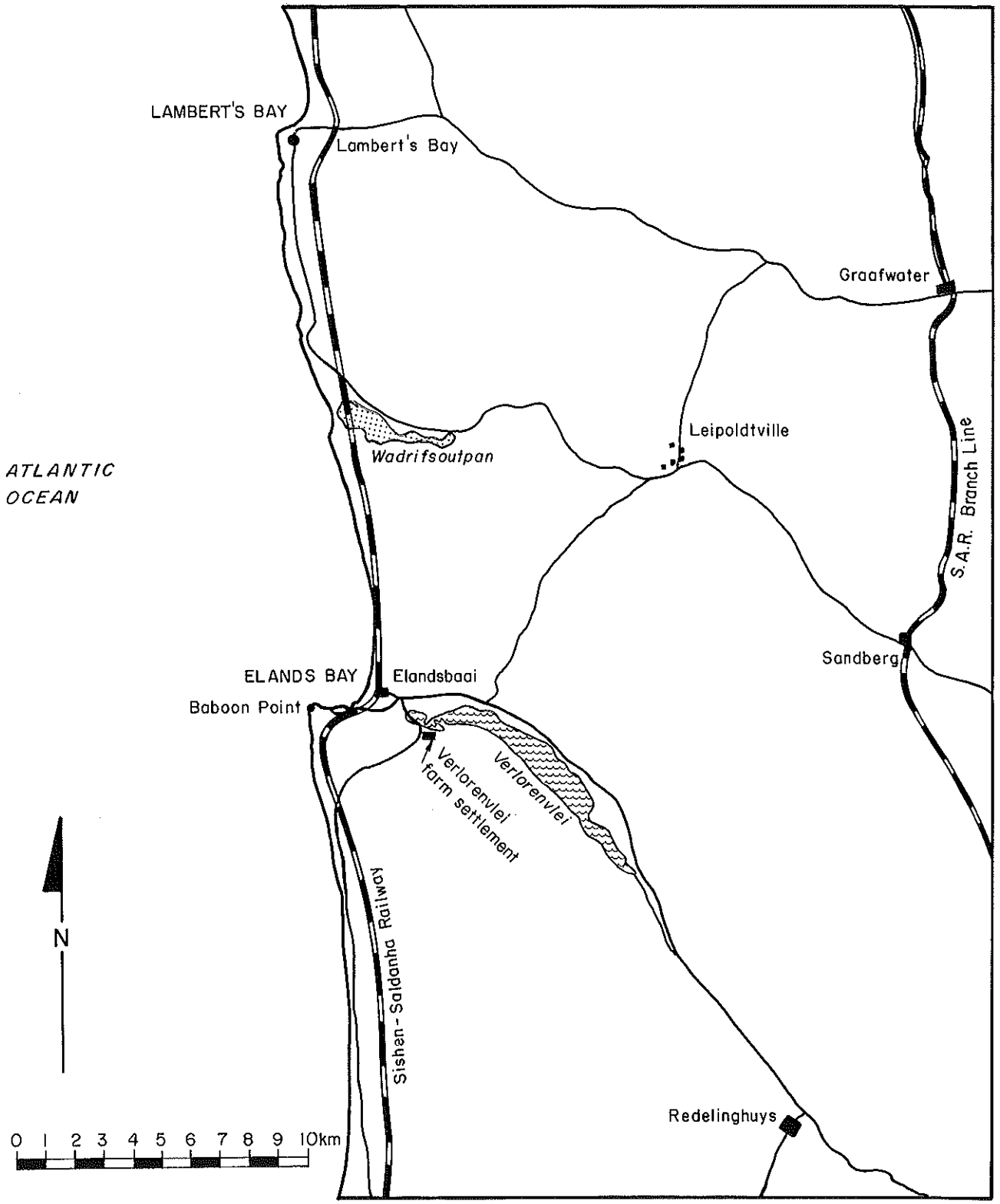


Fig. 1: Location of Verlorenvlei and the main access routes

The existing routes therefore make the entire northern bank of the vlei, and the south-western bank, relatively accessible. A limitation to access is that the vlei is surrounded by private property, and permission for entry must be sought from the landowners. Parts of the southern bank east of the Verlorenvlei farm settlement are accessible on private farm roads, with a four-wheel-drive vehicle being necessary at times, while other parts are accessible only on foot.

The driftsand area to the north of Elandsbaai is administered by the Directorate of Forestry, and permission for entry is required from the resident forestry officer.

There are long-standing plans for the extension of the tarred west coast national road northwards from Velddrif to the Verlorenvlei area. These plans have been delayed by the present economic situation, but the proposed alignment of the road is important to the future of this area. The potential for negative impacts justifies the requirement of an environmental and social impact assessment before any planning is finalised.

1.2 State, Provincial and Local Authorities

At the local authority level, jurisdiction over the catchment is divided between the Divisional Councils of Cedarberg to the north and Swartland to the south but the estuary itself lies entirely within the jurisdiction of the Swartland DC.

The Surveyor General's noting sheet 4480, CH-3BC, shows a strip of State-owned land (Admiralty Reserve) adjoining the high water mark and extending from Baboon Point northwards along the coast and along the southern bank of the estuary eastwards within the boundary of the Elandsbaai Local Area (Proclamation 17 of 1969). In addition the State owns an adjoining three-hectare erf at Baboon Point and a nine-hectare erf, designated Outspan, immediately west of the estuary mouth. North of the estuary mouth the Admiralty Reserve is restricted to the coastline. The strips to the north and south vary in width, from about 71 m to 39 m respectively.

A number of other authorities have jurisdiction over various activities in the estuary and along the coast:

- The Department of Water Affairs controls extraction of water, effluent inflow and degradation of water quality, and activities which modify water courses.

- The Department of Agriculture controls the use of the water for agricultural purposes, and its application to land for agricultural activities.

- The State-owned land mentioned above falls under the jurisdiction of the Department of Public Works and Land Affairs which administers it in terms of the Disposal of State Land Act No. 48 of 1961. The department is also responsible for the land underlying Verlorenvlei itself and the estuary. The Verlorenvlei Estuary has been described by the Surveyor General as being a non-tidal river in terms of the Sea Shore Act, No. 21 of 1935. This decision was made on the grounds that no (regular) rise and fall of the water level takes place as a result of the action of the tides, this being prevented by the rock sill at the first causeway approximately 500 m from the mouth. This description affects the legal and administrative position with regard to the estuary as it excludes all but the 500 m section closest to the sea from the jurisdiction of the Department of Environment Affairs which already covers the land and sea from the high water mark to the 12 nautical mile limit, that is, the intertidal zone and territorial waters*. Consequently management and control of activities affecting the coastal environment at Verlorenvlei is divided between two State departments with very different functions and philosophies.

NOTE: New Regulations in terms of the Environmental Conservation Act, No. 100 of 1982, were promulgated in the Government Gazette of 12 December 1986. These regulations provide for activities within 1 000 m from the high-water mark to be subject to the Administrator's or Minister's approval.

- The Department of Environment Affairs also has jurisdiction over the biota in the same area (high water mark to the 12 nautical mile limit) in terms of the Sea Fisheries Act, No. 58 of 1973, and the Sea Birds and Seals Protection Act, No. 46 of 1973. These acts are administered by the Marine Control Directorate of the Department of Environment Affairs. A local Sea Fisheries officer is stationed in Elandsbaai.

- The Cape Provincial Administration's Department of Local Government is responsible for all development planning, and applications relating to private land, excluding agricultural and mining activities.

- The Cape Provincial Department of Nature and Environmental Conservation has been delegated responsibility for the biota in the estuary in terms of the Sea Fisheries Act and assumes control through Ordinance No. 19 of 1974. The nearest conservator is stationed at Rocher Pan, to the south.

- The Elandsbaai Local Area Board participates in the administration of the local area.

As is evident from the above outline, there are many departments involved in administering the various activities which can affect the Verlorenvlei, its estuary and environs. The current situation does not render coastal management in the region as effective as it might be. However, the situation is being reviewed on a national basis by the Department of Environment Affairs and the Committee for Coastal and Marine systems of the Council for the Environment.

Robertson (1980) reported that the Divisional Council was planning to develop a holiday resort near Baboon Point. A 'Place of Public Resort' is demarcated on Map 3218 AD, and can be seen on diagram 374/1837 (Figure 2) as 'Govt land reserved for persons coming to fish.' On the Surveyor General's noting sheet 44180, CH-3BC, this area is shown as Elands Bay Outspan, but the description is deleted. The Divisional Council requested the National Research Institute for Oceanology of the CSIR to provide some indication of a suitable area for a camping/caravan park somewhere in the vicinity (Heinecken and Badenhorst, 1985).

The land around the vlei is privately-owned, and a list of landowners has been compiled (Burgers, 1980). The driftsands are on State Land, which is administered by the Forestry Directorate of the Department of Environment Affairs.

As with all natural areas in South Africa, man-made jurisdictional boundaries at Verlorenvlei do not coincide with natural ecosystem boundaries, leading to divided and confused control, artificial dissection and disruption, and administration by authorities who do not always have the necessary ecological expertise.

In their advisory and co-ordinating role the Chief Directorate of Environmental Conservation of the Department of Environment Affairs is required to motivate the controlling authorities to apply the necessary expertise to optimally manage such sensitive areas. Despite this, detrimental activities are still occurring, such as the interference with the flow regime in the estuary by blocking the culverts in the lower causeway, and the siting of an electricity supply pole in the centre of an historic threshing floor in the Verlorenvlei settement (Figure 3).

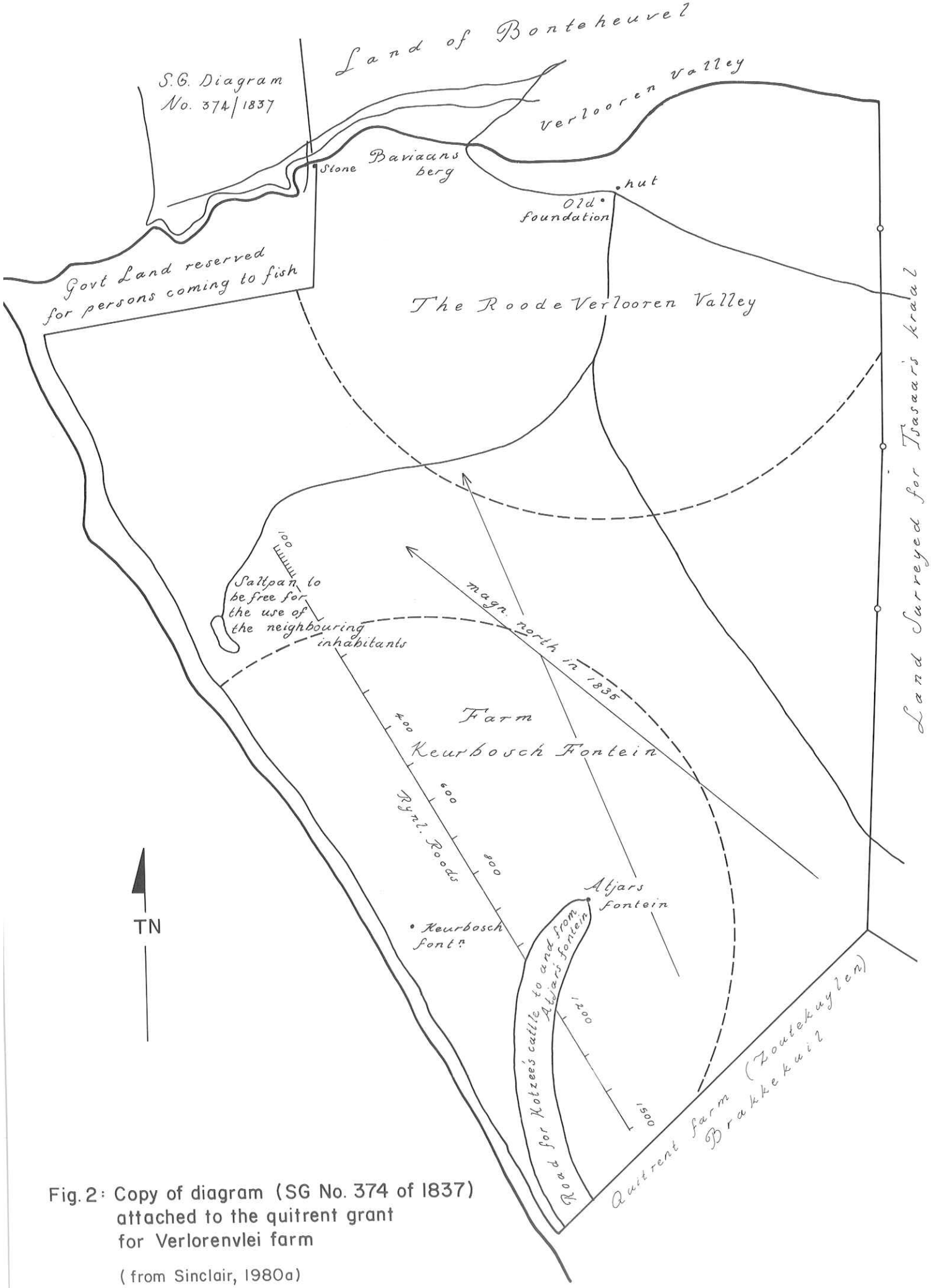


Fig. 2: Copy of diagram (SG No. 374 of 1837) attached to the quitrent grant for Verlorenvlei farm

(from Sinclair, 1980a)

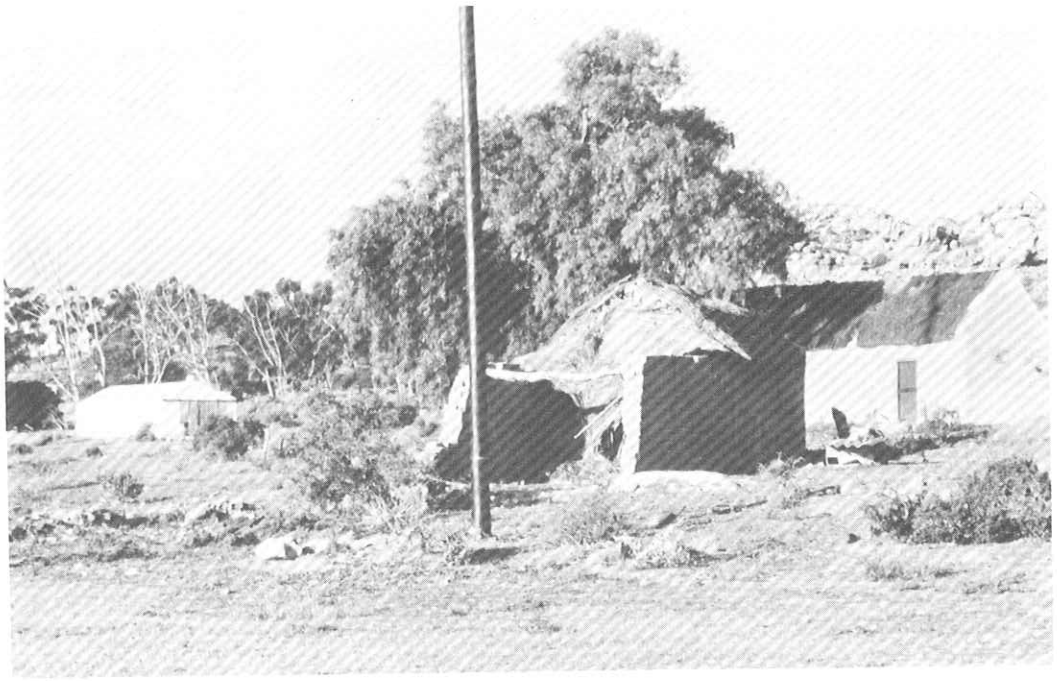


FIG. 3: Powerline support erected in centre of threshing floor. (Photo: S A Sinclair, May 1985).

2. HISTORICAL BACKGROUND

2.1 Synonyms and Derivations

Historical references to the Verlorenvlei area were compiled by Sinclair (1980a) to whom the reader should refer for the full bibliographic citations of these early publications. Olaf Bergh (1682 and 1683) named the river that feeds the coastal lake "de Zeekoe valeij off de Sandtrivier", which can be translated into Afrikaans as "die Seekoeivallei of die Sandrivier". Van der Stel's journal account of his expedition to the Copper Mountain in Namaqualand (1685 and 1686) refers to what may have been the Verlorenvlei area as "Zeekoejen-valey". Starrenburg (1704) used the Hottentot name of Quaecoma River. This name might be derived from the Hottentot meaning 'large water', or the Bushman meaning 'lonely/lost pan/vlei'.

Rhenius in 1724 was the first to use the name "Verloren Vallei". Thunberg (1774) used "Verloren-valley", while Paterson (1777-8) spoke of "Verloren Valley or Lost Valley". Le Vaillant (1783) gave the meaning of "Verloore-Valey" as lost lake, while Barrow (1797) translated "the Verloren valley" as "Forlorn Lake". Barnard (1800) visited the "Verloorn Valley", while Lichtenstein (1803) spoke of "a pretty large lake, which has the name of the Lost-valley". The name in its earlier form may have meant a lost or forlorn lake or valley (Sinclair, 1980a).

At present, the area is known as Verlorenvlei, Verlorevlei or Vloorvlei by people living outside the area. Local inhabitants call it Verlorevlei, the 'o' being lengthened, and the 'r' being pronounced with what is known as the Malmesbury 'brei', or palatalisation of the 'r' common to Afrikaans spoken on the Cape west coast. On the 1:50 000 topographical map (3218 AD Elandsbaai), the coastal lake and the settlement are Verlorevlei, but on the same map the original farm on which the settlement is situated is called Verlorenvlei. The most recent form of the name for the farm in the deeds of ownership is Verlorenvlei (Sinclair, 1980a).

The form with the 'n' retains its association with the original Dutch, while the form without the 'n' is the Afrikaans version. While it is usual to adopt the 1:50 000 topographical map name for a river or estuary within this series of reports, a number of researchers working in the area have used, and still use, the name 'Verlorenvlei' (Grindley, 1979; Lane, 1980; Robertson, 1980; Sinclair, 1980a; Burgers, 1980), although others use 'Verlore Vlei' (Parkington, 1980 and Van Ryssen, 1984). For consistency within this report, 'Verlorenvlei' is used to refer to the river, estuary, coastal lake, farm settlement and general area.

Alternative forms exist for various place names in the area. Some of the alternatives are more archaic forms, or derive from English and Afrikaans versions of the same name. For example, 'Piketberg' may appear as 'Piquetberg', 'Redelinghuys' as 'Redelinghuis', or 'Elandsbaai' as 'Elands Bay'. In the case of the last-mentioned, for the purposes of this report, 'Elandsbaai' has been used to refer to the town, and 'Elands Bay' to the bay.

2.2 Historical Aspects

Since 1655, a number of early travellers along the Cape west coast passed through the Verlorenvlei area, but some merely crossed the river inland, and did not venture along the vlei towards the sea. The travellers included Bergh in 1682 and 1683, Van der Stel in 1685, Thunberg in 1774, Le Vaillant during 1783-1785, Barrow in 1797, and Barnard in 1800.

In the early 1700s, loan places were granted to holders for the purpose of grazing. They were paid for partially by the delivery of one tenth of the annual wheat harvest to the Dutch East India Company. This evidence indicates that both grazing and wheat cultivation have been conducted in the Verlorenvlei area for almost three hundred years. The farm, Klaarfontein, was already held as a loan place in 1717 (Burger, 1975).

Four main series of loan place allocations have been traced (Sinclair, 1980a), each covering thirty- to sixty-year periods, and forming part of the record of land use prior to 1795, when the British abandoned the system of loan places in favour of perpetual quitrent tenure.

During the first half of the nineteenth century, most of the farms in the area were occupied, but the development process was slow (Burger, 1975). Settlement concentrations built up on Verlorenvlei farm, at Redelinghuys, and at Elandsbaai. Aspects of the development of school, church and community in Redelinghuys and Elandsbaai have been described by Burger, but detailed reference to sources is not included.

In 1857, the Piketberg Divisional Council took over responsibility for the area of Elandsbaai, where fishing was initially the main attraction for establishment. Burger (1975) outlines the growth of the West coast crayfish industry, including its development at Elandsbaai (Figure 4). The Elandsbaai crayfish fishery was established in 1946 and there are four factories on the southern shore of the bay (South African Sailing Directions, 1979). These factories freeze crayfish tails and one has facilities for handling live crayfish for export.

A detailed investigation of land ownership and land use since the 1830s for the Verlorenvlei farm on the southern bank of the coastal lake (Figure 5), has been conducted (Sinclair, 1980a). The rural settlement on this farm is situated 5 km inland from the coast. Approximately 25 houses, built at different stages in the development of the settlement, are grouped on either side of a boundary fence and an unoccupied sandy depression. Some of the houses are no longer

occupied, and have fallen into a state of disrepair or ruin, or have been converted for other uses. In the occupied houses live the few people that now make up the settlement community, all of them related to one another, by virtue of their membership of two families that have been associated with the area at

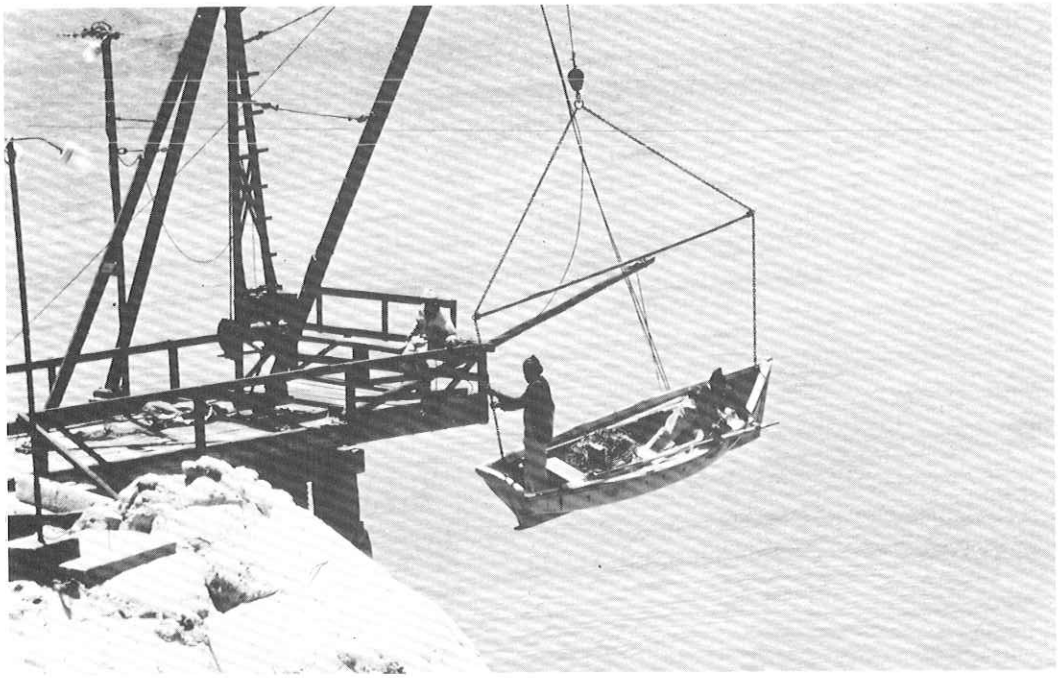


FIG. 4: Crayfish boat being hoisted at the crayfish factory, Baboon Point. (Photo: P D Morant, November 1977)

least since the beginning of the eighteenth century. Most members of the present community are middle-aged or elderly, with few children or young adults to regenerate what must once have been a growing population.

The settlement has been mapped in detail by a team of student engineer-surveyors from the University of Cape Town (Figure 6). A classification system has been developed whereby every man-made feature has been numbered, photographed, and described (Sinclair, 1980a). The historically significant features, including the horsemills used for flour-milling, have been recorded by a team of student architects and other researchers (Walton, 1974; University of Cape Town, 1980; Holtrop, 1981a; Sinclair and Holtrop, 1982 and Sinclair, 1985). A complete record of the status of this settlement as at 1979/80 therefore exists, and has provided a baseline for future historical research and conservation measures.

Some analysis of environmental factors leading to decay of the man-made features in this historically- and culturally-significant settlement has been carried out (Holtrop, 1981b). An annual update of the photographic record of the state of the settlement has been maintained from 1980 to the present (Sinclair, 1985). This visual record illustrates the severe degradation of an historical conservation resource that has taken place through failure to take timely conservation action.

2.3 Archaeology

(This section was contributed by W J J van Ryssen, Archaeological Data Recording Centre, South African Museum, Cape Town).

A number of archaeological sites have been, and are being, worked in the Verlorenvlei area. The exact location of these sites has not been publicised, in order to protect them from vandalism, but a general distribution map of the important archaeological areas has been compiled.

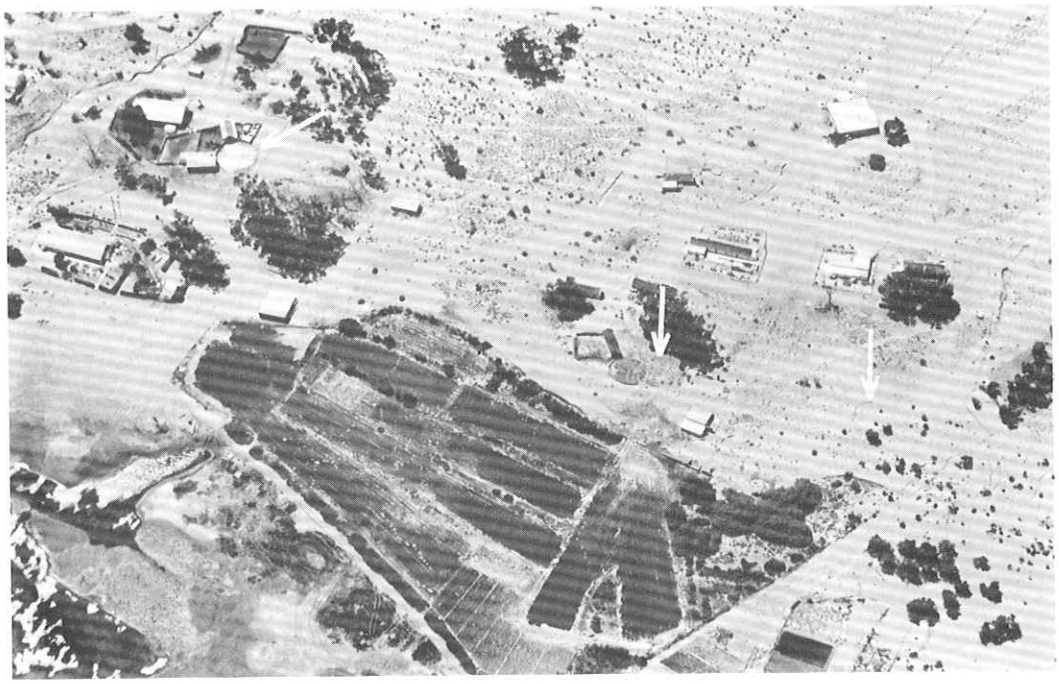


FIG. 5: Aerial photograph showing Smit section of Verlorenvlei farm settlement, with three threshing floors indicated. (Photo: S B Lane, 1979).

Important localities which must enjoy protection in any future planning for Verlorenvlei are:

- Baboon Point, including the Elands Bay Cave, which is particularly vulnerable because of its visibility. Baboon Point (32°19'S, 18°19'E), also known as Cape Deseada (Africa Pilot (1977) and South African Sailing Directions (1979)), has important historical associations which further justify its protection;

- The Diepkloof/Witklip/Grootdrif complex, including caves and rock-art sites;

- Two series of shell middens, one extending along the coast southwards from the river mouth and the other northwards.

Two major types of archaeological site occur at Verlorenvlei:

(a) Cave sites where, because of the containment by the cave walls, the occupation debris is concentrated in stratified layers;

(b) Open sites, where the archaeological material may be concentrated in some shell middens, or thinly scattered amongst sand-dunes or in scrubland.

From archaeological investigations, Parkington (1976b) concludes that the location of shell midden heaps reflects the location of settlement, and that the extensive but superficial surface scatters seem to represent forays to exploit the particular resources of each area.

Fig. 6: Verlorenvlei settlement
(Survey, November 1979; from Sinclair, 1980a)
The house numbers refer to the classification system used by Sinclair (1980a)

Parkington (1980) has re-orientated research, with the emphasis now on the recovery of as complete a record of prehistoric settlement in the locality as possible. Excavations at Elands Bay Cave and at other sites close by, are producing important data regarding palaeo-environmental changes, such as the rise and fall in sea level over the last 10 000 years which influenced the composition of the flora and fauna.

In addition a small cave, 'Tortoise Cave', some 2,5 km from the mouth of the vlei, has been investigated. An extensive external deposit of archaeological material is presently being examined and is expected to yield significant data.

Currently, archaeological research is concentrating on the subsistence patterns and settlement arrangements of the hunter-gatherers and pastoral peoples particularly during the Holocene period (Manhire, *et al.*, 1983; Buchanan, *et al.*, 1984). About 2 000 years ago, the arrival in the area of the pastoral peoples, with their different lifestyle and large herds of domesticated animals, affected the traditional hunter-gatherer way of life in a manner which is still not fully understood. It is clear, however, that the traditional systems were put under some stress, and that changes occurred. Archaeological research in the Sandveld generally, and at Verlorenvlei specifically, is designed to identify and examine these changes.

Rock Art

Since 1978, some 1 000 painting sites have been recorded in the western Cape. In the Verlorenvlei area, all rock outcrops have been systematically searched. Sites have been recorded photographically, as well as by tracing and written description. At least 90 sites have been located, most of them in the Table Mountain Group outcrops along the south bank of Verlorenvlei, on both the north-eastern, vlei-facing edge, and on the south-western edge. Analysis of the rock art elements at Verlorenvlei shows that this was an important area for both the hunter-gatherer and herding peoples.

Naturalistic images of animals and human beings are found throughout the rock-art of southern Africa, but elements such as handprints are much more limited in distribution. They are found mostly in the Cape, where they are restricted to the western and southern margins of the subcontinent, an area historically and archaeologically known to have been occupied by the Khoi herders. For a number of reasons, Van Ryssen (1984) concludes that the handprints are most probably the work of these herders. A few examples of handprints are known from the northern Transvaal and the northwestern Cape. They are, however, significantly more common in the Sandveld, especially in the vicinity of Verlorenvlei, than elsewhere in the southern African region (Figure 7).

The Verlorenvlei area was undoubtedly a major focal point for prehistoric and early historic hunting and herding peoples. It is, therefore, a natural laboratory for palaeo-research which may well facilitate the unravelling of the pre-European history of a large portion of South Africa, as well as contributing significant information to other disciplines.

Parkington (1976a) points out that artefacts suggest that man has been in the Verlorenvlei area, more or less continuously, for more than one hundred thousand years. There are very few situations in sub-Saharan Africa where the potential for prehistoric reconstruction over such a period is so promising. As few of these sites have yet been excavated, they must be conserved for their importance to both archaeology and palaeontology. He states:

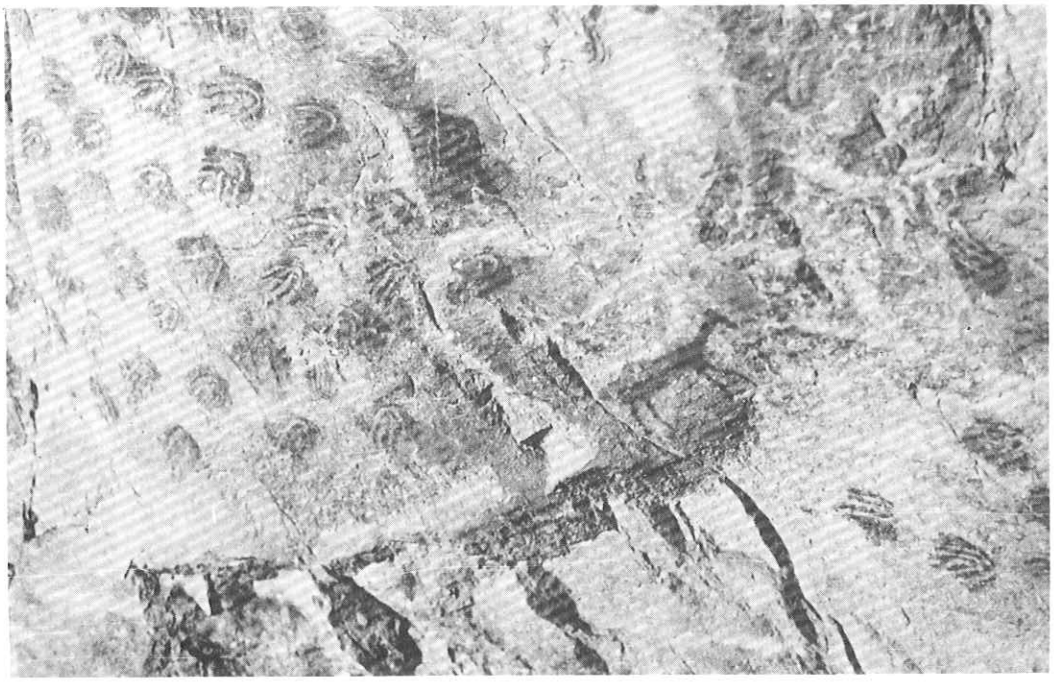


FIG. 7: Bushman paintings and handprints in Elands Bay Cave. (Photo: S A Sinclair, August 1978).

> "No other locality along the western Cape coast has such potential and it is imperative that the promise is not squandered by the lack of conservation measures."

While the cave sites are difficult to protect because of their visibility, the open middens are vulnerable to agricultural activity, to collection of shells for lime-making, and to use as beach parking-areas. Suitable conservation measures and methods of enforcement are urgently needed.

Not only must the known sites be protected, but also the as-yet undiscovered sites. "From the records of early Dutch travellers .... it seems clear that much hunter-gatherer settlement was ephemeral and in the open veld. Most explorers mentioned the large numbers of abandoned windbreaks which seem to have been occupied for only a few nights. If these were the most 'typical' sites then they remain almost entirely undocumented archaeologically. Along the same lines if herder settlement was dictated largely by pasture considerations then there would have been no phenomenon to concentrate occupation debris in any one spot and thus no 'sites' to excavate" (Parkington, 1976b). A broad archaeological conservation area is therefore proposed, encompassing more than the known archaeological sites, to allow this important research work to continue unhindered.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Area

The catchment (Figure 8) is about 87 km long in a north-west/south-east direction, and up to 43 km wide. Its surface area is estimated by Noble and Hemens (1978) to be 1 890 km^2, or 189 000 ha. Three of the rivers fall within the area controlled by the Swartland Divisional Council, while one falls into the Cedarberg Divisional Council area.

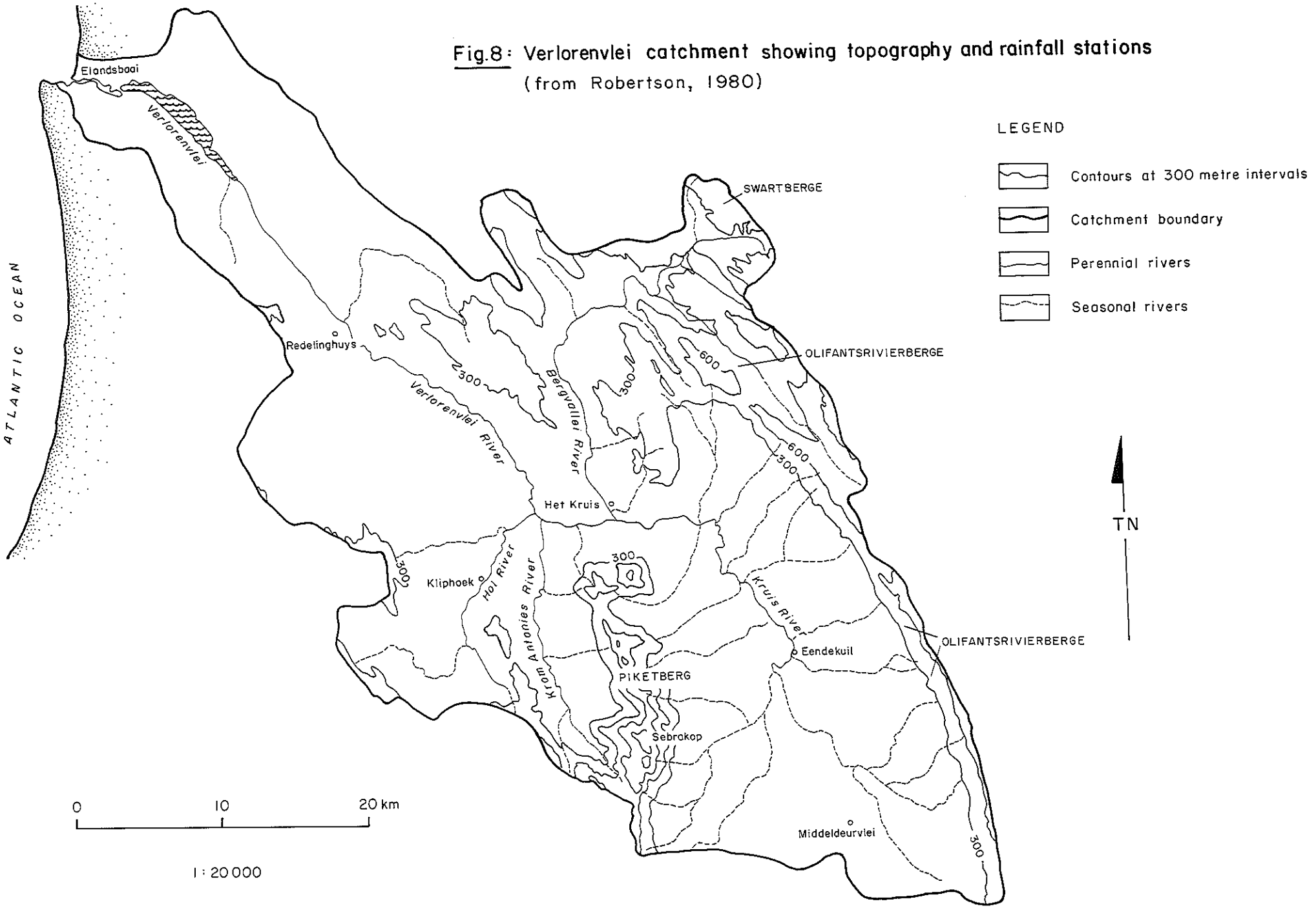


Fig.8: Verlorenvlei catchment showing topography and rainfall stations (from Robertson, 1980)

Lengths of rivers and tributaries entering Verlorenvlei:

River	Length (km)	Managing authority
Hol River/also Eselshoek River	25	Swartland DC
Krom Antonies River/ into Kruis	22,5	Swartland DC
Kruis River/also Kruismans River	50	Swartland DC
Bergvallei River	36	Cedarberg DC

All the above flow into the 30 km-long Verlorenvlei River (Figure 8).

The catchment is bounded by the Swartberg and Olifantsrivierberge in the east and by the Piketberg in the south, and includes the Eendekuil basin, a low-lying area lying between the Olifantsrivierberge and the Piketberg.

The Verlorenvlei River and its tributaries drain the entire Eendekuil basin (predominantly fine-grained rocks of the Malmesbury Group), the Table Mountain Group mountains around Paleisheuwel, the northern outliers of Piketberg (mainly Table Mountain Group with Malmesbury rocks exposed at the base), the extensive flats of Tertiary to Recent sands between Het Kruis and Redelinghuys, and the 5 km strip of low Table Mountain Group hills and sand flats on either side of the lake which contribute seepage.

The Hol River flows only after occasional good rains. The Verlorenvlei River flows during the winter and early summer. There are several springs along the Verlorenvlei, but those near the sea south of Baboon Point have very brackish water.

3.1.2 Coastal Lake

Because of its intermittent connection with the sea, Verlorenvlei can be regarded as a coastal lake. It is about 13,5 km long and 1,4 km wide at its widest point, covering an area of approximately 1 000 ha (10 km^2). Its mean depth is 2,5 m and its greatest depth is 5 m (Figure 9). A narrow estuarine channel about 2,5 km long connects the lake to the sea at Elandsbaai but an input of sea-water into the system only occurs very occasionally under extreme conditions of storm and tide.

3.1.3 Geomorphology

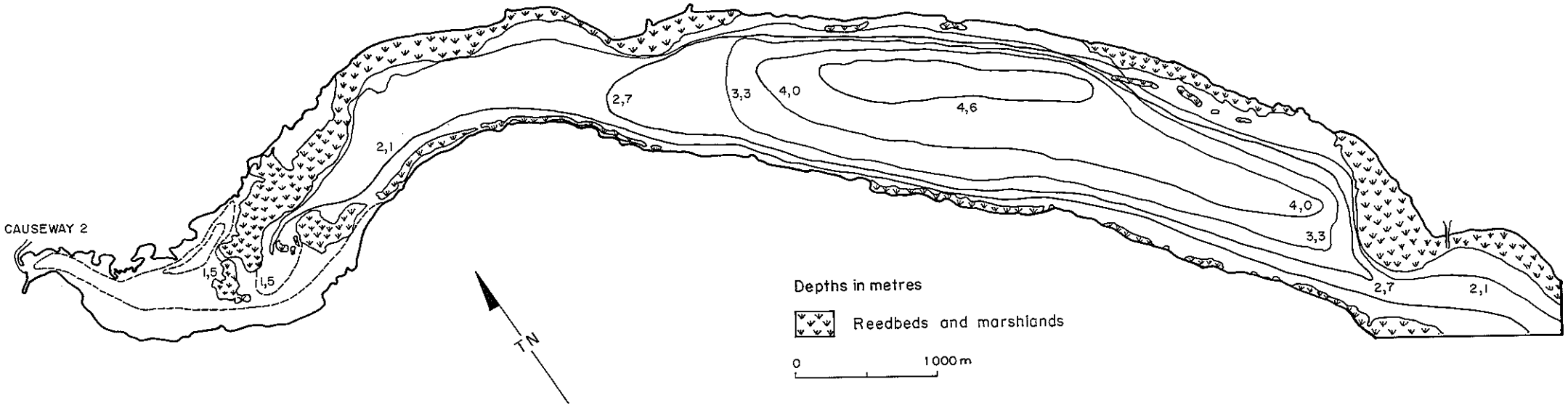
The following description by Visser and Toerien (1971) relates to the 1:125 000 Geological Survey maps, 3218C Doringbaai and 3218A Lambertsbaai.

Extensive low-lying sand flats (Tertiary to Recent) occur to the north and east of the lake, sloping gently up to a series of low hills of the Table Mountain Group (Piekenierskloof Formation), which form the catchment boundary in this area.

On the southern side, the lake lies against the base of a continuous range of low hills of sandstones of the Table Mountain Group, averaging some 120 m above sea-level, with Muishoekberg (300 m) forming the only prominent peak. A fairly

Fig. 9 : Bathymetry of Verlorenvlei

(Echo sounder survey, October 1976, from Robertson, 1980)



level plateau of Tertiary to Recent sands lies behind these hills. Outcrops of shales of the Klipheuwel Formation occur at a few places at the base of the hills on the southern side of the lake.

The vlei, the hills on its south bank, and the 'krantzline' all lie in the NW/SE plane. These features follow the direction of geological faults running through the area. The Table Mountain Group lies horizontally over large areas, but is also folded into broad open anticlines and synclines with axes striking north or northwest. Only along the Verlorenvlei two minor folds were formed along axes striking northeast.

3.1.4 Geology

The first geological survey and mapping of the area was carried out by Rogers (1904), whilst engaged on a survey of parts of the divisions of Piketberg, Clanwilliam, and Vanrhynsdorp. Haughton (1926, 1929 and 1932) looked at fossils found on raised beaches. In 1960, Visser's investigation into phosphate deposits around Lambert's Bay led to further mapping (Visser and Toerien, 1971). Geological data were collected during prospecting for and exploitation of diamonds in the northwestern corner of the Elandsbaai/Vredendal area.

The surface geology of the catchment consists of about 30 percent Table Mountain Group; 40 percent Tertiary to Recent sands; and 30 percent exposed, fine-grained rocks of the Malmesbury Group (Figure 10).

The following details are taken from Visser and Toerien (1971):

Malmesbury Group

The Malmesbury Group (Proterozoic) has been subdivided on purely lithological grounds into three groups, calcareous, quartzose and phyllite with greywacke. The calcareous group comprises pure limestone, dolomitic limestone and dolomite. Carbonaceous patches and calcareous rocks grade into quartz-rich varieties.

The quartzose group consists of white sheared quartzite, quartz-sericite schist, coarse-grained grey quartzite, conglomerate, arkose and grit, with inter-bedded phyllite and greywacke layers. Cross-bedding can be seen in the quartzite at numerous places. In some localities, the proportion of quartzitic rocks is more or less equal to that of greywacke and phyllite, making correlation subjective.

The remaining group contains greywacke and blue-black phyllite in varying proportions, with bands of grit, arkose and quartzite inter-bedded with them. In some localities the rocks have been altered to schist and paragneiss consisting of feldspar, quartz, mica and garnet.

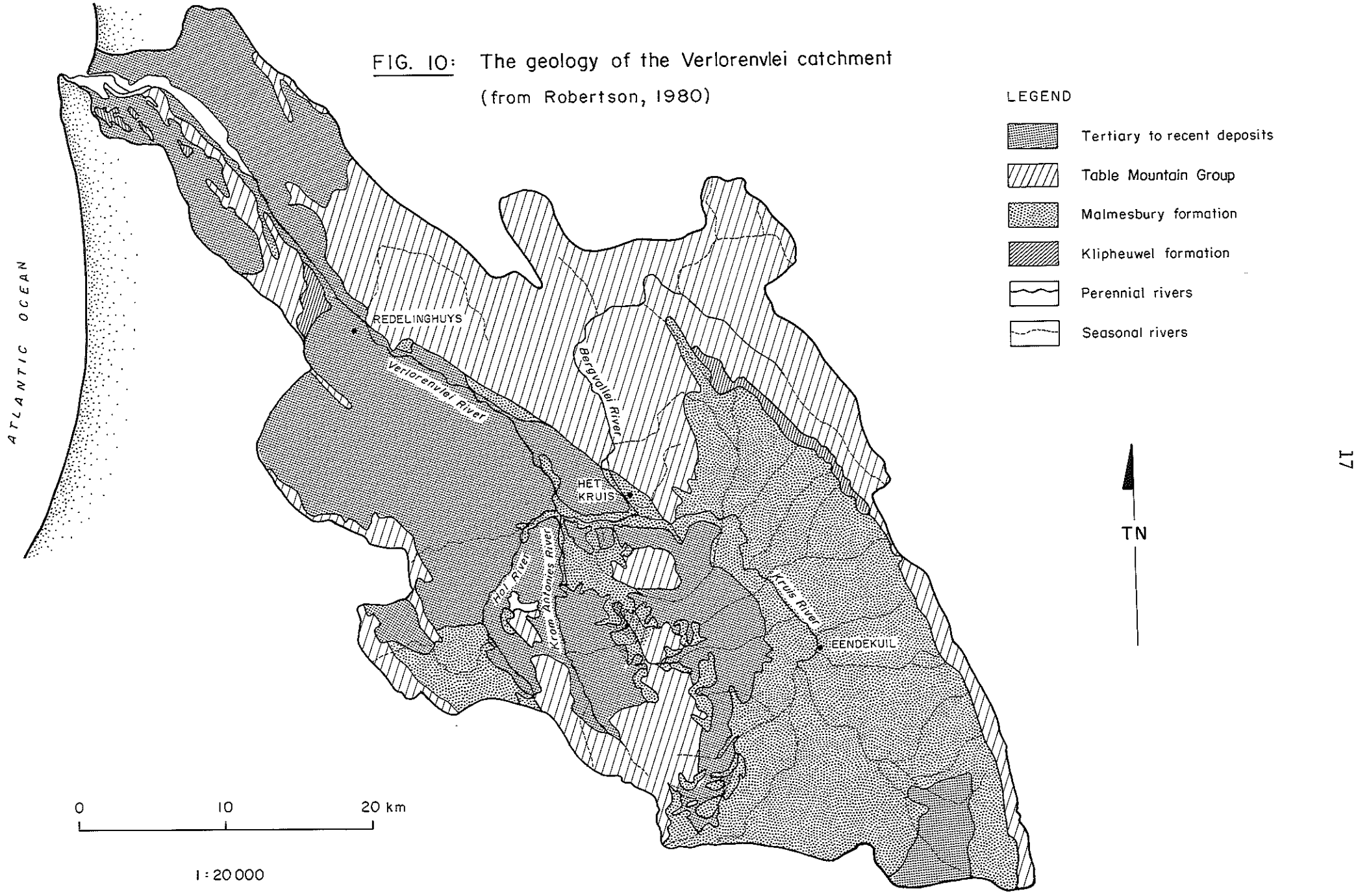
Klipheuwel Formation

Sediments showing a high degree of lithological similarity to the Klipheuwel beds of the type area are found in small occurrences along Verlorenvlei. No angular unconformity is visible between them and the Table Mountain Group but their regional relationships clearly show the presence of an unconformity. Rogers (1904) named these rocks Ibiqua Beds, which implies a correlation with the Nama System, for which there is no proof available yet.

The Klipheuwel Formation (Proterozoic) comprises the following: purple to reddish brown sandy micaceous shale which is mostly poorly-bedded and grades into mudstone; alternating beds of sandstone, shaly sandstone and sandy shale with

FIG. 10: The geology of the Verlorenvlei catchment

(from Robertson, 1980)



colours ranging from buff to purple and red; white and brightly coloured sandstone and grit with minor conglomerate and shale layers. The arenaceous strata are commonly cross-bedded, quite often feldspathic, and much softer than the Table Mountain Group sandstone. The maximum thickness exposed on the eastern boundary of this area amounts to about 375 m.

Table Mountain Group

The lower portion of the Table Mountain Group (Upper Silurian-Lower Devonian) is found throughout the area. The maximum thickness of strata is estimated at 750 mm to 900 mm.

The basal portion of the series is characterised by numerous thick but lenticular conglomerate bands, the pebbles of which consist predominantly of vein-quartz. (The conglomerates, of fluvial origin, constitute the Piekenierskloof Formation; above the Piekenierskloof Formation is the estuarine or lagoonal Graafwater Formation). The so-called lower shale band, well-developed at Piketberg, can be traced for many kilometres immediately east of the area, where it is clearly defined and some 150 m thick. In a southwesterly direction from Graafwater Station the lithology of this zone changes completely so that it is no longer recognisable along the Verlorenvlei.

The major constituent of the group is medium to coarse-grained, white to reddish brown sandstone, which is thickly bedded, and commonly cross-bedded. Fine-grained shaly sandstone is confined to the lower shale band. The latter consists of brightly-coloured shale, mostly sandy, and shaly sandstone. Sun-cracks, clay-pellet conglomerate, ripple-marks and numerous worm-burrows characterize these beds. Conglomerate is very plentiful and not confined to any particular portion of the series. The bands are mostly ill-defined and it is common to find scattered pebbles in sandstone and grit. Pebbles range in diameter from 1 cm to 25 cm and consist mainly of vein-quartz, quartzite types, hornfels and chert.

The cross-bedding of the dips prove the provenance of the sediments to have been mainly to the northeast, north and northwest.

Tertiary to Recent Deposits

White to slightly-reddish sandy soil found over large areas was formed at more than one period and at different altitudes. It originated mainly from the underlying unconsolidated to partly-consolidated sand and clay, and to a lesser extent from the Table Mountain Group, the coastal dunes, and fluviatile deposits of past and present drainage systems.

The stratigraphy is: Elandsfontyn Formation beneath, being peaty clay and sand; the controversial Saldanha Formation; the Varswater Formation, being conglomeratic phosphorite; and on top, the Bredasdorp Formation, with three aeolianite phases, the third being unconsolidated (Hendey, 1983; Rogers, 1982).

Brackish calcareous soil has been formed in the southern part of the Elands Bay/Vredendal area. A narrow strip of old sea floor, now dry land behind the dunes, has very shallow soil lying on surface-limestone which overlies coarse sand and shells.

Rubble and debris are found in numerous places at the foot of cliffs and along small streams that flow down hillsides after heavy downpours. The river is

flanked by strips of alluvium, part of it being black and rich in plant material. Several patches of driftsand and bare dunes away from the coast originated mostly from mismanagement of the veld. A large dune field occurs to the north of the river mouth and the town of Elandsbaai (Plate II).

TABLE 1: Tentative stratigraphical nomenclature for Cenozoic sediments at Elands Bay (Rogers, 1982)

Formation	Berg River/Elands Bay	Probable age and environment
Bredasdorp	Calcareous sand (Yzerfontein)	Holocene barrier
	Velddrif	Late Pleistocene beach
	Silica and muddy sand (Papkuils)	Pleistocene decalcified dune plume and vlei deposits
Varswater	Pelletal phosphorite	Early Pliocene inner shelf
	(Bookram)	Early Pliocene estuary
	Shelly gravel	Early Pliocene inner shelf
'Saldanha'		Late Miocene beach and lagoon
Elandsfontyn	Elandsfontyn	Middle Miocene meandering river

Boucher (1981) distinguishes three major dune ages in dune plumes. The first comprises the loose dunes which are constantly moving backward and forwards near the centres and the sources of the plumes. They continually lose sand to the surrounding second zone but equivalent volumes are added from the seashore. The dune relief is sharply angled. Surrounding these loose dunes are less angular dunes which form an undulating topography. The third zone represents the sand which has been stable for the longest period. The topography is rolling or gently undulating, and this zone is usually found on the inland side of the dune plumes. Vegetation associated with these three zones is discussed under Section 4. At Elandsbaai, the Sishen/Saldanha railway cuts across the source of the dune plume, just above the high water mark. Active stabilization is being carried out to ensure that the railway line does not become covered with beach sand. Boucher (1981) seriously questions the policy of dune sand stabilization on this and other west coast dune plumes.

Sand of some of the recent and also of some of the older dunes, as well as that of the beach, is white and contains much finely-fragmented shell. Between Verlorenvlei and Langvlei to the north, the marine sand and clay, so commonly found beneath the overburden of sandy soil, are phosphatized and consist of light brown to yellowish friable sandstone that may contain pieces of Table Mountain Group sandstone near outcrops of the latter. The weathered surface of this sandstone is strewn with phosphatic nodules.

Small deposits of white surface-limestone, and small amounts of ferricrete are found all over the area.

Enumerated in chronological order, the raised beaches along the coast are found at 45 m, 27 m, 18 m and 6 m above sea-level. A small raised beach at the foot of the dunes and abrasion cliffs lies only 3 m to 3,6 m above sea-level. At an altitude of 105 m to 120 m, a fairly old marine erosion surface can be recognized at numerous places from less than 1,6 km to some 4,8 km from the coast.

Most of the area is underlain by marine sands and clays that are usually covered by various types of sandy soil and are rarely exposed in small outcrops. Thicknesses vary from a few to more than 60 m. Gravel beds, mainly associated with the raised beaches and older erosion-surfaces, as well as black sand, are minor but very common constituents of these deposits. A certain amount of aeolian sand and fluviatile deposits of old degenerate, as well as present drainage systems, are included with the marine beds. There is much vertical and lateral variation in these sediments and no generalized succession for the entire area has been established yet. Several sections from the results of diamond-prospecting show the succession near the coast. Fossils from the 18 m and 27 m terrace gravel give no conclusive evidence as to the age of these beds.

As stated in Section 2.3, archaeologists have long emphasized the potential for archaeological and geoarchaeological discoveries in the Elands Bay region. Their predictions were proven recently, when the dating of a buried beach deposit near Elands Bay confirmed the existence of a mid-Holocene relative high stand of the sea on the south-western Cape coast of Southern Africa. The date of this Holocene beach is the first known in a primary stratigraphic context on the southern coast of Africa, and is a rare example of a geologically-important finding having been motivated primarily by archaeological investigation (Yates *et al.*, 1986).

'Heuweltjies' or Hummocks

The phenomenon of 'heuweltjies' occurs in the Verlorenvlei area, and is easily detectable both on the ground and in aerial photographs. Different theories have been propounded as to their origins. They include calcareous layers and a higher clay content in the soil deriving from old termitaria. The activity of mole rats may also contribute to the formation of 'heuweltjies' (Assoc. Prof J U M Jarvis, Zoology Department, University of Cape Town, pers. comm.). The natural vegetation associated with the 'heuweltjies' is discussed in Section 4.1.5.

3.1.5 Soils

Von Harmse, in his Schematic Soil Map of Southern Africa (1978), classifies the Verlorenvlei area as a zone of littoral sands which are arenosols, or of aeolian origin. He points out that the salient feature of such soils is their low reserve of weatherable minerals, and the low silt/clay ratio. Taylor (1978) describes these coastal lowlands as consisting of sands and conglomerates of Tertiary to Recent origins. He comments on their low water-retaining capacity, being either acid and relatively infertile or, nearer the coast, alkaline with a distinct horizons of lime accumulation. The 'heuweltjies' or hillocks have a higher clay content than the surrounding soils.

A soil classification project was carried out in the Western Cape for the Department of Agricultural Technical Services. A map of soil associations was produced at a 1:250 000 scale. This map shows the general Verlorenvlei area as being characterized by type B2 soil, a fine sand soil, in which the dominant types are Fernwood, and Mkambathi; the sub-dominant Hopefield; and the rare Langebaan, Sandveld, and Sonneblom. On the southern bank, extending from Elandsbaai to Redelinghuys, are isolated sections classified as R, being rock and undifferentiated lithosols.

Lane (1980) has examined the effect of soil reflectance on the usefulness of Landsat imagery interpretation. Surface soil texture and colour were recorded at 160 sites, and a map of distribution of surface soil types (Figure 11) produced from the satellite data; from the 1:250 000 Reconnaissance Soil Map of the

Western Cape (Ellis, 1976 and Table II); from the Geological Survey Map, 1:125 000, 3218A Lamberts Bay (1969); and from colour aerial photographs taken during a private flight in January 1979.

TABLE 2: Surface-soil description of the Verlorenvlei study area. Symbols indicating soil class are those used in Figure 11

Map symbol	Soil type	General description*
A	Fine sand	Deep calcareous - Fernwood/Villiafontes/Mispah forms
B	Fine sand	Deep acid - Fernwood/Constantia/Lamotte forms
C	Mesotrophic to dystrophic apedal soil	45 cm and 15% clay - Hutton/Clovelly/Avalon/Bainsvlei forms
D	Mainly rock	Undifferentiated
E	Alluvium	Saline and undifferentiated

* Source: Preliminary Legend for 1:250 000 Reconnaissance Soil Map of the Western Cape (Ellis, 1976).

3.1.6 Mineral Resources

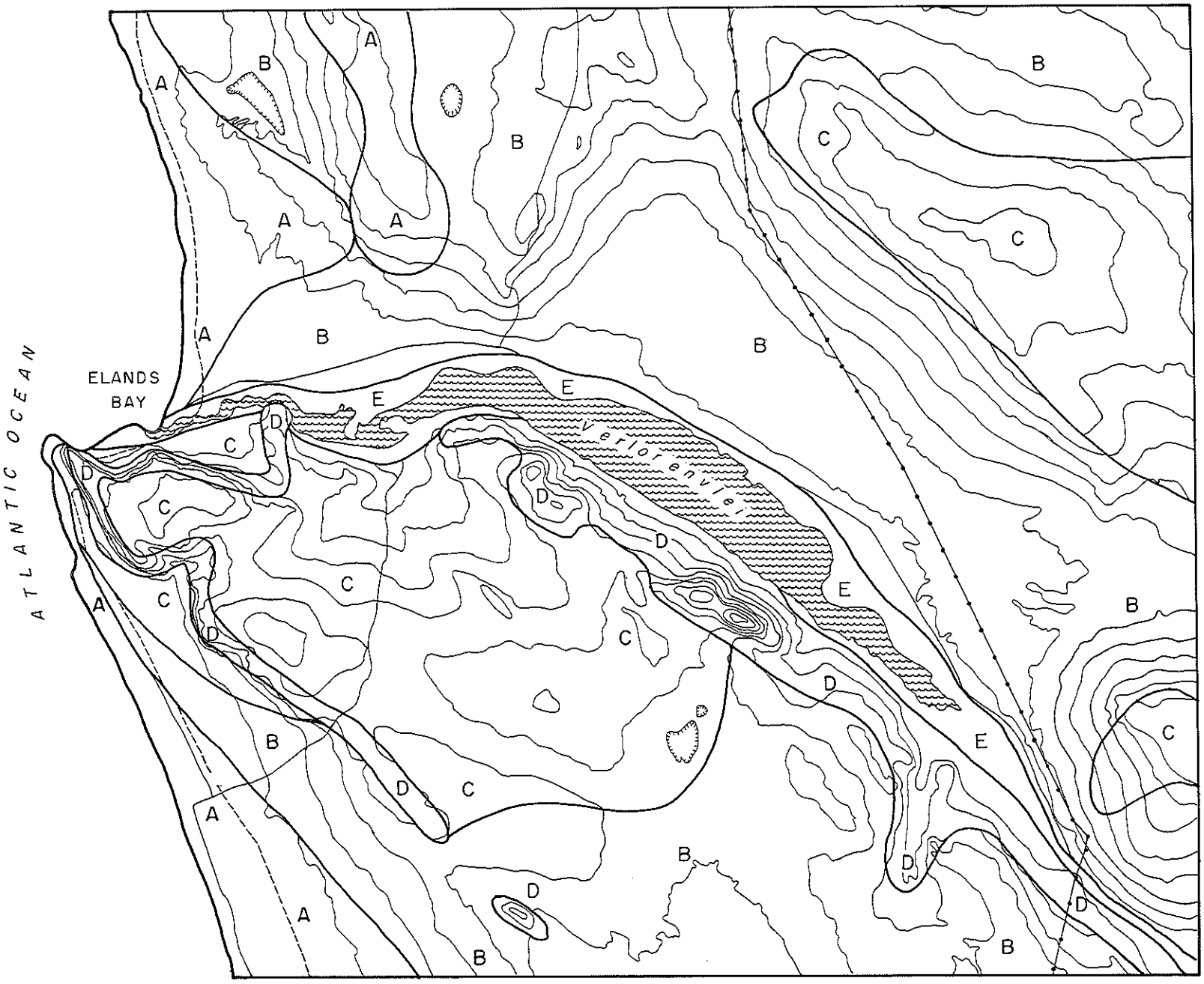
(Compiled from Visser and Toerien, 1971).

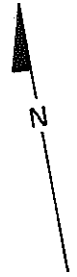
The Tertiary to Recent marine sediments occurring over most of the area have an average phosphorus content above normal for fertile soil. The gritty or gravelly sediments on the Table Mountain Group floor at numerous places contain from 1 percent to 20 percent phosphate. In a few areas the unconsolidated to semi-consolidated sand and clay have a much higher overall phosphate content and contain numerous phosphatic nodules and chips of phosphatized bone. These sands and clays may average as much as 5 percent phosphate over thicknesses up to 15 m. On top of this and below the sandy overburden, there occurs an enriched layer of nodular ore averaging 7 to 10 percent phosphate. Besides these deposits of marine origin there are a few small occurrences near the mouth of the Verlorenvlei where the phosphate has originated by leaching and enrichment from guano. Between Verlorenvlei and Langvlei, an extensively prospected area of 38 km^2 contains some 17 million metric tons with 7,5 to 9,5 percent of phosphorus, of which only 2,7 metric tons are of the citric acid soluble type.

A promising occurrence of very pure gypsum has been found in a well at Verlorenvlei but has not yet been prospected.

An existing salt pan south of Verlorenvlei, with another near Leipoldtville, yield a few hundred 200 lb-bags (90 kg) of salt annually. It is not certain if the salt pan referred to by Visser and Toerien (1971) is the same as that appearing on the diagram 374/1837 (Figure 2), with the legend: "Saltpan to be free for the use of the neighbouring inhabitants" (Sinclair, 1980a). The climatic and geological conditions may be favourable for much greater salt production from natural brine and sea water at these pans and numerous other localities on the coast. Any exploitation must be preceded, however, by an environmental impact assessment, which has not been the case at the Berg River to the south.

FIG. 11: Distribution of surface soil types at Verlorenvlei (from Lane, 1980)





LEGEND

A = White alkaline sand

B = Off white and ochre calcareous sands

C = Orange sand and clay

D = Dark grey and red soils

E = Dark alluvium

Contour interval every 50m

= Boundaries of soil types

= Powerline

--- = Sishen - Saldanha Railway Line

0 1 2 3 km

The Nama/Malmesbury rocks include much limestone and dolomite.

3.1.7 Rainfall and Run-off

Rainfall

The catchment of Verlorenvlei lies in the winter rainfall area, with more than 80 percent of the precipitation occurring between April and September, and very little in the summer. The level of the lake fluctuates considerably. During winter it fills up and overflows into the sea near Elandsbaai, but during the summer, it gradually drops through evaporation to reach low levels during March/ April (Figure 12).

FIG. 12: Vlei level in front of Verlorenvlei settlement during May 1981. (Photo: P D Morant).

Mean annual rainfall from data collected at five recording stations over the period 1951 to 1979 was less than 300 mm. The area is classified as arid (Noble and Hemens, 1978).

A graphical representation of the Redelinghuys records shows the variability of the annual rainfall (Figure 13). This variability is characteristic of areas in South Africa with a low annual rainfall (Noble and Hemens, 1978), and is as important to plant life as is the amount of precipitation (Werger, 1978). Plants are adapated to the unreliable water conditions by having complex mechanisms of germination, seed longevity and diversification.

Caution is required when examining annual rainfall figures in areas with variable precipitation. For example, in 1978 there was a drought during the winter months. Unusually high December rainfall concealed the drought by bringing the total annual rainfall for 1978 close to the 23-year mean (Figure 13). During the December 1978 rainstorm, 71,5 mm of rain fell in two days, causing severe donga erosion in areas exposed by overgrazing over a long period (Robertson, 1980).

Highest total	= 436,3 mm
Lowest total	= 145,2 mm
Difference	= 291,1 mm
Mean (1951 - 1979)	= 275,7 mm

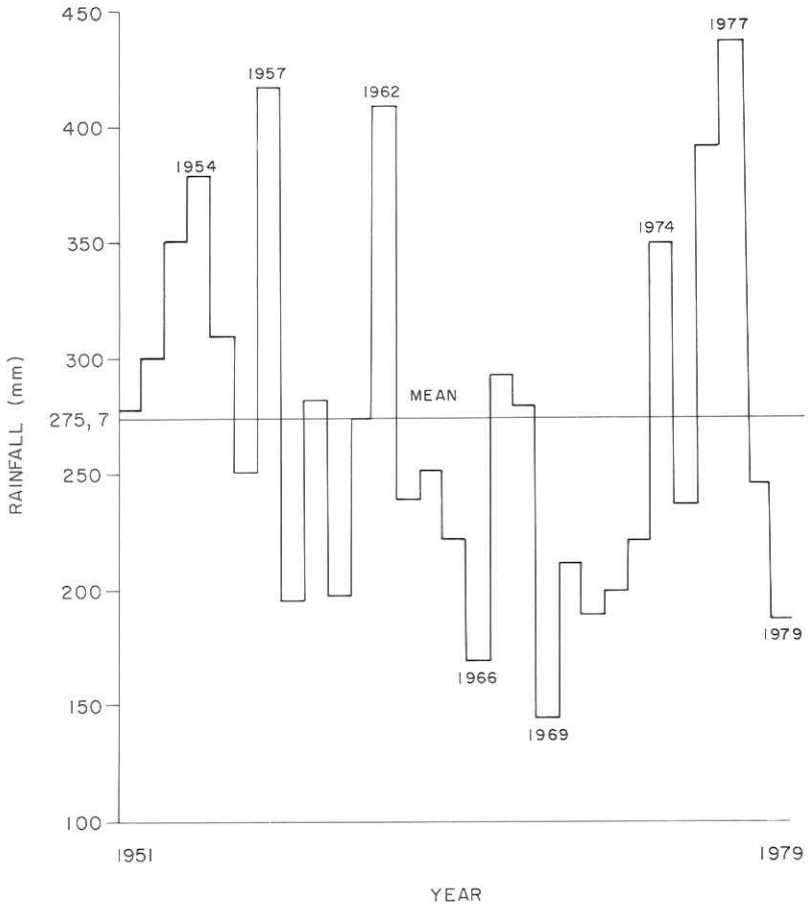


Fig. 13: Annual rainfall at Redelinghuys from 1951 to 1979 (mm)
(from Robertson, 1980)

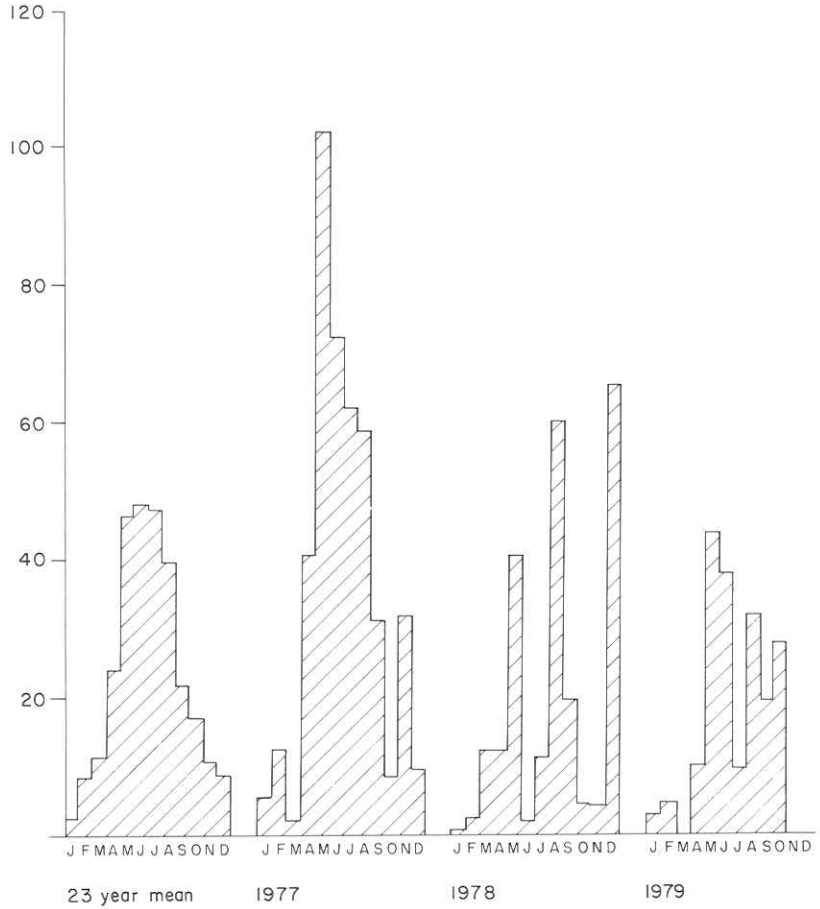


Fig. 14: Monthly rainfall at Redelinghuys (mm)
(from Robertson, 1980)

In a variable environment, extreme conditions therefore play a more important role than average occurrences. The seasonal timing and duration of rainfall are also important.

Run-off

Noble and Hemens (1978) estimate mean annual run-off at 102 x 10^6 m^3. No detailed quantitative data are available. A gauging station (G3M01) exists at Tweekuilen alias Kruis on the Kruis River (Department of Water Affairs, *in litt.*). As an urgent priority for monitoring purposes, flow gauges should be installed on all the main streams flowing into Verlorenvlei.

Evaporation

At the closest evaporation gauging-station further north at Lambert's Bay, average annual gross evaporation between 1954 and 1967 was 1404 mm, while average annual rainfall was 203,4 mm (Monthly Rainfall and Evaporation Records, n.d.).

Isometric lines of gross annual pan evaporation on a map compiled by the Department of Water Affairs show that evaporation in the coastal region of Verlorenvlei is in the vicinity of 1 140 mm per annum, and increases inland to about 1 520 mm per annum (Midgley and Pitman, 1969). Comparison with rainfall figures within the catchment indicates a large evaporative loss of water from the system.

Fog

Lane (1980) points out that interesting vegetation distribution patterns seem to be caused by the advective sea fog characteristic of the Verlorenvlei area (Figure 15). The vegetation benefits by being exposed directly to the prevailing onshore wind. Standard rain-gauge measurements for the area do not record any precipitation from the fog, and give a misleading indication of total precipitation. Studies in arid areas elsewhere indicate that 121 fog days per annum can provide the equivalent of 130 mm of rainfall, which can be 7 times the recorded annual rainfall for the arid area. There is, therefore, more moisture available to plants than is indicated by rainfall data, and a high priority is the recording of precipitation derived from advective sea fog for the Verlorenvlei area.

TABLE 3: Long-term average rainfall at some stations in the Verlorenvlei catchment (from Robertson, 1980)

Station	Latitude S	Longitude E	Height above sea level (m)	Number of years	Average annual rainfall (mm)	Number of days with rain per annum
Redelinghuys	32°29′	18°32′	61	23	284,4	59
Het Kruis	32°35′	18°44′	70	22	261,5	50
Wilgenhoutsdrift	32°40′	18°42′	122	15	335,4	63
Moutonshoek	32°44′	18°43′	137	15	600,6	58
Middeldeurvlei	32°47′	18°56′	152	5	254,5	No data

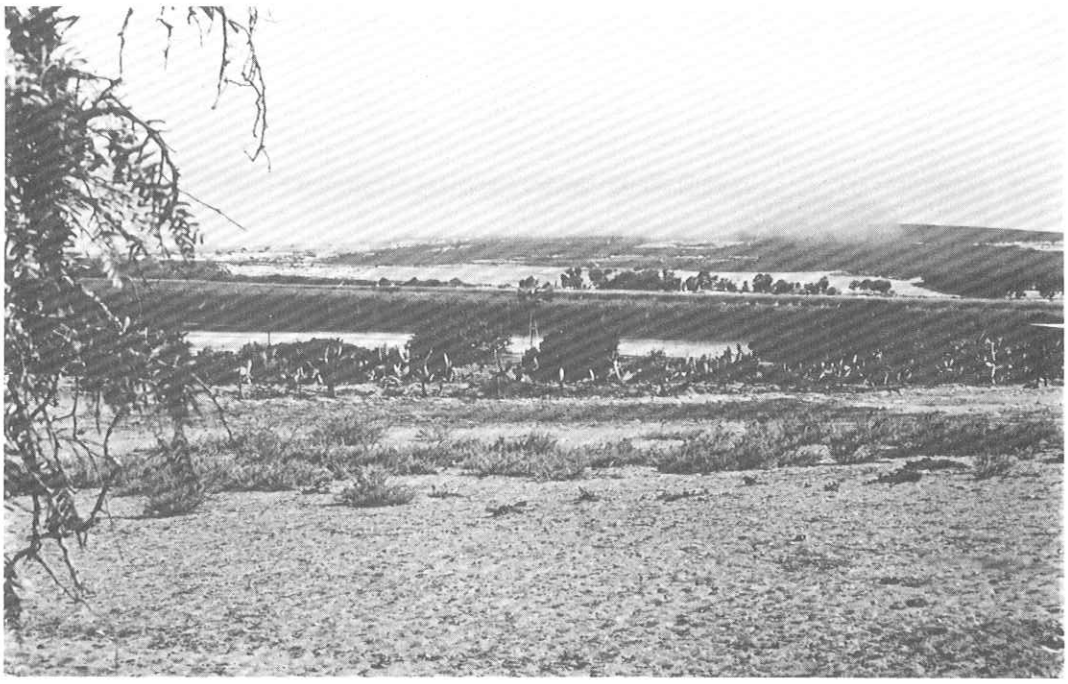


FIG. 15: Advective fog over the northern bank, opposite the Verlorenvlei farm settlement. (Photo: S A Sinclair, March 1979).

TABLE 4: Monthly rainfall at Redelinghuys (from Robertson, 1980)

Rain-fall (mm)	J	F	M	A	M	J	J	A	S	O	N	D	Total	Mean
23 year mean	2,6	8,4	11,2	24,0	46,1	47,7	47,2	39,7	21,5	16,8	10,6	8,6	284,4	23,7
1977	5,5	12,5	2,0	40,6	101,9	72,2	61,9	58,5	31,2	8,5	32,0	9,5	436,3	36,6
1978	0,7	2,4	12,5	12,5	40,4	2,0	11,5	60,0	19,8	4,6	4,57	4,7	245,6	20,5
1979	2,8	4,6	-	10,0	43,6	37,8	9,5	32,0	19,5	27,5	-	-	187,3	15,6

Underground Water

Water from boreholes and wells in the entire area is brackish. South of Verlorenvlei, and to a lesser extent between it and the Langvlei to the north, moderate to small supplies of water are obtainable from the unconsolidated sand and clay at almost any place at depths of 3 m to over 30 m (Visser and Toerien, 1971). The high proportion of bitter salts might be ascribed to the former presence of the sea over these flats. On the other hand, although the sea covered almost all of the coastal plain from time to time, not all the water is brackish (A K Martin, Marine Geoscience Division, NRIO, pers. comm.).

Boucher (1981) points out that drilling by the Department of Water Affairs has shown that there are good supplies of water associated with the stable third zone of the Western Cape's dune plumes, of which one occurs at Elands Bay. He

expresses concern at plans for drawing upon these underground water supplies on a large scale. Withdrawal lowers the water table to the extent that the surface vegetation starts to degrade, the driftsand problem may escalate, and water salinity may increase.

Water quality

The geology of the area has an important bearing on the composition of the water that enters the lake (Burgers, 1978). Sandstones and quartzites of the Table Mountain Group (Cape System) and Tertiary to Recent sands in the area are porous, so that any salts present have leached out in the past. Water draining such areas is very low in mineral salts and acidic. In contrast, rocks of the Malmesbury Group are mostly shales, schists and greywacke, which contain high concentrations of salts. These salts leach slowly into the ground water, and streams draining these areas tend to be brackish. In Figure 10 it can be seen that many of the tributaries that feed the Verlorenvlei River drain areas underlain by the Malmesbury Group.

The contribution of the Malmesbury Group to the geology of the catchment is, however, greater than the surface geology indicates, since large areas of Malmesbury rocks are overlain by Tertiary to Recent sands. At a rough estimate, 50 percent of the catchment is underlain by Malmesbury rocks, the remainder being sandstones and quartzites of the Table Mountain Group.

Cultivation in the catchment is extensive, particularly in the Eendekuil basin, where more than 90 percent of the Malmesbury-derived soils have been ploughed, mainly for wheat production. The breaking-up of the Malmesbury rocks through cultivation exposes new surfaces to weathering, which leads to a more rapid release of salts. The major ions leached from the Malmesbury Group are sodium and chloride (Robertson, 1980).

Since almost all available Malmesbury-derived soils have been ploughed, and no large sources of water are available for additional irrigation (which accelerates salt leaching), it is unlikely that the salt load of the streams draining into Verlorenvlei will increase further in the future (Burgers, 1978).

In the southern region of the catchment, where the Hol River rises, limestone occurs in the Malmesbury rocks. This is the probable source of the calcium detected in the water entering Verlorenvlei, and the cause of the 'hardness' of the vlei water. Differences in the salinity of seepage water in irrigation pits suggests that seepages of reduced salinities enter Verlorenvlei (Robertson, 1980).

3.1.8 Land Ownership/Uses

According to the historical record, the land around Verlorenvlei has been used for wheat cultivation and to provide rough grazing for sheep and cattle, over a few centuries. An historical review of land usage in relation to land ownership, from 1747 to the present, has been traced by Sinclair (1980a). A list of landowners in the Verlorenvlei area as at February 1980 was compiled by Burgers (1980).

At present, the main crops are potatoes and sweet potatoes. Originally, potatoes appear to have been grown for home consumption, but more recently spray irrigation has made three crops per year possible. The potatoes, particularly from upstream near Het Kruis, are marketed, and are said to provide 60 000 to 70 000 pockets to Cape Town annually. Riparian owners dig pits beside the vlei,

and use seepage water for irrigation, as it is less saline than vlei water. Landowners immediately behind the coastal dunes to the south are also presently excavating large pits, to gain access to fresh water, which is pumped out for spray irrigation (Sinclair, 1986a).

Oats, barley and wheat are grown on a smaller scale, and some farmers may rotate potatoes with wheat, threshing the latter for stockfeed. Lucerne, gourds, green peas, beans, sunflowers, and fruit trees (lemons, figs, pomegranates, guavas, and oranges) are cultivated on an even smaller scale, for local use. These are grown near the vlei, reportedly because the local inhabitants believe that the alluvium is more fertile, in contrast to the findings of the Soil Research Institute (Robertson, 1980).

According to a 1:250 000 reconnaissance soil map of the Western Cape compiled by the Soil Research Institute of the Department of Agricultural Technical Services, the only land of moderately high agricultural potential bordering Verlorenvlei is part of the Verlorenvlei farm to the south of the vlei near Rooiberg, much of which is already under wheat, part of this being strip cultivation (Robertson, 1980).

On the Verlorenvlei farm (Figure 16), some cultivation also takes place in an area which is undoubtedly the alluvial fan of a stream, now dry except during periods of heavy rainfall and rapid erosion, but shown on early maps as a stream (Sinclair, 1986c). Water from a temporary pit adjoining the vlei is used to irrigate the lucerne, fruit trees and sunflowers.

A recent development has been the installation of a power supply, pump, underground pipeline, and mobile irrigation system on the Verlorenvlei farm. The purpose of this installation is to increase use of vlei water for irrigation of fields on the southern bank of the vlei, and the implications for the ecosystem could be profound.

The utility of the vlei water for agricultural uses is a matter of some concern, because of its brackishness (Robertson, 1980). American standards suggest that water with a salinity of 2,0 to 5,0 parts per thousand can be used on tolerant plants grown on permeable soils with careful management practices. The effect of salinity is modified by plant tolerance, soil type and permeability, constituents in the soil solution or irrigation water, and climatic conditions. Crops should be watered during the evening and morning to lessen the salinization caused by evaporation but this is not always done.

Parts of the area near the vlei have porous sandy soil, low in nutrients and with a low agricultural potential. In practice, the cultivation of potatoes under spray irrigation in this soil is a profitable enterprise. The question arises as to whether the problems of soil salinization will result, through use of water with a high salinity. The monitoring of soil quality in irrigated areas is recommended (Robertson, 1980).

While certain crops are and have been grown around the vlei for a long time, it is possible that salinization of the soil through use of saline water will increase, to the long-term detriment of the natural system and agriculture. The fluctuating salinity of the water thus may prove to be a factor which imposes limits on agriculture around Verlorenvlei. In these circumstances further expansion of irrigated farmland in the area would appear to be extremely unwise (Robertson, 1980).

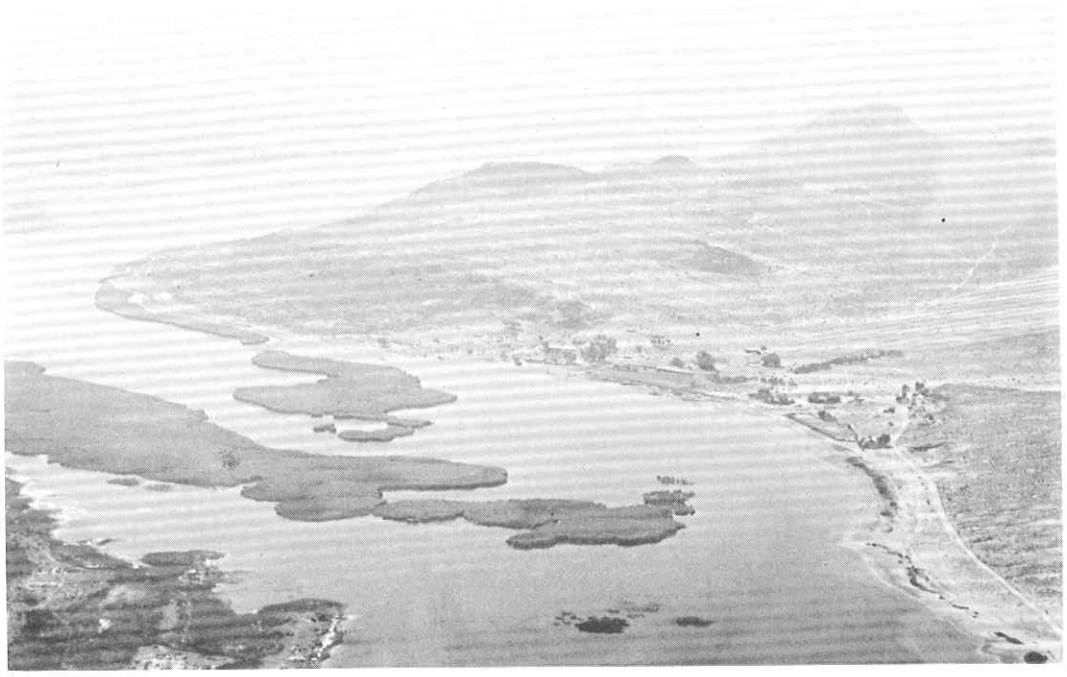


FIG. 16: The farm and rural settlement of Verlorenvlei on the southern bank of the coastal lake. (Photo: S A Sinclair, 1979).

Viljoen (1975) refers to inherent shortcomings of the Sandveld area with respect to its vulnerability to wind erosion, its marginal nature with periodic poor harvests, uneconomic farming units, and wheat pests: "... kleingraanverbouing is 'n baie riskante onderneming in die Sandveld ... Uit alle oogpunte beskou voldoen koringproduksie in die Sandveld dus nie aan die neergelegde vereistes van optimale bodembenutting nie en sien die Departement (van Landbou) nie sy weg oop om in belang van die Streek die onbeheerde verdere ploeg van nuwe grond in die Sandveld goed te praat nie."

The memorandum by Viljoen (1975) recommends that the Verlorenvlei area be proclaimed as a nature reserve, incorporating uneconomic farming units within a coastal strip 2 to 5 km wide extending the length of the Sandveld; that the balance of the Sandveld be recognized as being suitable for stock farming rather than wheat production; that uneconomic units be consolidated into economic units of 3 500 to 4 000 ha; that carrying capacity for stock be determined and enforced; that no further new ground be ploughed; and that strip cultivation and special implements be used in existing wheat areas. The recent introduction of mobile irrigation systems has led to extensive clearing of natural vegetation for cultivation, contrary to Viljoen's recommendations.

Presently, cattle, sheep and goats still graze the area, and are watered either at drinking troughs fed by windpumps, or are driven to the vlei to drink. According to American standards, water with a salinity of 3,0 parts per thousand is safe for livestock, while 5,0 to 6,9 parts per thousand is reasonably safe, but 7,0 to 10,0 parts per thousand and over is unfit for livestock consumption and is not recommended (Robertson, 1980). The livestock in the area is probably accustomed to the brackish water, and has been seen drinking at the Verlorenvlei farm shoreline, where salinity values of 7,0 parts per thousand have been measured before the winter rains.

In the case of the livestock, the condition of the vegetation and its ability to provide rough grazing, is probably more of a limiting factor to stock carrying capacity than water salinity and availability. The vegetation in the entire area has been severely overgrazed, as a result of its long history of use for grazing (Lane, 1980). Further expansion of stock numbers is extremely unwise, and a reduction is urgently needed if the natural vegetation is to be allowed to regenerate. Stock carrying capacity should be determined by research. It is more likely that the degraded state of the vegetation is a result of continual grazing over a long period, than of present stock numbers.

3.2 Estuary

3.2.1 Estuary Characteristics

(Section contributed by G A W Fromme, Sediment Dynamics Division, NRIO)

A very shallow, hydraulically-inactive estuary channel approximately 2,6 km long connects the lake to the sea, but a rocky sand-covered bar at the mouth and several, mainly artificial, obstructions make Verlorenvlei a virtually closed system.

As is the case with many South African rivers entering the sea, the Verlorenvlei mouth is not an estuary in the classical sense. The mouth is usually closed by a sandbar overlying a rock sill and the estuarine channel may be reduced to a series of stagnant saline pools during summer droughts. When good rains provide sufficient water the channel fills and the bar is overtopped by outflow. The outflowing water scours the sandbar away thus permitting some tidal interchange. Tidal interchange continues until the velocity of the outflowing water decreases sufficiently so as to allow the accretion of sand to form a new bar.

Historical references compiled by Sinclair (1980a) indicate that periodic natural breaching has been characteristic of the Verlorenvlei since the eighteenth century. In 1793, Thunberg described the mouth as follows:

> "It runs into the ocean to the northward, and, when it is low, the mouth appears dry, and the current there intirely choaked (sic) up with the sand, and stagnating."

Le Vaillant (1796) described Verlorenvlei as

> "...an extensive lake, separated from the sea by a narrow border of sandy downs,"

while Lichtenstein (1812) commented:

> "In heavy rains this lake empties itself into the sea, but for the greater part of the year the evaporation of the waters is as great as the flow from the hills."

During storms, particularly at high spring-tides, the sea washes over the sandbar. Sea water is reported by Robertson (1980) to penetrate as far as the Verlorenvlei farm. While extensive seepage to the sea takes place through the sandbar, water level in the estuarine channel is controlled by the rock sill over which the lower causeway has been constructed.

Both the rocks of Bobbejaansberg and the rocky bar across the mouth belong to the Table Mountain Group, the latter being merely the eroded talus of the former. The rocky bar is permanently covered by a layer of beach sand, 1 m to

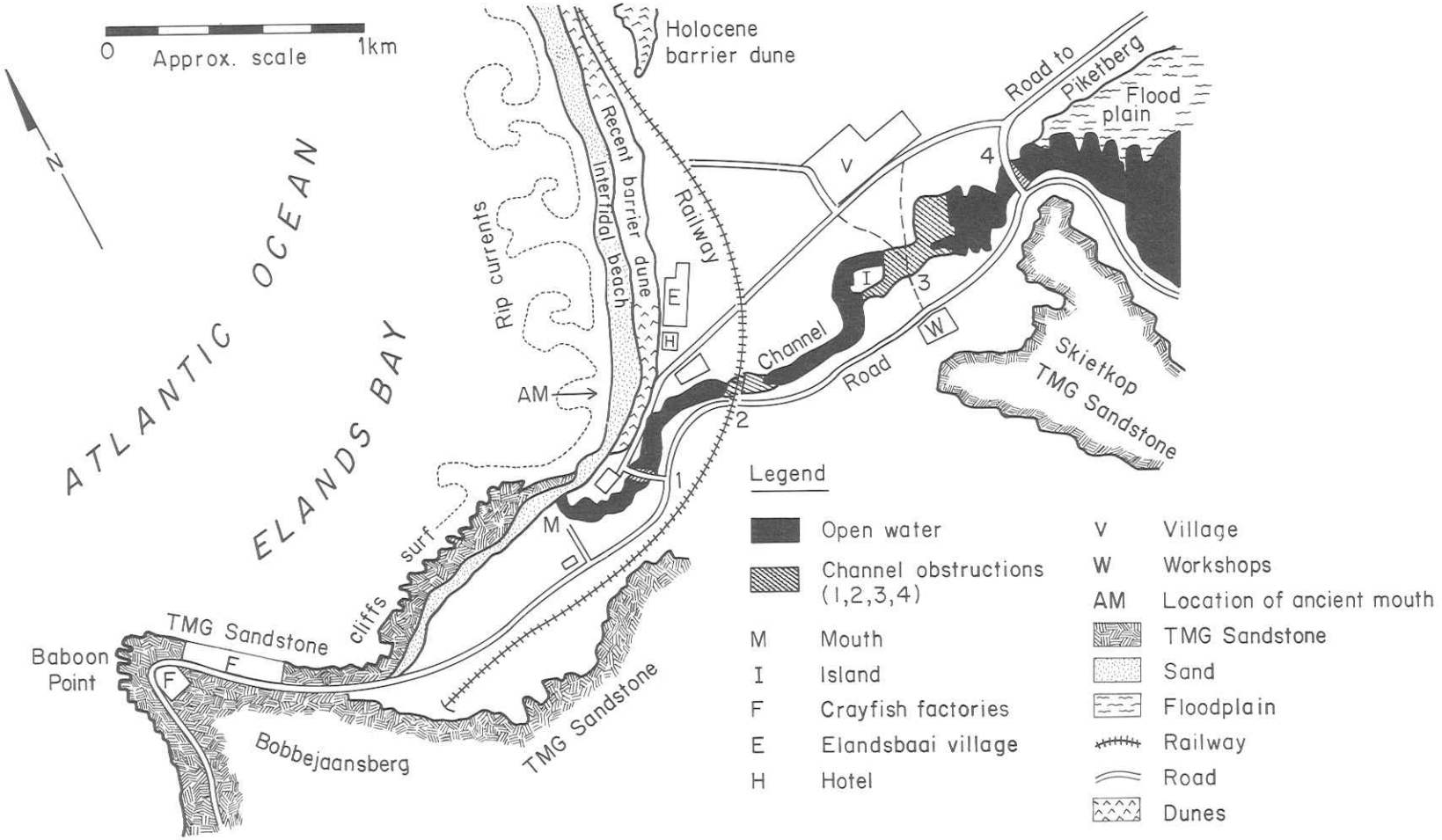


Fig. 17: Verlorenvlei Estuary channel and Elands Bay

(Based on aerial photograph 348/64, taken on 1 April 1980)

2 m thick, which brings the surface of the bar up to more than 2 m above MSL, forming an effective barrier between the estuary and the sea (Figure 17).

The sharp, appendix-shaped configuration of the lowest section of the mouth channel suggests that it was gradually pushed southward by the recent barrier dune. Excavations during the construction of the bridge for the Sishen/Saldanha railway line across the Verlorenvlei Estuary, revealed the existence of a previous deeper channel than the present one (Tankard, 1976b). On Figure 17, it can be seen that this ancient channel must have led straight out to sea, and, probably had the function of a tidal inlet.

Late Pleistocene fossil deposits, such as shells of intertidal molluscs embedded in fine quartzose sand at the south bank of the vlei, 3 to 4 km upstream of the mouth, are typical of an estuarine environment. As they adhere to the bedrock (Malmesbury shale and phyllite) at levels between 0,5 to 6 m above MSL, they indicate previous high sea levels and an open exit to the sea. These are ascribed by Tankard (1976a) to sea-level peaks caused by hyperthermal periods during the last inter-glacial (Riss-Würm inter-glacial, approximately 100 000 years BP).

Eustatic sea-level rises were always associated with periods of warm climate, which led to melting of the polar ice-caps, and consequent 'drowning' and filling of valleys with marine and fluvial sediments. Recessions of the sea occurred during cooler periods, because of the growth of the polar ice-caps, and resulted in a lowering of the sea level.

The most recent peak of the sea-level occurred after the end of the last of the Pleistocene glaciations (Würm Ice-Age), when the sea level rose to 1 to 3 m above MSL during the Flandrian Transgression, 12 000 to 4 000 years BP (Orme, 1975; Flemming, 1977; Rogers, 1980).

It can be concluded that the broad valley of Verlorenvlei was finally formed during the last Ice-Age (Würm). This valley was then flooded and filled with sediments during the Flandrian Transgression. When the sea level receded from its Flandrian peak of 4 000 years ago to its present level, the following processes took place:

(i) A new beach at a lower (that is, present) level and the recent barrier dune were created. (A second row of barrier dunes, more massive and higher than the recent one, and 100 to 150 m inland of it, marks the Holocene, or the Flandrian high sea level);

(ii) The estuary, which was an open embayment of the sea during the Riss-Würm inter-glacial and the Flandrian Transgression, drained to the present level, whereby the Flandrian deposits in the vlei were transformed into the present lagoon bed and the surrounding flood plains. Also the formerly large estuary mouth changed into a narrow inlet;

(iii) During the growth of the recent barrier dune during the past 4 000 years, the early post-Flandrian (narrowing) mouth channel was pushed southward and finally choked between the barrier dune in the north and the rocks of the Bobbejaansberg in the south.

More details on the dynamics of the mouth channel of Verlorenvlei can be found in Fromme, 1985.

3.2.2 Obstructions

a. Mouth exit to sea (see Figures 17 and 18).

As the rocky barrier at the mouth (1 m above MSL) is covered by a 1 to 2 m thick sand topping, and since the level of the mean high water spring-tide at Elands Bay is about 1,7 m above Chart Datum (CD), (about 0,8 m above MSL), washover from the sea is only possible during very high spring storm surges. The South African Tide Tables for March 1985 (equinox period) give a maximum sea level of CD + 2,03 m, or 1,13 m above MSL. This means that, assuming a top elevation of the sand bar at the mouth of 3 m above MSL, equinoctial spring storm waves have to run nearly 2 m vertically along the beach face to over-wash the bar and feed sea-water into the estuary.

During the ECRU survey on 23 March 1985, the sand bar at the mouth was 30 to 35 m wide between the high water (swash) line and the water's edge of the estuary, the water nearly reaching the crest of the bar. At the sea side, the bar had an inclination of only 2° to 3°.

The sea was relatively calm (1 m swell) and there was no sign of washover visible. It could, however, be envisaged that heavy seas do wash over the bar, which is also indicated by kelp debris present in the estuary behind the bar. During severe storms in May 1984, kelp debris was swept upstream over the first causeway.

FIG. 18: Verlorenvlei Estuary mouth showing the causeway (Obstruction 1). (Photo: ECRU 85-06-09).

The water in the estuary pool behind the bar was very salty (48 parts per thousand). This hypersalinity is caused by a combination of endogenous salinities of the feeder rivers (3 parts per thousand) plus washover from the sea (35 parts per thousand under the influence of high summer evaporation).

The estuary breaks out to sea during winter floods. When this happens, the sand-topping of the rocky bar at the mouth is scoured away, which establishes a short-lived (according to local inhabitants: 'a couple of weeks') tidal exchange. The tide then penetrates the entire estuary and spreads sea water salinities up to the road bridge (Figure 17), where it mixes with the water of the main body of the lake. During winter, Verlorenvlei becomes almost fresh as a result of the inflow from the rivers (see Section 3.2.5, Table 5).

b. Concrete causeway 500 m upstream of mouth (Figures 17, 18 and 19; Obstruction 1).

This causeway connects a fishing settlement with the gravel road leading to the crayfish factories at Baboon Point. The causeway is constructed on a rocky base which already formed a natural sill across the estuary channel. It is elevated about 1 m above the channel bed.

According to Robertson (1980), this causeway was constructed by a private land-owner, and was extended in 1970. It had no culverts, the consequent obstruction causing flooding upstream and preventing fish migration, possibly contributing to a decline in the harder (mullet) population in the system. In terms of its authority under the Water Act of 1956, the Piketberg Divisional Council replaced the causeway in December 1975 with one with culverts but failed to remove the rubble from the original crossing.

There is no record of a permit having been granted for the construction of this causeway on State land. It is, therefore, suggested that a permit be issued subject to conditions which will ensure restoration of the natural function of the estuary.

FIG. 19: Lower reaches of the Verlorenvlei Estuary showing obstructions 1 and 2. (Photo: ECRU 85-06-09).

Because of the blockage, flood waters are dammed behind the causeway. This causes heavy siltation of the channel more than 100 m upstream. A hollow in the low dune ridge seaward of the causeway indicates a possible breaching site if flood discharge from the Verlorenvlei is hampered by the causeway. Locals report that during floods, this causeway is sometimes overtopped, so that the fishermen's village can only be reached by a road from the sea and hotel side.

A recent development could have severe impacts on the entire coastal lake system. The lower causeway (Obstruction 1) was completely and permanently blocked with concrete, while the upper causeway was filled with rubble (Lane and Sinclair, May 1985, pers. obs.). At the time of observation, kelp was floating in the water on the seaward side of the lower causeway, indicating recent intrusion by the sea.

The persons responsible for the blockage are not known, nor is the authorizing agency, if any. It is likely that the blockage was intended to reduce marine inflow and therefore salinity in the vlei water, while maintaining the vlei level, possibly for irrigation purposes. This action completely blocked the free flow of water in the estuary, isolated the section between the causeways from any water supply except seepage, and could have adversely affected vlei vegetation, the use of the vlei by waders, and fish migration. This obstruction was removed after representation by the Dapartment of Environment Affairs to the Swartland Divisional Council, and was subsequently replaced. Further action is urgently required to maintain free water movement in the Verlorenvlei as a whole.

c. Rubble causeway at the railway bridge (Figure 17, Obstruction 2; and Figures 20 and 21).

This causeway is situated about 1 km upstream of the mouth and forms part of the maintenance road which runs along the Sishen/Saldanha railway line, constructed in 1974 by the railway authorities.

The road is raised 1 m above the river bed on a crude rubble-and-clay causeway, and the drum-culverts underneath it have proved totally inadequate for free water flow. After bridge construction, a 6 m wide trench was opened across this road, but the gravel dammed the channel. In 1979 the gravel was removed, but in June 1979, another access road was built with gravel (Robertson, 1980). This road periodically obstructs water and fish movement, as the culverts are almost completely blocked. The concrete columns of the railway bridge do not obstruct water flow. It is ironic that thousands of rands were spent to build a bridge which does not obstruct water movement, only to be negated by the building of a 'temporary' causeway to facilitate bridge construction.

The temporary breaching of the causeway by a narrow channel, visible on the aerial photographs of 12 May 1979 and 1 April 1980, shows sediment flow patterns which demonstrate the constricting and obstructing effect of this road embankment.

d. Pedestrian pathways (Figure 17, Obstruction 3; and Figure 22).

Shallow sanded-up sections in the channel, 350 m and 850 m upstream of the railway bridge (that is, 1,4 km and 1,9 km upstream of the mouth) are used during dry periods by pedestrians crossing from the village on the north bank to the workshops at the south bank (Figure 17). Particularly the upper ford, upstream of a circular island, shows heavily-compacted, and probably artificial, crudely built-up tracks. Water-flow at these sections is almost non-existent.

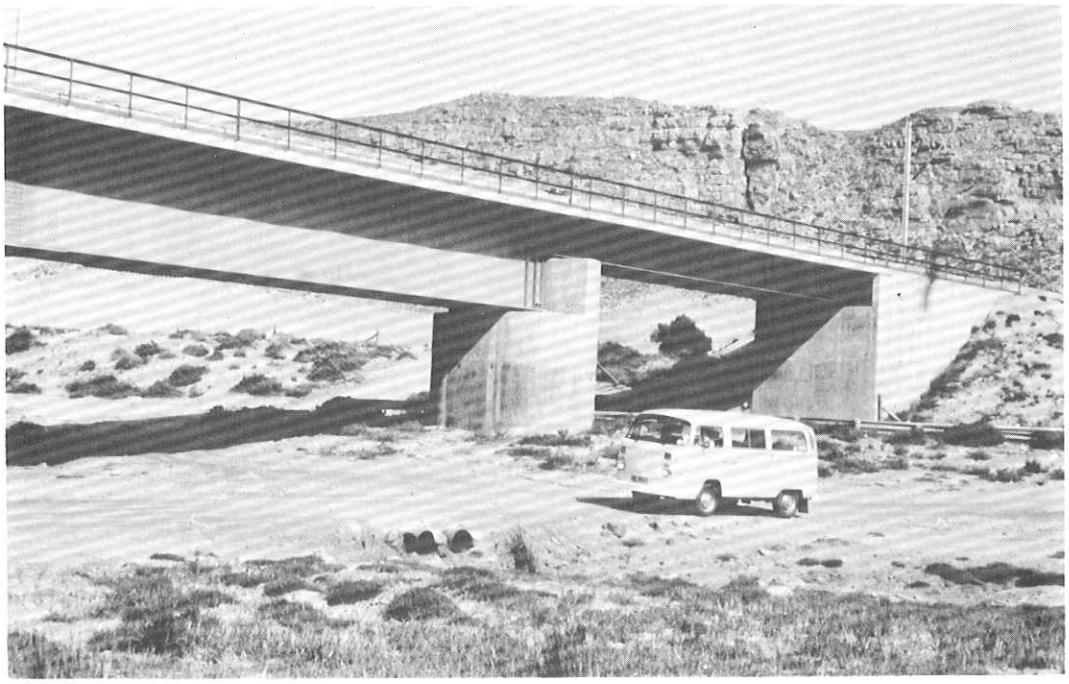


FIG. 20: The causeway below the Sishen/Saldanha railway bridge, showing the lack of water in the vlei in May 1980. (Photo: ECRU, 80-05-02).

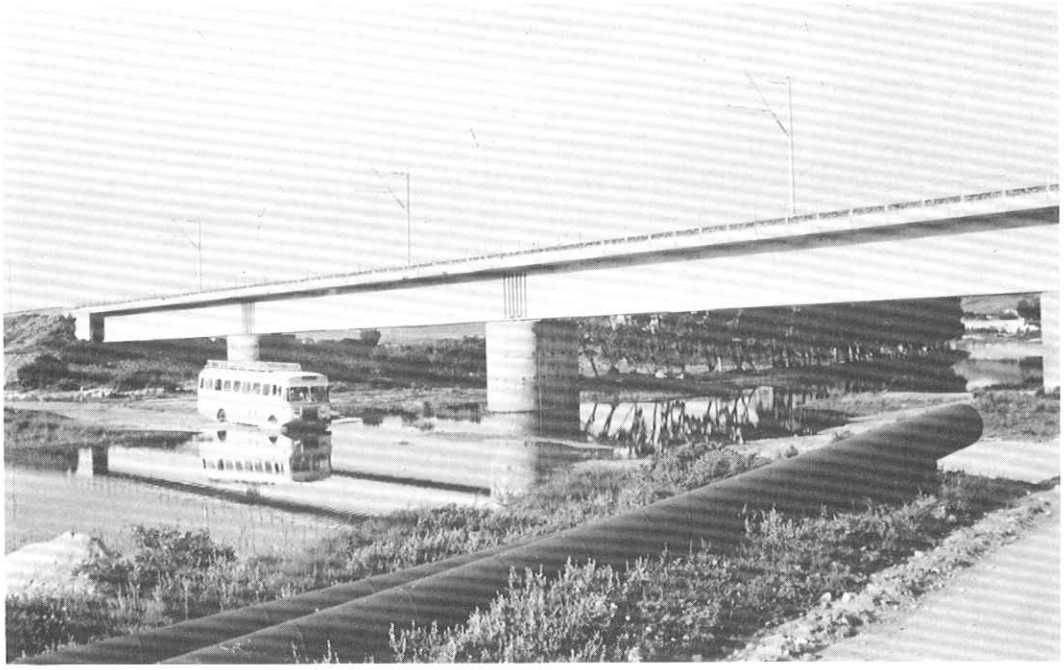


FIG. 21: The causeway below the Sishen/Saldanha railway bridge, showing the water level in July 1985. (Photo: ECRU, 85-07-07).

The upper, very shallow section appears also on earlier aerial photographs from 1960, where the entire area of some 300 m up- and downstream of the island appears to be sanded-up and dry. At present, only the estuary arm north of the island contains some stagnant water, while the southern arm consists of dry sand.

e. Road causeway (Figure 17, Obstruction 4; and Figure 22).

The gravel road from the south to Elandsbaai crosses the uppermost narrow section of the estuary channel (2,6 km upstream of the mouth) via a 180 m-long embankment, about 2 m above bed level. About 20 percent of the length of the causeway is open, with four large square culverts which allow normal flow to pass through.

FIG. 22: Narrowing of the Verlorenvlei into a channel, with Obstructions 3 and 4. (Photo: P D Morant, October 1980)

The culverts are, however, insufficient to allow a spate flood to pass through, as in 1977, when damming-up of water to road level led to inundation of the low marshy pastures around the vlei, and of several causeways on farms at the head of Verlorenvlei.

3.2.3 Inshore Oceanography

In Elands Bay, a north-going longshore current is induced by the oblique incidence of the predominant southerly and south-westerly deep-sea waves (Figure 23). Even after diffraction around Baboon Point, and partial alignment parallel to the beach by refraction, these waves mostly retain a southerly angle of approach to the coast which provides sufficient energy to move the surf-zone water to the north.

An opposing southward component of the longshore current seems to be alternately generated by differential wave set-up caused by diffraction of the southerly and south-westerly waves around Baboon Point.

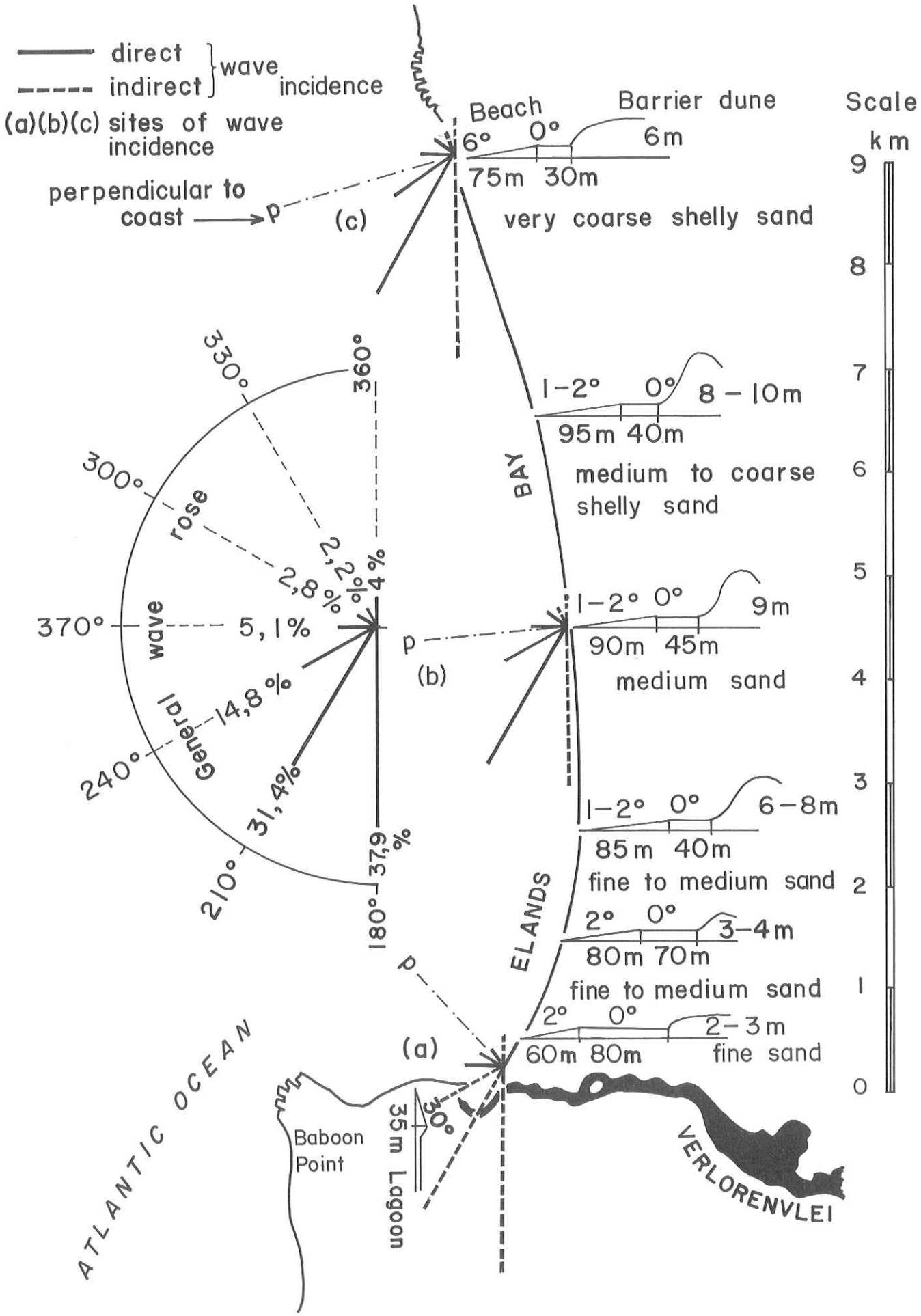


Fig. 23: Wave incidence and beach conditions, Elands Bay

(from Fromme, 1985)

At Baboon Point, the southward flow is deflected out to sea. This is indicated by strong rip currents in the southern bay. It seems, however, that sand washed out to sea from the southern beaches by the rip currents is re-cycled to the beach by the general north-trending energy flux caused by the predominant waves from the south.

The north-going component of the longshore current appears to be predominant, as expressed in narrower beaches in the south than in the north. The consequent losses of beach in the south seem, however, to be adequately compensated by sand supply from south of Baboon Point and occasional outbreaks of the Verlorenvlei Estuary, and by re-cycling of sand via the rip currents in the southern corner of the bay. Flat equilibrium beach profiles seem to be proof of this (Figure 23).

When calm conditions prevail in summer and cold upwelling is limited, red water sometimes occurs in Elands Bay. This is caused by the accumulation of planktonic dinoflagellates, one of which *(Gonyaulax catenella)* is toxic, and causes mussels to become dangerously poisonous (Grindley and Sapeika, 1969).

3.2.4 Estuary Mouth Dynamics

The entire channel is very shallow (about 0,5 m deep), tending to inhibit free water circulation. As mentioned earlier, a natural obstruction at the mouth is a rocky sill topped by a sand bar, above the normal reach of high tides. The sand-topping is formed by a south-going longshore current, in combination with frequent onshore winds. A very shallow sanded-up section at the island (1,4 to 1,9 km upstream of the mouth (Obstruction 3), further impedes the influx of sea water, or estuarine tidal or flood flow.

Secondly, the very shallow passage, which is virtually only active during rare winter floods or very high spring-tide storm surges, is seriously obstructed by the two crudely-constructed causeways, situated 0,5 km and 1 km upstream of the mouth (Obstructions 1 and 2). They contain completely inadequate culverts, and should be removed completely if estuarine circulation is to be improved.

The third causeway (Obstruction 4) at the upper end of the estuary channel (2,6 km upstream of the mouth), which carries the main road link from the south to Elandsbaai and Lambert's Bay, contains large culverts allowing free water circulation during normal, but not during flood conditions. The construction of a proper bridge, or at least the insertion of more culverts, is necessary.

Aerial photographs taken in 1960, 1971, 1979 and 1980 show (with the exception of variations of the water level in Verlorenvlei) no significant changes in the configuration of the estuary or beaches and surrounding dune areas.

It is the arid climate and the minimal flow in the three feeder rivers, which contribute largely to the physical stability of this estuary. The moderate sea conditions of the west coast, compared with the south or east coast, do not cause great changes from the seaward side.

The geomorphology of the estuary suggests, and the geology of Verlorenvlei (estuarine fossil beds in the vlei, and an ancient deep channel discovered under the railway bridge) proves, that only small rises in sea level, or a small deepening of the channel, would convert it into an open estuary. No significant changes of the configuration appear to have taken place in the recent past.

The 200 m high promontory of Baboon Point protects Elands Bay against the predominant southerly winds and deep-sea waves. This protection creates a sheltered corner at the southern extremity of the bay and at the Verlorenvlei Estuary mouth. The further the bay emerges from this shelter towards the north, the higher is the wave energy received on its beaches.

The two types of wave-induced inshore currents, one north-going and the other southward, appear to keep an hydraulic and sedimentological near-equilibrium at the beach (Section 3.2.3 and Figure 23). Consequently, provided the balance (including sources of sand) is not disturbed, a sufficient sand supply from the beach will always tend to cover the rocky barrier at the mouth, to such an extent that the mouth has little chance to remain open for any appreciable length of time after breaching.

In order to upgrade the estuary and enhance the estuarine water circulation, it is clear that the four artificial obstructions in the channel must be removed, or replaced by longspan bridges.

3.2.5 Physico-chemical Characteristics

Physico-chemical characteristics of Verlorenvlei were investigated by Robertson (1980), and by postgraduate students of the University of Cape Town. Analyses of concentrations of nitrate, nitrite, inorganic (reactive) phosphate, total phosphorus (inorganic and organic) and silicate were carried out in the drought year of 1978 (University of Cape Town). Photosynthetic activity was low, giving rise to a pH lower than in some years, when pH had been approximately 8 at all stations. The low photosynthetic activity was confirmed by relatively low levels of all nutrients.

pH

The pH ranges from 6,7 to 9,6, with most values on the alkaline side (Robertson, 1980). The pH is lower near Redelinghuys than in the vlei itself. This suggests either a higher contribution of alkalinity from ground water seepage into the vlei than from river input, or the concentration of alkaline salts in the vlei through evaporation (Robertson, 1980). The former results because ground-water flow is much slower than surface flow, allowing a longer time for solution to occur. Nearer the sea, the effect of sea water intrusion and the buffering capacity brings the pH to near 8.

Temperature

Temperature sampling was carried out from shallow shoreline sites where the temperature can be expected to be higher than in deeper areas (Robertson, 1980). As mid-summer and night measurements were not taken, the temperature range is likely to be greater than shown by Robertson's measurements. Mean temperatures at the various stations range from 15,2°C at the mouth to 20,4°C at Redelinghuys at Robertson's Station 11 on the north shore approximately 10 km from the mouth.

Transparency

Water transparency measurements (Secchi disc method) vary from 17 to 114 cm, with a mean value of 36,6 cm (University of Cape Town, 1978). In 1976, an extremely high density of phytoplankton was present, which limited light penetration.

Nutrients

Measurements carried out by postgraduate students of the former School of Environmental Studies at the University of Cape Town in 1978 indicate that Verlorenvlei is an oligotrophic system. The nutrient status of the vlei, however, will vary with the water level. As the water recedes during the summer the lake will become mesotrophic, and possibly even eutrophic. Nitrate levels exceeded those of nitrites, although both nutrients were absent at the mouth during the drought period of 1978, having been high during 1976. During 1978, total phosphate was high at the mouth, with high values also occurring at the railway bridge approximately 1 km upstream, which may be due to phosphate enrichment from the droppings of large numbers of birds in the vicinity of this station. Silicate concentration was relatively high at all stations, suggesting that this is not a limiting factor for diatom growth.

Salinity

Robertson (1980) measured salinity at five stations along the vlei, with results showing a decline in salinity with increasing distance from the sea. On the eastern side of the railway bridge, salinity was 11,5 parts per thousand; on Verlorenvlei Farm shoreline it was 3,5 parts per thousand; further up on the north bank it was 1,8 parts per thousand; closer to Redelinghuys it was 0,5 parts per thousand; and at Redelinghuys Bridge it was 0,6 parts per thousand.

The cation ratios for sodium (Na), magnesium (Mg), calcium (Ca) and potassium (K), of the Verlorenvlei samples deviate significantly from those of sea or average river water. The order of abundance of the four cations is as listed above. A large amount of Na enters the vlei in the river, and there also appears to be an enrichment of Ca. The values also indicate the enrichment of Na, Mg and Ca in vlei water as opposed to pit water, which has seeped through sandy slopes (Robertson, 1980).

The Malmesbury rocks which underly about 50 percent of the catchment contain high concentrations of mineral salts, mostly in the form of sodium chloride. The enrichment of Na in the vlei water is derived from this source. Limestone deposits are a characteristic of the area and result in enrichment of Ca.

In contrast, Tertiary to Recent sands are low in salts. This is reflected by the lower concentration of Ca and Na in water that seeped from the northern bank of Verlorenvlei into an irrigation pit, which was also sampled.

Dissolved oxygen

The vlei water is generally well-oxygenated, both on the surface (highest value 13,2 mg per litre), and below. Levels measured in 1978 (University of Cape Town), closely represent the oxygen content of fresh water saturated with air at normal pressure (760 mm Hg), and indicate little or no photosynthesis. Where the mud is thick, and the water shallow and slow-flowing, oxygen concentrations are reduced to as low as 3,6 mg per litre (Robertson, 1980).

Wind and water circulation

There are no data on the wind regimes, or on water circulation patterns under the influence of the main wind regimes.

A recent survey was undertaken (ECRU, 28 September 1985) when the water level was high and when there was active discharge to the sea. The entire water body was fresh (salinity less that 1 part per thousand), and there was no thermal stratification. The system was well-oxygenated throughout, although the bottom values were slightly lower than those obtained at the surface (Table 5).

3.2.6 Pollution and Public Health Aspects

Local residents warn against swimming in the vlei in the vicinity of the road bridge to Elandsbaai, and one case of illness (vomiting and dysentery) has been reported after swimming in the vlei water. Low levels of dissolved oxygen, and a high nitrate level, suggesting organic pollution, were recorded along the south shore east of the Verlorenvlei settlement during the drought year of 1978 (University of Cape Town, 1978).

TABLE 5: Physico-chemical survey. Verlorenvlei, 28 September 1985

Station	Depth (m)	Dissolved oxygen (mg/l)		Salinity (‰)		Temperature (°C)		Secchi (m)	Water colour
		Top	Bottom	Top	Bottom	Top	Bottom		
1: 10h15	2,4	10,5	7,8	1,1	1,0	17,7	16,5	0,8	Greeny-brown
2: 12h15	5+	9,6	7,6	0	0	17,9	17,2	0,7	Browny-green
3: 12h50	5+	9,6	8,9	0	0	17,9	17,3	0,8	Browny-green
4: 13h25	2,5	9,2	7,1	0	0	18,1	17,1	0,6	Browny-green

Notes:

Station 1: Opposite Lambert's Bay road. Extensive *Myriophyllum* cover. Substrate fine unconsolidated greyish organic mud.

Station 2: Opposite Nuwerus. No *Myriophyllum*. Wind: WNW.

Station 3: Opposite Muishoekberg beacon. No *Myriophyllum*. Substrate fine dark grey organic mud. Wind: WNW waves ca. 0,3 m.

Station 4: Opposite Muishoek farm. No *Myriophyllum*. Substrate very fine black mud (no H_2S smell). Wind: W.

(Station names appear on the 1:50 000 topographic map 3218 AD Elandsbaai).

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton/Diatoms

No detailed work on the phytoplankton of Verlorenvlei has been undertaken. However, some phytoplankton productivity measurements have been carried out at various times of the year. Results indicate generally low levels of productivity, to be expected in view of the oligotrophic nature of the vlei water at the time of the study (Robertson, 1980). Variations in water transparency at different times of the year suggest changes in phytoplankton abundance, although this turbidity is due partly to variations in suspended solids (Robertson, 1980).

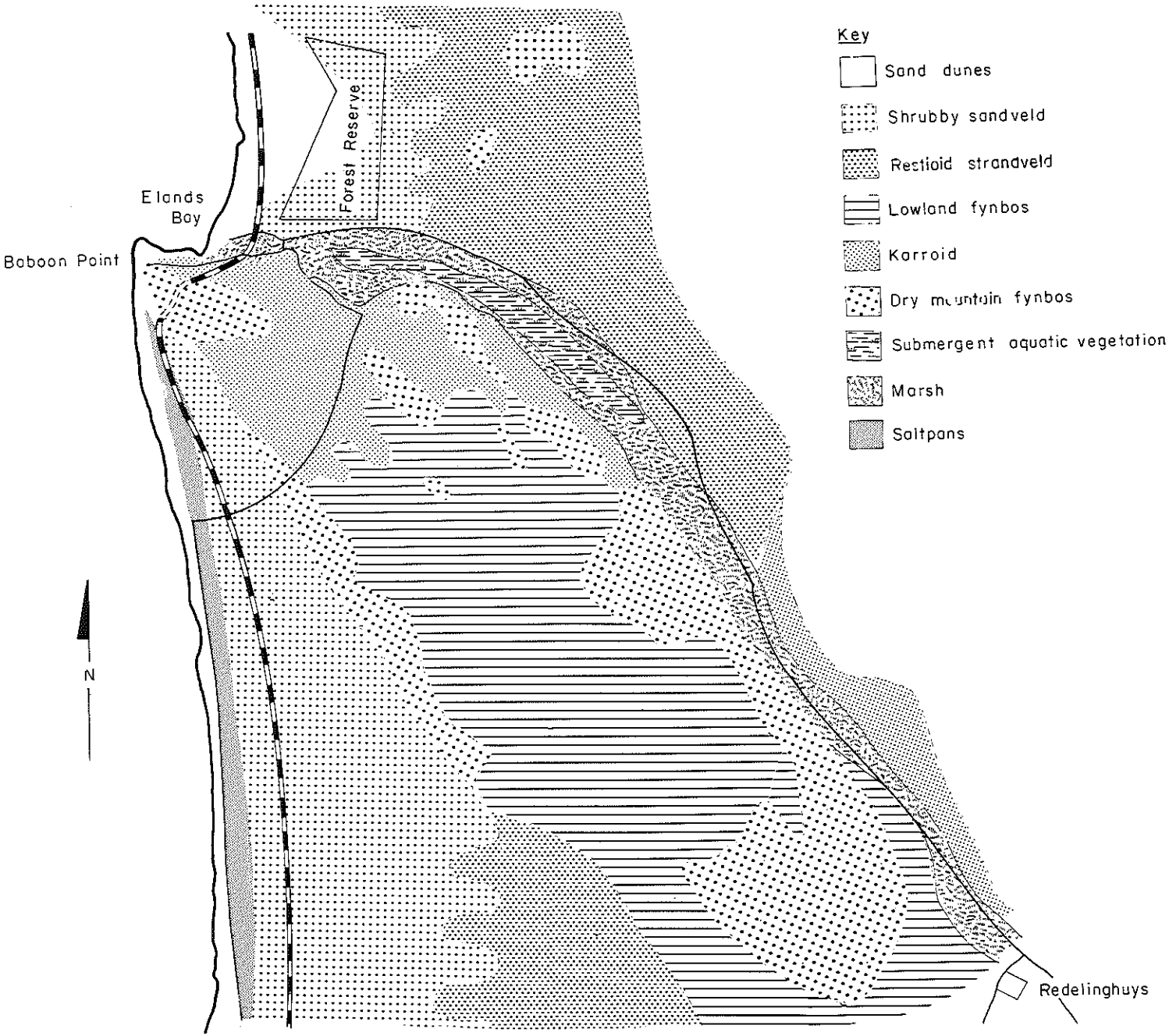


Fig. 24: Vegetation of Verlorenvlei and environs
(Botanical survey and mapping by S. Dean, S.B. Lane and F. Stemmet; 1986)

4.1.2 Algae (Shore and Estuary)

No detailed work on the algae of Verlorenvlei, either on the shore or in the estuary, has been carried out.

Large masses of filamentous green algae, including *Chaetomorpha* and *Cladophora*, are common in the channel, particularly between the railway bridge and the lower causeway, where the water is often stagnant and hypersaline (Robertson, 1980).

Other filamentous algae from this area, identified by R Simons of the Sea Fisheries Research Institute's Algology Research Unit in November 1975 and September 1979, included *Enteromorpha compressa*, *Enteromorpha* sp. indet., *Cladophora* sp., *Percusaria* sp. (Ulvaceae), *Lyngbya* sp., *Phormidium* sp. (Lyngbyaceae), and *Urospora* sp. (Cladophorales).

Blooms of algae, including blue-green algae such as *Microcystis aeruginosa*, occur in spring. Certain strains of *Microcystis* are toxic to domestic animals, but no farmers in the Verlorenvlei area have reported stock losses from this cause (Robertson, 1980).

4.1.3 Aquatic Vegetation

The indigenous *Myriophyllum spicatum* (sub-aquatic macrophyte) dominates large areas of the vlei at various times. *M. spicatum* is able to grow in slow-flowing water up to about 2 m deep, where it can root itself in the mud. At Verlorenvlei, it grows extensively in the upper reaches below the reed beds, and in the lower reaches where the reeds extend into the vlei. When the water level drops at the end of summer, it forms thick mats. After the winter rains, the plants become submerged. *Myriophyllum* provides food for fish and birds, and is eaten by cattle and horses, which wade deep into the water to reach it. Other plants and animals become attached to or associated with *Myriophyllum*, supplementing this food source. *Myriophyllum* also plays a role in oxygenating water through photosynthesis (Robertson, 1980).

From 1980 the *Myriophyllum* declined and disappeared completely for a time. It reappeared in 1983 and has since recovered so that by September 1985 considerable areas of the vlei in the vicinity of the Verlorenvlei farm were again covered by this plant (Table 5, notes).

4.1.4 Terrestrial Vegetation

The following description of the vegetation of Verlorenvlei and its environs was compiled by S Dean, botanical consultant *(in litt.)* based on field surveys and mapping carried out for the Department of Environment Affairs in 1986 (Figure 24).

Many researchers have noted the botanical importance of Verlorenvlei and its environs, because of its position at the transition between the Karroid and Fynbos vegetation types. The region, therefore, has a high diversity typical of an ecotone area.

In 1980, S Lane and S Milton (Lane, 1980) drew up a map of vegetation patterns around the Verlorenvlei coastal lake, to indicate what the vegetation would be, had it not been disturbed by cultivation and grazing, and were it allowed to regenerate. This map was based on field surveys by the two researchers, aerial

FIG. 25: Reed houses previously on southern shore of Verlorenvlei. (Photo: P D Morant, October 1976).

photographs, and mapping of soil types. Subsequently, botanical mapping was carried out for the Fynbos Biome programme, using satellite imagery, but the maps give only a broad indication of vegetation patterns in the region (Moll and Bossi, 1983).

There was, therefore, a need to obtain a more detailed and extensive vegetation map for the Verlorenvlei region, which could provide a baseline map for further refinement in the course of botanical field research. This map has been compiled by S Dean (formerly Milton), based on photographs, orthophoto maps, existing vegetation maps and extensive field surveys. The vegetation map (Figure 24) is provisional, in the sense that it must be refined in the course of future research.

The different vegetation types that have been mapped are:

1. Strandveld
   a. Seaward dune strandveld
   b. Shrubby strandveld
   c. Restioid strandveld
2. Saltpan Vegetation
3. Lowland Fynbos
4. Dry Mountain Fynbos
5. Mountain Fynbos
6. Karroid Shrubland
7. Marsh Vegetation

1. Strandveld

The three types of strandveld that have been identified intergrade, changing with distance from the seashore and with sand dune stability.

a. *Seaward dune strandveld*

Boucher (1981) has provided a general description of the vegetation of west coast dune plumes. The vegetation of unstable littoral dunes is characterized by low, sprawling evergreen shrubs, grasses and annual herbs. The trailing stems of many of these plants root at the nodes, thereby compensating for sand movement. The succulence prevalent in littoral plants is a feature shared with plants of other saline or highly-alkaline substrates. Boucher and Jarman (1977) describe this vegetation (as it occurs at Langebaan) as 'littoral dune open grassland.' Characteristic plants are: *Didelta carnosa, Hebenstreitia cordata, Carpobrotus* spp., *Senecio maritimus, Senecio elegans, Arctotheca* cf. *nivea, Eragrostis cyperoides, Ehrharta villosa* and *Tetragonia* spp.

The alien *Acacia cyclops* has been planted along unstable dunes, from whence it has spread into inland deflation hollows and to disturbed areas such as road margins. Deflation hollows and unstable inland dunes support vegetation similar to that of littoral dunes, and share such species as *Eragrostis cyperoides, Carpobrotus* spp. and *Hebenstreitia* sp.

b. *Shrubby strandveld*

This shrubby, evergreen community inland of the littoral dunes comprises clumps of succulent or broad-leaved sclerophyll shrubs up to 3 m in height. Interspersed with the bush-clumps are grasses and smaller shrubs, many of which are succulent or drought-deciduous. During the winter, annual herbs and geophytes increase the cover to beyond the *ca.* 40 percent supplied by perennial vegetation. Grasses and herbs dry out towards the end of summer, and are heavily grazed by cattle, sheep and goats. This vegetation has been described for the Langebaan area (Boucher and Jarman, 1977) as 'consolidated dune dense evergreen shrubland.' It also conforms with Acocks Type 34: 'Strandveld' (Acocks, 1975).

Characteristic species include evergreen shrubs such as *Rhus* spp., *Euclea racemosa, Diospyros* sp., *Colpoon compressum,* the spinescent *Maytenus lucida* and *Putterlickia* sp; drought-deciduous and spinescent shrubs such as *Lebeckia, Lycium* and *Protasparagus;* and non-spinescent *Zygophyllum, Salvia,* and *Eriocephalus.* Many of the bush-clump shrubs bear bird-dispersed fruits, as do a number of the creepers associated with bush-clumps: *Galium, Kedrostis, Protasparagus, Microloma, Cynanchum,* and *Cysticapnos* .

Succulents include *Euphorbia mauritanica, E. caput-medusae, Crassula, Tylecodon* and a number of shrubby and creeping mesembryanthemums and Asteraceae. *Helichrysum, Limonium perigrinum* and asteraceous herbs such as *Felicia, Senecio, Pteronia,* together with geophytes *Trachyandra, Albuca, Lachenalia, Ferraria, Antholyza,* and grasses *Ehrharta* spp. and *Pentaschistis,* seasonally provide cover between bush-clumps.

On clayey substrates and road verges, the proportion of Karroid shrubs and succulents increases and evergreens decrease, as strandveld intergrades with succulent Karroid vegetation.

c. *Restioid strandveld*

Perennial cover in this type is dominanted by *Willdenowia incurvata.* Scattered clumps of evergreen shrubs include *Diospyros glabra, D. natalensis, Olea europea, Euclea racemosa, Rhus* spp., *Maytenus* and *Putterlickia pyracantha* as well as succulent Euphorbiaceae and mesembryanthemums.

Geophytes and grasses continue to be important, as do annuals. The proportion of drought-deciduous, thorny and succulent shrubs is lower than in Shrubby sandveld. The general height of the vegetation is 1-2 m, with the bush-clumps rising above this height. Boucher and Jarman (1977), in describing this type at Langebaan, refer to it as 'dense evergreen restioid shrubland.'

On leached sands further from the coast, Restioid strandveld intergrades with Lowland Fynbos. The ericoid element increases and the restioid component becomes more diverse, as succulence decreases and evergreen bush-clumps are replaced by scattered proteaceous shrubs.

2. Saltpan Vegetation

Saline, marshy areas with a dense cover of low-growing, halophytic vegetation, are found immediately inland of the seaward dunes between Velddrif and Wadrifsoutpan, as well as around the mouth of the Verlorenvlei, along the margins of Wadrifsoutpan, and in the bed of its influent river.

This vegetation varies in composition with the degree of salinity, but comprises a number of Chenopodiaceae (including *Salicornia*, *Sarcocornia*, and *Chenolea*), *Limonium*, *Sporobolus virginicus*, *Triglochin*, *Cotula*, *Plantago* and *Onixotis (Dipadax)*. Despite their salinity, these pans are grazed by cattle and sheep.

Aizoon, *Mesembryanthemum crystallinum*, *Salsola kali*, and *Cynodon dactylon* are found on these saline flats, and on road verges, as well as on the offshore guano islands, an indication of their tolerance of high nitrogen and halide levels.

Juncus is found along the high water level of the saltpans, as well as fringing open water bodies, such as the Verlorenvlei itself.

3. Lowland Fynbos

This type occurs on deep sand. It ranges from restioid types, where Restionaceae provide 50-60 percent of the cover, to a more diverse type where the Proteaceae and ericoid shrubs provide over 50 percent of the cover. In the dry season, Lowland Fynbos cover is 30-40 percent.

Lowland Fynbos lacks most of the drought-deciduous and succulent elements which characterize the Strandveld and Karroid types, and grasses are less abundant. The vegetation is 1-2 m high, the Proteaceae generally being taller than the ericoid shrubs and Restionaceae.

Characteristic genera and species are:

Nylandtia spinosa
Diospyros glabra
Asparagus
Cynanchum
Mesembryanthemum
Rhus
Stoebe
Lessertia
Aspalathus divaricata
Heliophila
Maytenus
Brunsvigia
Dodonea
Serruria
Leucodendrum pubescens
Leucospermum
Metalasia
Willdenowia
Crassula
Passerina
Chondropetalum
Grielum
Phylica stipularis
Anthospermum

Where shallow sand occurs over clay, as on the Baboon Point plateau, the topography is generally flat and the soils nutrient-rich. For this reason, they have been ploughed and grazed for over 200 years, and little natural vegetation remains. Such areas probably bore a mixed vegetation, karroid species predominating where termite activity brought clay to the surface, and Lowland Fynbos in the sandy matrix.

4. Dry Mountain Fynbos

Structurally and floristically, this vegetation resembles arid fynbos types described by Taylor (1978), Milton (1978), Boucher (1980), and Milton and Linder (1980).

Dry Mountain Fynbos is found on sandstone outcrops including Baviaanspunt, Olifantsberg and Grootberg to the south of Langvlei, as well as outside the Verlorenvlei study area on the lower slopes of the Cedarberg and Olifants ranges, on either side of the Olifants River valley. Vegetation ranges from small-leaved sclerophyll shrub-land with a high percentage of succulent and drought-deciduous shrubs on shale-sandstone interfaces, to evergreen shrubland and scrub forest in gullies and on shaded cliffs. Diversity and cover by such major Fynbos families as Ericaceae, Restionaceae and Proteaceae is lower in dry fynbos types than in the mountain fynbos at higher altitudes and in more mesic conditions.

Scrub forest elements include: *Olea europaea* subsp. *africana, Maytenus oleoides, Podocarpus elongatus,* and *Rhus undulata.* Characteristic species of cliffs and rocky sites are *Phylica oleoides, Heeria argentea, Diospyros glabra, Solanum incanum, Euryops abrotanifolius, Ficus cordata, Aloe* spp., *Buddleja* sp., *Salvia* sp., *Crassula, Conophytum, Velthemia, Spiloxene,* and *Babiana.* On sandy soils, the fine-leaved sclerophyll element increases to include *Phylica,* spp., *Passerina glomerata, Stoebe* spp., *Struthiola, Thesium, Anthospernum, Agathosma, Aspalathus,* and *Helichrysum,* as well as Restionaceae, sedges, *Dodonea viscia,* and *Leucodendron pubescens.*

On lower slopes where the clay content of the soil is higher, karroid genera such as *Tylecodon, Carpobrotus, Euphorbia, Elytropappus, Ruschia, Felecia, Eriocephalus, Senecio, Othonna, Pelargonium,* and *Hermannia* make their appearance.

At the break slope between shale and sandstone, there are often cracks and hollows in the rocks, which have been used for centuries by dassie colonies, periodically by sheltering animals, and in some cases by man and his livestock. The plant communities found on the nitrogen-rich soils around such sites typically comprise low-growing succulents, herbs and grasses, and have a high annual and geophytic component.

Together with annual grasses, the following occur:

Aizoon canariense
Ursinia
Empodium
Rumex
Oxalis spp.
Cynodon
Manulea
Crassula
Cotula
Haemanthus
Echinochloa
Arctotheca calendula
Urtica
Sutera
Romulea

Bushes include *Eriocephalus, Rhus incisa, Rhus undulata, Didelta spinosa, Ruschia, Lycium, Pteronia,* and *Montinia.*

5. Mountain Fynbos

In the Verlorenvlei catchment this vegetation type occurs only marginally on the higher mountain ranges above 1 000 m. It resembles true mountain fynbos (as described by Taylor, 1978) in that it is dominated by Restionaceae, and evergreen schlerophyllous shrubs, including Asteraceae, Ericaceae, Proteaceae, Bruniaceae, and Fabaceae. Cover generally exceeds 70 percent and the vegetation is stratified, with the proteaceous shrubs up to 3 m in height standing out above the ericoid layer. Sedges, grasses, geophytes and perennial herbs form a field layer.

Mountain fynbos occurs on shallow, acid soils on sandstone, and in moist sites, on shales. In the Het Kruis area, dominance of the fynbos by *Protea laurifolia* indicates that in the Verlorenvlei area it is transitional to Dry Mountain Fynbos, that is, Arid Fynbos, as described by Taylor (1978).

6. Karroid Shrubland

On the shaley, lower slopes of sandstone koppies, there is a shrub community with karroid affinity. Drought-deciduous and succulent species dominate, including *Athenasia parvifolia, Galenia africana, Galenia crystallinum,* many shrubby mesembryanthemums, *Hermannia, Pteronea camphorata, Atriplex, Tylecodon, Zygophyllum, Protasparagus, Crassula, Lycium, Euphorbia* sp., *Eriocephalus, Felicia, Grielum,* and *Lebeckia.*

7. Marsh Vegetation

Detailed descriptions of semi-aquatic vegetation can be found in Robertson, (1980), and Lane (1980). Marsh vegetation includes that typical of moist, undifferentiated saline alluvial soils of the vlei and pans (Lane, 1980). Verlorenvlei exhibits a transition from salt tolerant species near the mouth to fresh water species further inland. Pans occur to the landward side of the dunes, and have similar vegetation communities to those found at the vlei mouth. Predominant species include: *Sarcocornia natalensis, Scirpus maritimus, Mesembryanthemum crystallinum,* and the salt-tolerant, but not -dependent, *Juncus kraussi.*

In the less saline areas, *Typha capensis, Phragmites australis, Cyperus marginatus, C. fastigatus* and *Juncus kraussii* are predominant on land. *Juncus kraussii* provides a useful indicator of the high-water level of the vlei. Reed bed distribution is affected by factors such as water table, salinity, and substrate.

Phragmites australis is the dominant reed because of its ability to tolerate saline water. It fringes the vlei, with its landward growth limited by water availability, and apparently indicating the level to which the water table may drop in summer. Its outward growth is limited by water depth.

Typha capensis is less tolerant of saline water and is frequently found on the landward side of the *Phragmites.* Although this may be unfavourable during dry periods because *Typha* requires a higher water table than *Phragmites,* it benefits from the less saline seepage water on the landward side.

Reed distribution is affected by factors such as water-table, salinity, and substrate. Distribution patterns have remained relatively similar over the period 1947 to 1980, as shown by an examination of a sequence of aerial photographs.

The reeds surrounding the vlei (Figure 24) are dominated by *Phragmites australis*, with smaller communities of *Typha capensis*. Downstream of Redelinghuys fairly wide and open wetlands occur, with patches of mixed sedges and reed communities. After about 8 km, the valley narrows, and the reeds (mainly *Typha*) become denser. About 2 km lower, below Grootdrif Farm, the reeds form an expanse about 1 km wide for another 2 km. They then form fringes along both banks of the vlei, disappearing in places, which are often the points at which seasonal streams enter the vlei. The reed beds then increase in width again in the lower regions where the vlei narrows. There are no reeds in the channel connecting the vlei with the sea (Robertson, 1980).

According to Noble and Hemens (1978), stands of *Phragmites* may indicate areas 'where the water level is somewhat below the soil surface in the dry season', such as along the fringes of non-perennial streams. Thus the *Phragmites* below Redelinghuys may indicate a dry riverbed during summer. Mixed communities (including *Typha*, *Scirpus* and *Cyperus*) indicate a wetter situation 'where the water level remains close to the soil surface in the dry season'. The merging of *Phragmites* into *Typha* indicates a wetter area near the Grootdrif Farm. The probable presence of more perennial freshwater streams entering the vlei in the past is suggested by a sequence of historical maps (Sinclair, 1986c), and by the names of farms in the area, such as Klaarfontein, Mooifontein and Pietersfontein. Marshes merge into reed swamps where there is perennial water.

During summer droughts, the reed beds attract cattle grazing at the edges of the vlei. The cattle enter the mud surrounding the vlei in an attempt to reach the reed beds, at the same time increasing nutrient input at the vlei edges. They can be trapped in the mud, in danger of dying from exhaustion and starvation unless rescued.

The reed beds turn brown in winter. The tops of the reeds are harvested for use by the Directorate of Forestry in stabilizing the driftsands on the northern bank. The reed beds are also burnt annually in winter, the objective apparently being to provide food for cattle in the form of young reed shoots.

Reeds from the vlei were used in the construction of the 'langhuise' surrounding the vlei and in the Verlorenvlei farm settlement (Sinclair, 1980a). They were used in ceiling construction, while *Juncus kraussii* clumps were inverted for use as capping material on the thatched roofs. Some examples of houses constructed entirely out of reeds by the Coloured population existed until fairly recently (Figure 25).

'Heuweltjies'

These circular patches, dotted over the Strandveld, Renosterveld and Lowland Fynbos of the western Cape, support succulent and drought-deciduous plant communities which may differ greatly in structure and floristic composition from those of the surrounding vegetation.

Clearly visible as lighter circles in natural vegetation, or as darker circles on ploughed fields, 'heuweltjies' are patches of finer-grained soils 15-20 m in diameter, and slightly raised above the surrounding soil surface. 'Heuweltjies' contain large underground termitaria, and the distinctive vegetation they support is indicative of changes in soil texture and chemistry resulting from decades of termite activity. The termitaria extend at least 2 m into the soil, contain much organic matter and have a calcareous core. Heuweltjies attract termite-eating animals, such as the aardwolf *Proteles cristatus* and aardvark *Orycteropus afer*, the diggings of which are evident on most 'heuweltjies'.

Browsers and grazers appear to favour the 'sweet', grassy, and probably nutrient-rich vegtation of 'heuweltjies', and more dung is seen here than in surrounding vegetation. Typical plants of the heuweltjies are 1-2 m high drought-deciduous, spinescent shrubs such as *Lycium, Tylecodon, Lebeckia sericea, Hermannia, Didelta spinosa, Protasparagus, Zygophyllum,* and *Rhus.* Succulent shrubs also occur, including *Euphorbia mauritanica* and mesembryanthemum species. 'Heuweltjies' also support a number of grasses and annuals including: *Scrophulariaceae, Chenopodiaceae, Asteraceae, Aizoaceae,* and geophytes including *Oxalis, Urginea, Babiana,* and *Trachyandra.*

Sometimes the centre of a 'heuweltjie' is dominated by a single, large, evergreen bush, usually *Olea europaea* or *Euclea undulata.* In the vicinity of *Acacia cyclops* (rooikrans) infestations, this position is occupied by a rooikrans tree. These fruiting shrubs are often associated with the bird-dispersed species, including *Viscum, Protasparagus, Diospyros* and *Euclea.*

Conservation value of vegetation at Verlorenvlei

According to Boucher (1980), the Table Mountain Group ridges, to the south of the coastal lake, support a very interesting and exceptional Dry Mountain Fynbos vegetation in which low *Ficus cordata, Heeria argentea* and *Podocarpus elongatus* trees survive. This is probably the lowest rainfall at which this yellowwood species can exist.

Boucher also points out that the area is important for comparative studies between Coastal and Mountain Fynbos types, because the two vegetation types are in contact at Verlorenvlei. Acocks(1975) did not map any contact between these two veld types in the western Cape coastal foreland, and in fact, did not indicate the presence of either of these types in the area, recording only Strandveld vegetation.

The Verlorenvlei area shows a high degree of structural and physiognomic diversity (Lane, 1980). It is also characterized by low average total vegetation cover of less than 30 percent, partially relating to the degree to which evapotranspiration exceeds precipitation for substantial periods of time.

The low cover is exacerbated by use of the Verlorenvlei environs for rough pasture, with small and large stock being noted in almost all areas (Lane, 1980). Historical studies indicate that Verlorenvlei has been used for grazing, originally under a system of loan places, since the 1790s and probably earlier, as indicated by early travellers' journals (Sinclair, 1980a).

Overgrazing and trampling appear to have caused dramatic changes in the vegetation structure and physiognomy, as well as in floristic composition. As the shallow-rooted grasses and annuals are grazed out, the deeper-rooted woody plants and succulents recieve more water, and tend to dominate. Removal of the lower strata results in a general thinning of the vegetation and a decrease in the amount of dead biomass/litter. The decrease in litter reduces the organic content of the soil, while the lack of the stabilizing influence of litter allows wind erosion to remove topsoil and cause mass movement of sand. During periodic flash floods, there is less interception of rainfall, with sheet and donga erosion resulting (Lane, 1980).

4.2 Fauna

4.2.1 Zooplankton

The plankton of Verlorenvlei includes estuarine and freshwater elements (Grindley (1979) and Robertson (1980)). The most abundant organisms were Copepoda, of which the estuarine species *Pseudodiaptomus hessei* and the freshwater species *Diaptomus purcelli* were dominant. Various harpacticoid species and the cyclopoids *Mesocyclops* sp., *Leptocyclops sublaevis* and *Hemicyclops* sp. were less abundant. Large numbers of nauplius larvae and copepodite stages of Copepoda were also present.

The freshwater cladoceran *Leydigia propinqua* was absent at the mouth, but occurred throughout the vlei. Four species of freshwater Ostracoda were present. *Zonocypris tuberosa* and *Cypridopsis gregaria* occurred at the mouth as well as throughout the vlei, while *Eucypris purcelli, Isocypris priomena* and *Paracypretta rubra* were only recorded in the vlei.

Zoea and mysis larvae of Decapoda were present in the vlei. The amphipod *Afrochiltonia subtenuis* was present at the mouth. Small numbers of Chelicerata, fish larvae, and fish eggs (diameter 0,25 mm) were also present. Detritus was present in all samples and some diatoms were recorded.

4.2.2 Invertebrates

Insects

A variety of insect larvae were obtained in the plankton samples, including Chironomidae and other Diptera, Ephemeroptera, Coleoptera, and Hemiptera.

The folloing insects and larvae were recorded by Robertson (1980) as common at Verlorenvlei during 1979 to 1980:

Sigara contortuplicata
Tendipes ? sp (chironomid larva)
Ischnura senegalensis
Anisops gracilis
Micronecta scutellaris
Hydrophyllidae
Chironomid pupae
Mesogomphus ? cognatus
Egg jelly
Chironomid (adult)
Dytiscid (beetle larva)
Water spider
Nychia limpida

Other invertebrates

Specimens of the mollusc *Trigonephrus globulus* (Müll) were collected by C J Hannocks on the northern bank of Verlorenvlei during 1985, and identified by Dr W F Sirgel, Department of Zoology, University of Stellenbosch. Found along the Cape west coast, up to the Orange River, this species digs down into the sand during the dry summer, and emerges onto the surface when rain falls.

The crab, *Potamonautes perlatus*, was found along the southern shore of the coastal lake during the ECRU survey in September 1985.

4.2.3 Fish

Three indigenous freshwater fish species occur in the Verlorenvlei area (Robertson, 1980):

Family Anabantidae: *Sandelia capensis* (Cape kurper)

This fish has a restricted distribution, the northernmost limit being the Langvlei River which flows into Wadrifsoutpan to the north of Verlorenvlei. It is an omnivorous feeder and tolerates a wide range of physical and chemical water conditions. It has an accessory breathing organ which allows it to survive warm or muddy water and is thus suited to Verlorenvlei conditions. It is difficult to distinguish from tilapia, with which it is often found (Jubb, 1967).

Family Galaxiidae: *Galaxias zebratus* (Cape galaxias)

This striped fish occurs in the Verlorenvlei River and in the vlei itself. It is omnivorous and grows to a maximum size of 38 to 40 mm (Jubb, 1967).

Family Cyprinidae: *Barbus burgi* (Berg River redfin)

This species is also known as *Pseudobarbus burgi* although this name has yet to be published formally in the scientific literature (P Skelton, JLB Smith Institute of Ichthyology, pers. comm.). However, the Cape Department of Nature and Environmental Conservation has already adopted this name *(Pseudobarbus burgi)* for the Berg River redfin in its publications (Scott and Hamman, 1984).

Skelton (1977) reports the occurrence of this fish in the Verlorenvlei River. Juveniles of a *Barbus* sp. were found in 1975. *B. burgi* occurs in the Berg River system and adjacent Eerste and Verlorenvlei Rivers, but has become depleted through agricultural practices, industrial pollution, and introduction of exotic predatory fish species. It is listed in the Red Data Book (Fishes) (Skelton, 1977). Protection under the Nature Conservation Ordinance, and the declaration of the Eerste River catchment as a conservation area, have not proved sufficiently effective measures. The establishment of sanctuary streams and exclusion of exotic predatory species has been proposed by Skelton (1977). A conservation plan for Verlorenvlei would enable implementation of recommendations for ensuring the continued existence of the indigenous *B. burgi*.

Marine fish can enter the Verlorenvlei when the mouth is open. Four species have been identified: *Lithognathus lithognathus* (white steenbras), *Liza richardsoni* (southern mullet), *Mugil cephalus* (flathead mullet), and *Gilchristella aestuarius* (estuarine round-herring). Local inhabitants have in the past dried harder or mullet and eaten the dried fish, called 'bokkoms', but J Whitmore (local resident, pers. comm.) reports a decrease in this activity during the last ten years, perhaps reflecting a decline in the estuarine fish population in the vlei. Fish were being dried at the Baboon Point crayfish factory in the summer of 1979 (Sinclair, pers. obs.). The preparation of dried estuarine fish species, for small-scale local or large-scale commercial consumption, represents a natural resource usage at Verlorenvlei which could be developed in the future, depending on correct management.

The present fish fauna of Verlorenvlei does not represent its natural population. The most common species are introduced: the carp *(Cyprinus carpio)*, and the Mozambique tilapia *(Oreochromis mossambicus)*. Neither are indigenous to the area, although the Mozambique tilapia is indigenous to South Africa, being introduced into Verlorenvlei in 1967 and 1968 by the Cape Department of Nature and Environmental Conservation. Other introduced species are the small mouth bass *Micropterus dolomieu*, the largemouth bass *M. salmoides* and the tench *Tinca tinca*. Introductions are no longer the policy of the Department (C Hamman, CDNEC, pers. comm.). The banded tilapia *Tilapia sparrmanii* has been identified at Verlorenvlei, but because it is unable to tolerate saline conditions, it probably occurs only in the upper reaches.

At Verlorenvlei, riparian owners net fish by licence in the vlei, but they tend to keep only the tilapia (Appendix IV).

4.2.4 Amphibians and Reptiles

Reptile and amphibian checklists have been compiled by A L de Villiers and M E Steyn of the Cape Department of Nature and Environmental Conservation (Appendix I).

Although frogs are present, they are not abundant (Robertson, 1980).

Snakes actually recorded are *Psammophylax rhombeatus* (skaapsteker), *Psammophis leightoni namibensis* (Namib sand snake), and *Psammophis crucifer* (Cross-marked grass snake).

The Cape cobra *(Naja nivea)* is commonly seen in summer, and is known to enter the farmhouses, causing consternation to residents (Sinclair, pers. obs.). Paterson reported during a journey through the Verlorenvlei area in 1778: 'We saw also the Yellow Snake, or Cobra Capel' (full reference quoted in Sinclair, 1980a).

4.2.5 Birds

In two surveys carried out by the Western Cape Wader Study Group during January and February 1976, 934 and 1 371 waders respectively were recorded in the lower reaches of Verlorenvlei (Summers *et al.*, 1977). In an analysis of resident and migrant waders from the same survey data, migrants constituted 95 percent of the wader population. Totals for all the areas surveyed in the south-western Cape were 8 731 resident waders, 76 881 migrant waders, and a combined total of 85 612 (Summers *et al.*, 1977). In a survey of the whole Verlorenvlei area in December 1980 by Underhill and Cooper (1983), 3 655 waders were reported, of which 2 928 were migrants and 727 residents. This same survey yielded a total of 6 829 birds of 60 species in the environs of Verlorenvlei.

Verlorenvlei is ranked tenth on a list of the ten most important wetlands in the south-western Cape by Cooper *et al.* (1976). The wetland area is given as 1 070 ha, with 11 different species of waders occurring. It is described as a permanent vlei (being the only listed area of that type), with its status being unprotected, and its wader population of 1 371 representing 1,2 percent of the estimated total coastal south-western Cape population.

Verlorenvlei's importance as a bird habitat is not restricted to waders. The vlei provides feeding, nesting and roosting sites for many bird species (Appendix II). Thunberg, after his visit in 1774, said of Verlorenvlei:

> *"Its banks are in many places overgrown with reeds and rushes (Carex, Arundo), which sometimes shoot up to the height of several yards, insomuch that the rivulet, in such places, cannot be seen. In these impenetrable recesses innumerable multitude of birds have their haunts and places of refuge, such as different sorts of herons (Ardea major and Coerulea), Ducks (Anates), and Coots (Fulicae)."* (Full reference quoted in Sinclair, 1980a).

Verlorenvlei is the type locality for the Hottentot Teal *Anas hottentota* (Clancey, in press). The specimen was collected by Sir Andrew Smith during one of his visits to the region. Smith is known to have made at least two collecting trips (in February 1829 and August 1832) to Verlorenvlei where he obtained a number of specimens of wetland birds (Roberts, 1936).

Waterbirds seen at Verlorenvlei include herons, egrets, ibises, spoonbills and flamingos. The presence of Glossy Ibises and African Spoonbills is important, since these species are uncommon in the south-western Cape (Cooper, 1976). Flamingos (260 in May/June 1976) appear at Verlorenvlei when other vleis, such as Rocher Pan 35 km to the south, and Wadrifsoutpan 13 km to the north, dry up. Flamingos are listed in the South African Red Data Book as requiring conservation (Brooke, 1984).

Other Red Data Book species include the Little Bittern and the Caspian Tern. The area is possibly also an important moulting ground and summer refuge for ducks, with 600 Cape Shoveller and 1 200 Yellow-billed Duck being observed in May 1979 (C Heyl, CDNEC, 1985, pers. comm.). In addition, Verlorenvlei is a type locality for several species of birds, including the White-backed Duck (Cooper, 1976).

Up to 150 Great White Pelicans were counted by the FitzPatrick Institute in 1976, representing 26 percent of the total south-western Cape population (Cooper, 1976). On 23 March 1982, 212 pelicans were counted by C Heyl and M Currie. The Great White Pelican is rated as 'rare' in South Africa, and therefore in need of special protection (Brooke, 1984).

Since Verlorenvlei is at present little-developed and in a relatively natural state, it would be suitable for proclamation as a nature reserve in order to give its birdlife full protection. In addition to its importance in its own right, Verlorenvlei is one of a 'chain' of wetlands on the Atlantic coast of the south-western Cape. Several of the 'links' in the chain are already protected, others are not (Summers *et al.*, 1976). By increasing the number of protected 'links' in the 'chain', the future of birdlife over the whole system will be greatly improved (Cooper, 1976).

Cooper *et al.* (1976) points out that South Africa, as a contracting party to the 'Ramsar Convention of Wetlands of International Importance, especially as Waterfowl Habitat' (Burgers, 1984), has a clear duty to increase the number of protected wetlands by proclaiming new nature reserves, and to protect Palaearctic waders already protected on their northern Hemisphere breeding grounds. He recommends Verlorenvlei for elevation to nature reserve status and concludes that, ornithologically, Verlorenvlei could become a "superb nature reserve of international importance."

4.2.6. Mammals

Little information exists on mammal populations at Verlorenvlei, making this an area for future research. Archaeological and historical evidence suggests that larger mammals were present at Verlorenvlei in abundance in the past, whereas they are non-existent today.

Animal paintings found in the Sandveld as a whole have been recorded by Manhire, 1981 (Table 6). Eland remains have been recovered from the lower levels of Elands Bay cave, several specimens of *Sylvicapra grimmia* and *Raphicerus* sp. at Elands Bay, and seven *Raphicerus melanotis* specimens at Diepkloof (Manhire, 1981).

TABLE 6: Animal paintings in the Sandveld (from Manhire, 1981)

Animal type	Sandveld No.	%
Antelope	333	54,6
Other wild species	85	13,9
Domestic animals	2	0,3
Unidentified animals	190	31,2
Total	610	100,0
Eland	167	27,4
Hartebeest	0	-
Small antelope	57	9,3
Other antelope	109	17,9
Elephant	58	9,5
Equid (horse-like)	19	1,6
Canid (dog-like)	6	1,0
Feline	3	0,5
Baboon	4	0,7
Other wild animals	4	0,7
Domestic animals	2	0,3
Unidentified animals	190	31,2
Total	610	100,1

No remains of elephant, *Loxodonta africana* have been found at Diepkloof or Elands Bay caves, but an elephant molar was found in a rock shelter on the south side of the vlei by Christopher Grindley in 1976. Dr Q B Hendey of the South African Museum established that the molar was that of an immature animal. A bushman painting found on the southern bank of the vlei depicts an elephant (Figure 26). Manhire (1981) comments on the complete absence of tusks in any of the Sandveld elephant paintings. Historical evidence relating to the occurrence of elephant (and other species) at Verlorenvlei is discussed by Sinclair (1980a and 1986b) and Skead (1980).

The presence of elephants south of Verlorenvlei is confirmed by a map showing pictures of elephants along the Berg River, with the annotation "Halt of elephants in December and January" (Map 1/1178, Cape Archives). Johannes Starrenburg passed through Verlorenvlei in 1705, then visited the kraal of Hannibal comprising 23 huts. The inhabitants reported that "to get food and meat for their wives and children (they) must daily fight against the elephants." The kraal is shown on Map M1/1184 (Cape Archives) as being just to the north of the "Quaecoma" River (now Verlorenvlei) in about 1700 (Sinclair, 1986c).

The Cape clawless otter *Aonyx capensis* and the water mongoose, *Atilax paludinosus* occur in the vlei. The fresh-water crab, *Potamon perlatus*, found at various stations throughout the system (Robertson, 1980), frequently composes part of the diet of the otter and water mongoose.

A questionnaire survey was carried out by the Cape Department of Nature and Environmental Conservation, amongst landowners during the period 1969 to 1974 (Lloyd and Millar, 1983). It must be remembered, however, that these survey results apply to the Piketberg Division as a whole, and not only to the Verlorenvlei area. The species recorded are:

Papio ursinus	Baboon
Hystrix africaeaustralis	Porcupine
Otocyon megalotis	Bat-eared fox
Aonyx capensis	Cape clawless otter
Mellivora capensis	Honey badger
Proteles cristatus	Aardwolf
Felis caracal	Caracal/lynx
Panthera pardus	Leopard
Orycteropus afer	Antbear
Procavia capensis	Rock dassie
Antidorcas marsupialis	Springbok
Oreotragus oreotragus	Klipspringer
Raphicerus campestris	Steenbok
Raphicerus melanotis	Grysbok
Taurotragus oryx	Eland (reintroduced)
Sylvicapra grimmia	Grey duiker
Pelea capreolus	Grey rhebuck

A survey by Stuart (1981) indicates the presence of the following mammals in the vicinity of Verlorenvlei:

Otocyon megalotis	Bat-eared fox
Vulpes chama	Cape fox or silver jackal
Canis mesomelas	Black-backed jackal
Ictonyx striatus	Striped polecat
Genetta genetta	Small-spotted genet
Suricata suricatta	Suricate
Cynictis penicillata	Yellow mongoose
Herpestes pulverulentus	Cape grey mongoose
Atilax paludinosus	Water mongoose

Panthera pardus	Leopard
Felis lybica	Wild cat
Felis caracal	Caracal

Mammal species which occur or are likely to occur in the environs of Verlorenvlei are listed in Appendix III.

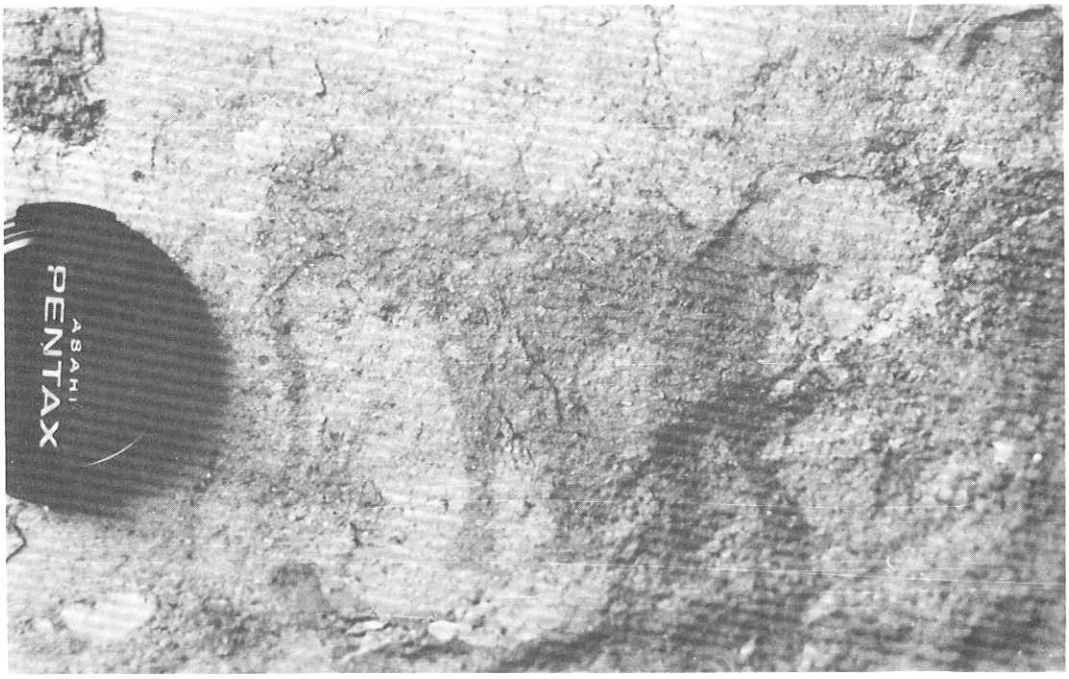


FIG. 26: Bushman painting of an elephant at Verlorenvlei. (Photo: S A Sinclair, August, 1978)

5. CONSERVATION HISTORY

Verlorenvlei is one of the most important Cape estuarine/lacustrine systems. It is rated as a conservation priority, both in the Cape and nationally. This section reviews the various attempts to secure formal conservation status for the estuary, coastal lake and surrounding areas.

The conservation motivations have been well-substantiated by the research which has been carried out in the area since 1967. While the research interest provides a basis for conservation action, if such action is not taken, the research base will be degraded or destroyed before various projects can be completed, or necessary future research initiated.

Motivations for the conservation of Verlorenvlei have continued for a decade. It was designated as a Category B coastal/marine reserve by Grindley, Cooper and Hall (1976); Grindley and Cooper (1979) and Heydorn and Tinley (1980). Formal reserve status was proposed, with no exploitation to be allowed. Public entry was to be controlled so that the recreational carrying capacity would not be exceeded. The Verlorenvlei/Elandsbaai area was rated as a high national priority for conservation action.

In 1977, the Committee for the Coastal Zone of the Planning Advisory Council to the Prime Minister requested that the Cape Provincial Department of Nature Conservation take steps to ensure that the Verlorenvlei area was given the conservation status and protection it deserved, but without success.

In 1980, various researchers at the University of Cape Town invited representatives of all interested organizations to a symposium. Research progress in various fields was summarized, and research and conservation proposals were presented. It was hoped that some form of conservation action would result, and that future research in the area would receive strong official support.

The following recommendation was made at this symposium:

> "A natural outgrowth of this study would be the formulation of a proposal for conservation of the man-made environment at Verlorenvlei, to supplement the proposals already made for natural and archaeological conservation. The end-product would be a total conservation proposal backed by considerable ecological, archaeological, and historical research. If the proposals were accepted by the relevant authorities, and the conservation potential of Verlorenvlei realised, the area would be unique in South Africa as the first and only site of integrated conservation of all natural and man-made components of a coastal lake system" (Sinclair, 1980b).

At a National Committee for Nature Conservation (NAKOR) workshop meeting in 1982, when various national priorities were being rated, it became apparent that Verlorenvlei is unique amongst all other priority areas in that it possesses a multiplicity of conservation assets, not only ecologically, but also in terms of its social, historical, cultural, architectural and archaeological assets.

In 1985, a meeting of the South African National Committee for Oceanographic Research (SANCOR) assessed the condition of the Verlorenvlei Estuary as 'fair', and assigned it to Category 2. The category includes estuaries where limited development has already taken place, but which are considered to be in a good enough state to be conserved, with further development to be strictly controlled at a low intensity compatible with conservation criteria.

At present, the committee for Coastal and Marine Systems of the Council for the Environment is compiling a report entitled: "A plan for the protection of special natural features and systems in the South African coastal zone." Second only to the Garden Route, the Elandsbaai coast is regarded as top priority for formal designation to ensure special protection.

Another report, entitled "Conservation priorities in the lowland regions of the Fynbos Biome" (Jarman, 1986), recommends that the Verlorenvlei area be proclaimed as a Nature Area, with a core nature conservation area to be purchased by an appropriate conservation organization.

In the various motivations, it has been argued that Verlorenvlei is a conservation priority from the ornithological viewpoint alone (Section 4.2.5). Equally strong motivations have been based on historical, cultural and architectural grounds (Section 2.2), as well as for archaeological (Section 2.3) and botanical (Section 4.1.4) reasons. The combination of all these arguments forms a compelling rationale for integrated conservation of the multiple resources of Verlorenvlei.

Despite the efforts of concerned individuals in their private and official capacities, and despite innumerable submissions to various authorities, no offical conservation action has resulted during the six years following the 1980 symposium. The formal conservation status of Verlorenvlei has not yet been secured, nor have ecological and conservation management principles been formally incorporated into land-use policies or practices.

With regard to the historical, cultural and architectural resources, severe degredation has taken place in the period of delay (Figures 27 to 29). Similarly, the natural components of the system have been degraded during recent years, as shown by examination of a chronological series of aerial photographs and orthophoto maps of the area. A major source of concern is that the rate of degradation is increasing.

1a

Settlement house VV06B in November 1979. The house had been neither occupied nor maintained for some years. (Photo: S A Sinclair)

1b

Settlement house VV06B in August 1984, showing decaying effects of natural environmental factors such as wind, rain, birds, rodents, insects and plant growth. (Photo: S A Sinclair).

2a

Settlement house VV03M in 1972. Detailed drawings of the house were made by J Walton. (Photo: J Walton, Cape Archives).

2b

Settlement house VV03M photographed in August 1984, after deliberate demolition some time previously. (Photo: S A Sinclair).

FIG. 27: Degradation of the historical, cultural and architectural resources that has taken place at Verlorenvlei during delay in conservation action. (The house numbers refer to the classification system used by Sinclair, 1980a).

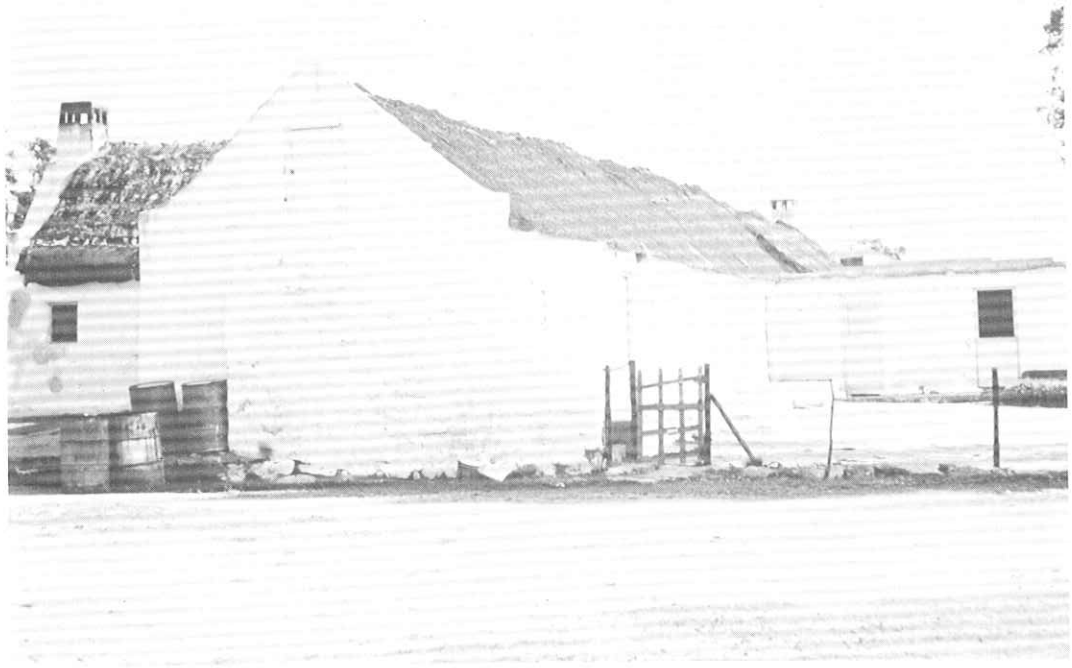


FIG. 28: Settlement house VV06C in August 1984, an example of a well-conserved historical building. (Photo: S A Sinclair).

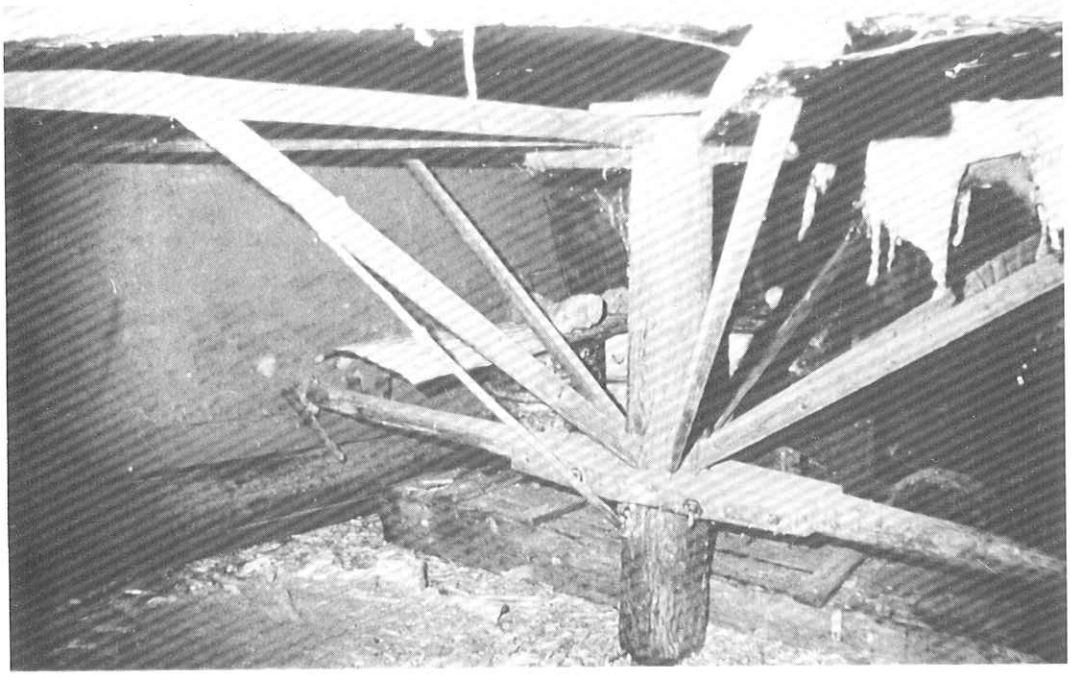


FIG. 29: Horsemill in the Verlorenvlei farm settlement. (Photo: J Walton, 1972, Cape Archives).

Conservationists believe that the initiative should now be taken by private individuals, private enterprise, and by relevant official bodies, to ensure that Verlorenvlei and its multiple resources are given formal conservation status and protection as soon as possible. A detailed conservation and development plan for Verlorenvlei, based on research to date, is in the process of being formulated for implementation by the relevant authorities (Sinclair, 1986a). The provision of formal conservation status will be a time-consuming process, but specific recommendations contained in the synthesis should be directed to the responsible authorites in the interim.

6. SYNTHESIS AND RECOMMENDATIONS

Present state of the system

Verlorenvlei is a relatively shallow coastal lake, fringed by wetland vegetation, and fed by the Verlorenvlei River. The lake is subjected to fluctuations in water level, ranging from periods when the section immediately in front of the Verlorenvlei farm settlement is completely dry, to periods when the road running to the settlement along the southern bank is totally inundated.

These fluctuations in level are both seasonal and affected by longer-term climatic cycles. They are important in determining the distribution patterns of the wetland vegetation, with the position of different species being related to different water levels (Section 4.1.4, vegetation type 7). They also determine the abundance and distribution of different bird species within the system (Section 4.2.5). The variable nature of Verlorenvlei is, therefore, critical to the functioning of the natural system.

Natural closure of the mouth (Section 3.2.1) tends to dam up a water store for the arid summer, and allows for a slow decline in water level. As the water recedes to lower levels, more of the gently-sloping shores are exposed and this creates an attractive environment for waders.

The water is generally brackish, with salinities ranging from hypersaline towards the mouth, to brackish further inland. Water inflow is saline to some degree, whether it is from the sea, or from the catchment. Periodic natural breaching during good rains may have a flushing effect, countering the build-up in salinity during periods of closure.

Present state of knowledge

For a number of years since 1967, various university departments, particularly within the University of Cape Town, have been using Verlorenvlei as a research base and teaching resource. As a result, numerous aspects of the system have been well-researched, at undergraduate and postgraduate levels.

Insight into pre-historical settlement and subsistence patterns, cultural artefacts, faunal assemblages, and the effects of sea-level fluctuations, has been provided by extensive archaeological research in the Verlorenvlei area (Section 2.3). Historical research has centred on the development in knowledge about the area and its natural resources; ecological conditions at different periods in relation to changing settlement, land-use and land ownership patterns; the establishment and development of rural settlement, particularly on the Verlorenvlei farm; and historical, cultural and architectural artefacts (Sections 2.1 and 2.2). Although much has been uncovered, both archaeologically and historically, further research is required before the pre-history and the history can be fully-explained, and linked into a continuous record as a basis for future management.

The climatic, hydrological, geological, geomorphological, pedological and biological characteristics of the Verlorenvlei area have been investigated and explained in broad terms. Enough is known about the inshore oceanography, estuary characteristics and dynamics to make specific recommendations for estuarine management.

The way in which the system functions as a whole, however, is not yet understood in detail. Such understanding is crucial for successful management. Much of the research to date has been determined by academic objectives, rather than directed by the need to find solutions to environmental management problems through applied research. Research has therefore not received adequate support from the official authorities responsible for various aspects of environmental management.

Problems: present and foreseeable

Development pressure in the Verlorenvlei area has been concentrated along the coastline, in the vicinity of Elandsbaai. This pressure is beginning to increase, in the form of applications for township extensions (Heinecken and Badenhorst, 1985). The coastal environs attract weekend and holiday visitors, particularly in the summer, causing short-term, seasonal increases in the demand for facilities.

The land surrounding the coastal lake is privately-owned. Most of the present owners are related, or belong, to a few major family groups which have been associated with the area for centuries. The land and its vegetation cover have been degraded, mainly by grazing and by the clearing of land for agriculture and rural settlement. Despite the long history of human use of the area for grazing and cultivation (Section 3.1.8), the level of degradation is presently low enough to allow for natural rehabilitation, but the rate of degradation is escalating. For example, agricultural activities have led to interference with the natural function of the estuarine channel. The culverts in the causeway near the mouth have been blocked in order to dam fresh water for irrigation of recently cleared land.

As pressures and degradation have increased in the Verlorenvlei area, the need for conservation measures, and for the integration of ecological principles into environmental management, has become more pressing (Section 5). One of the most important problems at present, and in the forseeable future, is the uncontrolled *ad hoc* nature of estuarine and terrestrial management action.

This situation is anomalous, in view of the considerable research base that already exists for management application. It arises, partially, from a communication problem. While most of the research/conservation activity has been reported in English, the day-to-day management of the area is in the hands of a predominantly Afrikaans-speaking community. The resultant limited liaison has failed to prevent management actions which are contrary to recommendations.

The situation also arises from divided control and jurisdiction (Section 1.2). Too many authorities are involved, and there has been no co-ordinating body with overall authority and final responsibility to which they could be addressed. In the interim, *ad hoc* management action has continued unchecked.

Likely sources of future problems include:

- existing and additional obstructions which interfere with natural estuarine and coastal lake dynamics;

- increases in domestic stock, particularly goats;
- the clearing of natural vegetation for the extension of agriculture;
- the introduction of mechanized irrigation systems, leading to increased extraction of underground and lake water for irrigation;
- the increased vandalism and degradation that almost inevitably accompany uncontrolled visitor pressure.

Recommendations

Future management of Verlorenvlei requires co-ordination if it is to be successful. This report, in summarizing available information on the system to date, establishes a broad basis for co-ordination and control of future management action. A single authority should now be assigned overall responsibility for the area.

This authority should examine all research-based recommendations; formulate a regional management plan that reconciles development objectives with the conservation of the natural and cultural assets; and direct all the recommendations consistent with this plan to the relevant authorities for attention and implementation.

In the interim, because of the sensitivity of this ecosystem, and its conservation and research importance, all local, provincial and national authorities should consult with the Department of Environment Affairs. Consultation should take place before the authorization of any actions likely to affect land or water use in the area, including the estuary, coastal lake and catchment.

In addition, all future development applications (including agricultural), should incorporate environmental impact assessment by qualified professionals in the planning phase, and should be formulated within the context of the regional management plan.

When implementing management and conservation proposals, it is essential to recognize that most of the land at Verlorenvlei is privately-owned by a predominantly Afrikaans community. Limited liaison and communication barriers have already led to a number of management actions which are contrary to research recommendations. One of the most direct ways in which this problem can be overcome is through the preparation of relevant publications in Afrikaans for circulation amongst all landowners in the Verlorenvlei area. Consequently, a translation of this Synthesis is included (Section 7).

Specific recommendations arising from this report are:

(1) Artificial obstructions (Obstructions 1, 2 and 4) and illegal structures at the mouth of the estuary should receive urgent attention. Unnecessary obstructions should be removed altogether, while necessary crossing points should be redesigned and reconstructed, in consultation with the Department of Environment Affairs, and the Estuarine and Coastal Research Unit of the National Research Institute for Oceanology.

(2) The extent of use of mobile irrigation systems in the area should be determined. All impacts associated with such systems should be investigated, including those deriving from the use of vlei water for irrigation, excavation of irrigation pits in wetlands, withdrawal of groundwater, installation of

pumphouses and pipelines, salinization of soil and water, and total clearing of natural vegetation for fields. Steps should be taken to control the use of these irrigation systems and their impacts.

(3) The exact numbers and species of domestic stock using the natural grazing in the area should be determined. Stock carrying capacity of the natural grazing areas bordering the coastal lake should be calculated, in relation to present veld and climatic conditions, and to conservation objectives. Adjustments to stock numbers should be made, monitored and updated continuously with landowners.

(4) Steps should be taken to plan for, and to manage the pressures caused by the temporary influx of weekend and holiday visitors. The maintenance of environmental, and consequently of recreational carrying capacities for the area; the planned provision of temporary facilities with minimal impact and disturbance; and the control of influx patterns and concentrations of use. It may prove necessary, in all coastal areas, to introduce charges for recreational activities that are related to the cost of providing and maintaining the facilities and environmental quality required.

(5) Recreational use of the coastal lake itself has been, up to now, virtually non-existent. Because of the lake's unique qualities, this situation should be retained and reinforced, particularly if water quality, the aquatic macrophyte and fringing vegetation, and bird habitats are to be maintained. For example, use of the lake surface for boating would immediately lead to demands for the removal of the indigenous *Myriophyllum*. Re-evaluation of existing legislative control, the introduction of new conservation measures, and more stringent enforcement should be undertaken.

(6) Active efforts must be made to involve the Verlorenvlei landowners directly in management and conservation efforts, and to develop an awareness of the conservation values of their property. Such efforts could include encouragement of landowner participation in the Natural Heritage and National Monuments programmes (Figures 28 and 29). The local agricultural extension service should also be expanded to encourage the integration of ecological and conservation principles into environmental management and land-use practices.

(7) Eradication of alien vegetation should be undertaken, particularly in source areas, before this problem assumes unmanageable proportions through exponential growth. Timely action could obviate considerable expenditure and loss in the future.

Considerable research has been carried out, but the overall coverage is far from complete. In certain areas, there is detailed coverage; in others, there are major omissions. Research projects have been determined according to the independent interests and needs of different disciplines. While the projects are directed and co-ordinated within their disciplinary boundaries, they are not integrated into a totality with well-defined unifying objectives, nor are they management-directed.

In management terms, water is a critical limiting factor. Future research must examine inputs in the form of rainfall and fog; processes such as evaporation, stream flow, run-off, infiltration, percolation, aquifer recharge, and physico-chemical fluctuations in the coastal lake and its catchment; and the effects of human actions on these processes, on water availability and quality, and consequently on the biotic components of the system (Section 4). Such information is a prerequisite for future estuarine and terrestrial management recommendations.

The following are research priorities from a management-based perspective:

- the monitoring of soil and water quality in relation to different land-use practices;

- the recording of precipitation derived from advective sea fog, and its importance for the natural vegetation;

- the determination of aquifer recharge rates;

- the recording of stream flow through the installation of flow gauges on all the major streams entering the Verlorenvlei River and coastal lake.

Verlorenvlei has the potential to support a centrally-directed, holistic ecosystem research project. Traditionally, projects of this nature have been coordinated by the Foundation for Research Development of the CSIR. It is recommended that a Coastal Lake Ecosystem project be initiated, possibly under the auspices of the CSIR, with the support of the Department of Environment Affairs. A motivation for such a project should be drawn up, including research proposals which will contribute to the formulation of detailed management recommendations for the Verlorenvlei estuary, coastal lake, and surrounding area.

Verlorenvlei and its environs form a unique natural asset which should be conserved for the use and enjoyment of future generations. There are few areas in South Africa which provide the opportunity to combine conservation of the natural environment with the culture which developed in association with it. Furthermore, the rich archeological resources of the region provide an insight into the pre-European way of life in this part of Southern Africa. It follows that a holistic approach to the management of the area is necessary to safeguard both the natural environment and the cultural historical heritage. It is hoped, therefore, that this report will provide some of the information and stimulus necessary to ensure the protection of Verlorenvlei.

7. SAMEVATTING EN AANBEVELINGS

Huidige stand van die sisteem

Verlorenvlei is 'n betreklik vlak kusmeer wat deur vleilandplantegroei omsoom is en deur die Verlorenvleirivier gevoed word. Die watervlak in die meer wissel aansienlik - van tye wanneer die gedeelte regoor die Verlorenvleiplaasnedersetting heeltemal droog is tot tye wanneer die pad na die nedersetting op die suidelike oewer heeltemal oorstroom is.

Hierdie wisseling in watervlak is seisoenaal en hang ook saam met langtermynklimaatsiklusse. Dit het 'n belangrike invloed op die verspreidingspatrone van die vleiplantegroei, waar die ligging van die verskillende spesies verband hou met verskillende watervlakke (Deel 4.1.4, plantegroeitipe 7). Dit bepaal ook die getalle en verspreiding van verskillende voëlspesies in die sisteem (Deel 4.2.5). Die wisselende aard van Verlorenvlei is dus deurslaggewend vir die wyse waarop die natuurlike sisteem funksioneer.

Natuurlike sluiting van die mond (Deel 3.2.1) help om water vir die droë somer op te berg en die watervlak stadig te laat sak. Namate die watervlak sak, word al hoe meer van die effens skuins oewer blootgelê, en dit bied 'n aantreklike omgewing vir waadvoëls.

Die water is oor die algemeen brak, met soutgehalte wat wissel van uiters sout by die mond tot effens brak dieper die land in. Die water wat invloei, hetsy van die see of van die opvanggebied af, is altyd meer of minder souterig. As die mond periodiek tydens swaar reëns vanself oopgaan, word die meer as't ware uitgespoel sodat die soutgehalte (wat opbou wanneer die mond toe is) afneem.

Huidige stand van kennis

Verlorenvlei is sedert 1967 etlike jare lank as basis vir navorsing en praktiese onderrig gebruik deur verskeie universiteitsdepartemente, veral van die Universiteit van Kaapstad. Gevolglik is verskeie aspekte van die sisteem deeglik bestudeer op sowel voorgraadse as nagraadse vlak.

Uitgebreide argeologiese navorsing in die Verlorenvlei-gebied (Deel 2.3) het insig gegee in oertydse bewonings- en lewenspatrone, artefakte, dieresamestelling en die uitwerking van seevlakwisseling. Geskiedkundige navorsing was hoofsaaklik toegespits op die verbreding van kennis van die gebied en sy natuurlike hulpbronne, ekologiese toestande in verskillende tydperke in verhouding tot veranderende patrone grondbewoning, grondgebruik en grondbesit, die totstandkoming en ontwikkeling van landelike nedersettings, veral op die plaas Verlorenvlei, asook op historiese, kulturele en argitektoniese artefakte (Dele 2.1 en 2.2). Hoewel reeds heelwat van sowel argeologiese as historiese belang ontdek is, is verdere navorsing nodig vir behoorlike opklaring van die voorgeskiedenis en geskiedenis, en die aaneenskakeling daarvan om 'n deurlopende rekord as basis vir toekomstige bestuur te verkry.

Die klimatologiese, hidrologiese, geologiese, geomorfologiese, pedologiese en biologiese kenmerke van die Verlorenvleigebied is in breë trekke nagevors en verklaar. Daar is genoeg oor die nabystrandse oseaangesteldheid en oor die estuarium se eienskappe en dinamika bekend om spesifieke aanbevelings ten opsigte van estuariumbestuur te kan maak.

Dit is egter nog nie heeltemal duidelik hoe die sisteem as geheel funksioneer nie, en duidelikheid hieroor is noodsaaklik vir suksesvolle bestuur. Ongelukkig was die navorsing tot dusver grotendeels gerig op akademiese doelwitte eerder as op die oplos van omgewingsbestuursprobleme. Derhalwe was daar nie toereikende steun vir navorsing van die kant van instansies wat vir verskillende aspekte van omgewingsbestuur verantwoordelik is nie.

Huidige en voorsienbare probleme

Die druk van ontwikkeling in die Verlorenvleigebied was hoofsaaklik toegespits op die kuslyn, in die omgewing van Elandsbaai. Die druk, in die vorm van aansoeke om die uitbreiding van woongebiede, is besig om toe te neem (Heinecken en Badenhorst, 1985). Die kusomgewing lok naweekbesoekers en vakansiegangers, veral in die somer, sodat daar tydelike, seisoenale toenames in die vraag na geriewe is.

Die grond om die kusmeer is in private besit, en die meeste van die huidige grondeienaars is onderling verwant of behoort aan enkele groot families wat reeds eeue lank met die gebied verbind is. Die grond en die plantegroei het agteruit gegaan, hoofsaaklik weens beweiding en die verwydering van natuurlike plantegroei met die oog op bewerking of bewoning. Ondanks beweiding en bewerking oor 'n baie lang tydperk (Deel 3.1.8) is die agteruitgang betreklik gering sodat natuurlike rehabilitasie nog moontlik is. Die mate van agteruitgang neem egter vinnig toe. Landboubedrywighede het byvoorbeeld die estuariumkanaal se natuurlike funksionering versteur. Die deurlaatopeninge in die spoelbrug naby die mond is naamlik toegemaak om water te laat opdam vir die besproeiing van onlangs bewerkte grond.

Namate ontwikkelingsdruk toegeneem en die natuurlike omgewing agteruitgegaan het, het dit al hoe dringender geword dat bewaringsmaatreëls getref word en dat omgewingsbestuur op ekologiese beginsels moet berus (Deel 5). Een van die grootste probleme vir die hede en die voorsienbare toekoms is die onbeheerde, willekeurige optrede in verband met die estuarium en grondgebruik.

Hierdie toedrag van sake is nogal vreemd, aangesien daar reeds 'n aansienlike navorsingsbasis vir bestuurstoepassing bestaan. Dit is egter deels te wyte aan gebrekkige kommunikasie. Oor die meeste van die navorsing en bewaringswerk is daar in Engels verslag gedoen, terwyl dit 'n oorwegend Afrikaanssprekende gemeenskap is wat vir die bestuur van die gebied moet sorg. Vanweë die gebrek aan skakeling was dit dan ook onvermydelik dat sekere optredes strydig met die aanbevelings sou wees.

Nog 'n probleem is die van verdeelde beheer en jurisdiksie (Deel 1.2). Daar is te veel instansies by die gebied betrokke en daar is geen duidelike bestuursbeleid of konsekwente doelwitte nie. Gevolglik het aanbevelings in die lug bly hang by gebrek aan 'n koördinerende liggaam met oorhoofse gesag en finale verantwoordelikheid aan wie aanbevelings gerig kan word. Intussen gaan die willekeurige optrede voort.

Aspekte wat waarskynlik in die toekoms probleme kan oplewer, is onder andere die volgende:

- bestaande en bykomende versperrings wat die natuurlike dinamiek van die estuarium en kusmeer versteur;
- toename in die veestapel, veral bokke;
- die verwydering van natuurlike plantegroei om landboubedrywighede uit te brei;
- die gebruik van meganiese besproeiingstelsels waardeur meer water vir besproeiing uit die grond en uit die kusmeer onttrek sal word;
- toenemende vandalisme en agteruitgang wat noodwendig met onbeheerde toestroming van besoekers gepaard gaan.

Aanbevelings

Die bestuur van Verlorenvlei sal voortaan behoortlik gekoördineer moet word om te kan slaag. Die beskikbare inligting oor die stelsel, wat in hierdie verslag saamgevat is, bied 'n breë basis vir gekoördineerde beheer oor toekomstige bestuursoptrede. Verantwoordelikheid vir die gebied as geheel moet nou aan 'n enkele instansie opgedra word.

So 'n instansie moet deeglik ingaan op alle aanbevelings wat op navorsing berus en dan 'n streeksplan formuleer waarin ontwikkelingsdoelwitte versoen word met die bewaring van die natuurlike en kulturele bates. Hy moet ook alle aanbevelings wat met die plan bestaanbaar is, vir aandag en uitvoering aan die betrokke owerhede voorlê.

Intussen, met die oog op die sensitiwiteit van die ekosisteem en die belangrikheid daarvan ten opsigte van bewaring en navorsing, moet alle plaaslike, provinsiale en nasionale owerhede met die Departement van Omgewingsake oorleg pleeg. Sodanige oorlegpleging moet geskied vóór die magtiging van enige optrede wat grond- of watergebruik in die gebied - met inbegrip van die estuarium, kusmeer en opvanggebied - mag raak.

Boonop moet daar by die toekomstige ontwikkeling (met inbegrip van landbou-ontwikkeling) reeds in die beplanningsfase voorsiening gemaak word vir omgewingsimpakstudies deur deskundiges. Dit moet binne die bestek van die streeksbestuursplan geformuleer word.

By die uitvoering van bestuurs- en bewaringsvoorstelle moet steeds in ag geneem word dat die meeste van die grond by Verlorenvlei privaateiendom in besit van 'n oorwegend Afrikaanssprekende gemeenskap is, en dat daar weens gebrek aan skakeling en kommunikasie in die verlede in sommige gevalle strydig met aanbevelings gehandel is. Daar moet dus gesorg word dat publikasies met toepaslike inligting in Afrikaans onder alle grondeienaars in die Verlorenvleigebied versprei word.

Die volgende **spesifieke aanbevelings** spruit uit hierdie verslag:

(1) Kunsmatige versperrings (versperringnommers 1, 2 en 4) en ongemagtigde bouwerke by die mond van die estuarium moet dringend aandag geniet. Onnodige versperrings moet heeltemal verwyder word terwyl noodsaaklike oorgange herontwerp en herbou moet word in oorleg met die Departement van Omgewingsake en die Eenheid vir Getyrivier- en Kusnavorsing van die Nasionale Navorsingsinstituut vir Oseanologie.

(2) Die gebruiksomvang van mobiele besproeiingstelsels in die gebied moet bepaal word. Alle nodige impakstudies moet in die verband gedoen word, onder andere wat betref die gebruik van vleiwater vir besproeiing, die grawe van besproeiingsputte in vleigrond, die onttrekking van grondwater, die aanbring van pomphuisies en pype, die verbrakking van grond en water en die algehele verwydering van natuurlike plantegroei om landerye te maak. Daar moet stappe gedoen word om die gebruik van hierdie besproeiingstelsels, en die uitwerking daarvan, te beheer.

(3) Die presiese getalle en veesoorte in veestapels wat die natuurlike weiding in die gebied gebruik, moet bepaal word. Die dravermoë van die natuurlike weiding langs die kusmeer moet bereken word met inagneming van die veld- en klimaatstoestande asook van bewaringsdoelwitte. Die veestapel moet dienooreenkomstig aangepas word en dan gereeld gekontroleer en van tyd tot tyd weer aangepas word na gelang dit nodig is.

(4) Daar moet behoorlik voorsiening gemaak word vir die periodieke toestroming van naweekbesoekers en vakansiegangers. Om die omgewingsgehalte en derhalwe die ontspanningswaarde te handhaaf, moet die gebied se dravermoë vir ontspanningsgebruik bepaal word, moet tydelike fasiliteite so beplan word dat dit minimale impak en versteuring sal meebring, en moet toestromingspatrone en gebruikskonsentrasies beheer word. Dit mag ook nodig wees om in alle kusgebiede gelde vir ontspanningsgebruik te vorder in ooreenstemming met die koste daarvan om die nodige fasiliteite en die verlangde omgewingsgehalte in stand te hou.

(5) Die kusmeer self wat dusver nog nie juis vir ontspanningsdoeleindes benut is nie, moet vanweë sy heel besondere eienskappe, so gehou word - veral om die gehalte van die water, die waterplante, die plantegroei om die meer en die habitat van die voëls te bewaar. As mense byvoorbeeld toegelaat sou word om met bootjies op die meer te vaar, sal hul spoedig begin aandring op verwydering van die inheemse *Myriophyllum*.

Die bestaande wetlike beheermaatreëls moet krities evalueer word, nuwe bewaringsmaatreëls moet ingestel word en daar moet strenger toepassing van die maatreëls wees.

(6) Daar moet allerweë probeer word om die grondeienaars van Verlorenvlei regstreeks by die bestuurs- en bewaringsaksie te betrek en om hulle bewus te maak van die bewaringswaarde van hul eiendom. Die grondeienaars kan onder andere aangemoedig word om mee te doen aan die programme vir die bewaring van ons natuurerfenis en nasionale gedenkwaardighede (Figure 28 en 29). Die plaaslike landbouvoorligtingsdiens behoort ook uitgebrei te word om te sorg dat ekologiese en bewaringsbeginsels by omgewingsbestuur en grondgebruik geld.

(7) Indringerplante moet uitgeroei word, veral in brongebiede voordat die probleem onbeheerbare afmetings aanneem. As daar betyds opgetree word, kan groot uitgawe en verlies in die toekoms voorkom word.

Hoewel daar reeds heelwat navorsing in die Verlorenvleigebied gedoen is, is alle moontlike terreine nog geensins gedek nie. Sekere aspekte is wel deeglik bestudeer, maar wat ander betref is daar nog groot leemtes. Navorsingsprojekte is dusver grotendeels bepaal deur individuele belangstelling en die behoeftes van verskillende vakgebiede. Gevolglik is die projekte nie ingeskakel by 'n geheelpoging met aanvullende doelwitte nie, en is hulle ook nie bestuursgerig nie.

Vanuit 'n bestuursoogpunt is water 'n belangrike beperkende faktor. Daar moet dus navorsing gedoen word oor: die mate waarin die water deur reënval en mis aangevul word; prosesse soos verdamping, stroomvloei, afloop, insyfering, sypeling en hervulling van akwifers; fisies-chemiese wisselings in die kusmeer en sy opvanggebied; die uitwerking van menslike bedrywighede op hierdie prosesse asook op die beskikbaarheid en gehalte van die water en gevolglik op die biotiese komponente van die sisteem (Deel 4). Die verkryging van die inligting is 'n voorvereiste vir toekomstige aanbevelings oor estuarium- en grondbestuur.

Die volgende navorsingsprioriteite word vanuit 'n bestuursoogpunt bepaal:

- die monitering van grond- en watergehalte in verband met grondgebruikspraktyke;
- die registreer van neerslag uit mis wat van die see af invloei, en die belangrikheid daarvan vir die natuurlike plantegroei;
- bepaling van die tempo waarteen ondergrondse water weer aangevul word;
- die registreer van stroomvloei wat in die Verlorenvleirivier en die kusmeer invloei.

Verlorenvlei bied die geleentheid vir 'n sentraal gerigte, holistiese ekosisteemnavorsingsprojek - die soort projek wat tradisioneeel deur die WNNR se Stigting vir Navorsingsontwikkeling gekoördineer word. **Daar word aanbeveel dat 'n kusmeerekosisteemprojek aangepak word, moontlik onder beskerming van die WNNR en met die steun van die Department van Omgewingsake.** Daar moet 'n motivering vir so 'n projek opgestel word, onder andere met voorstelle vir navorsing gerig op die formulering van aanbevelings oor die bestuur van Verlorenvlei se estuarium, kusmeer en omgewing.

Verlorenvlei en omgewing is 'n unieke natuurlike bate wat vir die gebruik en genot van toekomstige geslagte bewaar moet word. Daar is min plekke in Suid-Afrika wat só 'n geleentheid bied om die natuurlike omgewing saam met die kultuurgoed wat daarin ontwikkel het, te bewaar. Die ryk argeologiese hulpbronne van die gebied gee ook insig in die voor-Europese leefwyse in hierdie deel van Suider-Afrika. Uiteraard is 'n holistiese benadering tot die bestuur van

die gebied noodsaaklik om sowel die natuurlike omgewing as die kultuurhistoriese erfgoed te bewaar. Daar word vertrou dat hierdie verslag die nodige inligting en aansporing vir die bewaring van Verlorenvlei sal help verskaf.

8. ACKNOWLEDGEMENTS

The following persons, institutions and organisations are thanked for the information and assistance received during the compilation of this report:

South African Museum: Mr W J J van Ryssen, Archaeology Department. Cape Department of Nature and Environmental Conservation: Drs K C D Hamman and D J Coetzee, Messrs P H Lloyd, C J Burgers, C W Heyl, A M Coetzer, A L de Villiers and Ms. A le Roux. University of Stellenbosch: Prof. R C Bigalke, Dr H van Hensbergen and Messrs C J Hannocks and P Rohloff, Department of Nature Conservation, Forestry Faculty; Dr W F Sirgel, Department of Zoology. University of Cape Town: Mr R K Brooke, Mr J Cooper, Dr P A R Hockey, Percy FitzPatrick Institute. Sea Fisheries Research Institute: Dr J H M David. JLB Smith Institute: Dr P Skelton. Ms. S Dean, botanical consultant, Knysna.

The advice and assistance of all members of ECRU is acknowledged.

The survey was carried out at the request and with the financial support of the Department of Environment Affairs. The encouragement of this Department, the Steering Committee for Estuarine and Coastal Research and the SA National Committee for Oceanographic Research is gratefully acknowledged.

9. REFERENCES

Literature Cited

ACOCKS, J P H (1975). Veld types of South Africa. *Mem. Bot. Surv. S. Afr.*, 40. 128 pp.

AFRICA PILOT (1977). Volume II. West coast of Africa from Bakasi Peninsula to Cape Agulhas; Islands in the Bight of Biafra, Ascension Island; St Helena Island; Tristan da Cunha Group and Gough Island. (12th edition) Taunton UK, Hydrographic Department, Ministry of Defence. 248 pp.

BOUCHER, C (1980). Brief comments on some of the vegetation adjoining on the Verlorenvlei. *Unpublished memorandum.* Stellenbosch, Botanical Research Unit.

BOUCHER, C (1981). Dune plumes in the western Cape. *Veld and Flora,* 67(1): 11-13.

BOUCHER, C and JARMAN, M L (1977). The vegetation of the Langebaan area, South Africa. *Trans. Roy. Soc. S. Afr.* 42(3/4): 241-272.

BROADLEY, D G (1983). *FitzSimons' snakes of southern Africa.* Johannesburg. Delta Books.

BROADLEY, D G and GREER, A E (1969). A revision of the genus *Acontias* Cuvier (Sauria: Scincidae). *Arnoldia* 26(4): 1-29.

BROOKE, R K (1984). South African red data book - birds. Pretoria. *S. Afr. Nat. Sci. Prog. Report* 97. 231 pp.

BUCHANAN, W F, PARKINGTON, J E, ROBEY, T S and J C VOGEL (1984). Shellfish, subsistence and settlement: some western Cape holocene observations. In: *Frontiers: Southern African Archaeology today:* 121-130. *Cambridge Monographs in African Archaeology 10.*

BURGER, W A (1975). *Piket teen 'n berg.* Cape Town, privately published.

BURGERS, C J (1978). A preliminary assessment of the conservation and recreation potential of Verlorenvlei. *Unpublished memorandum.* Cape Town, Cape Provincial Administration, Department of Nature and Environmental Conservation.

BURGERS, C J (1980). Bewaring van Verlorenvlei en omgewing. *Unpublished memorandum.* Cape Town, Cape Provincial Administration, Department of Nature and Environmental Conservation.

BURGERS, C J (1984). Ramsar directory of wetlands of international importance: Verlorenvlei. *Unpublished proposal.* Cape Town, Cape Provincial Administration, Department of Nature and Environmental Conservation.

CAPE OF GOOD HOPE ORDINANCE 19 of 1974. To consolidate and amend the laws relating to nature conservation and to provide for matters incidental thereto. Cape Town. CPA. 21 February 1975.

CAPE OF GOOD HOPE PROCLAMATION 17 of 1969. Regulations relating to Ordinance 15 of 1952. Cape Town. CPA. 17 January 1969.

CAPE OF GOOD HOPE PROCLAMATION 357 of 1972. Regulations relating to the *Nature Conservation Ordinance* 26 of 1965. Cape Town. CPA. 25 September 1972.

CAPE OF GOOD HOPE PROCLAMATION 326 of 1974. Regulations relating to the *Nature Conservation Ordinance* 26 of 1965. Cape Town. CPA.

CAPE OF GOOD HOPE PROVINCIAL NOTICE 955 of 1975. Regulations relating to the *Nature Conservation Ordinance* 19 of 1974. Cape Town. CPA. 29 August 1975.

CAPE PROVINCIAL ADMINISTRATION (1968). A preliminary survey and report of Cape coastal townships and resorts. *Unpublished report*. Cape Town. 79 pp.

CLANCEY, P A (ed.) (in press). Report of the SAOS List Committee. *Ostrich*.

COOPER, J (1976). The ornithological importance of Verlorenvlei and its value as a nature reserve. *Unpublished memorandum*. University of Cape Town, Percy FitzPatrick Institute of African Ornithology.

COOPER, J, SUMMERS, R W and PRINGLE, J S (1976). Conservation of coastal habitats of waders in the South-Western Cape, South Africa. *Biological Conservation* 10: 239-247.

ELLIS, F (1976). Preliminary legend for 1:250 000 reconnaissance soil map of the western Cape. *Unpublished report*. Stellenbosch, Soil and Irrigation Research Institute.

FLEMMING, B W (1977). Distribution of recent sediments in Saldanha Bay and Langebaan lagoon. *Trans. Royal Soc. S.A.* 42: 317-340.

FROMME, G W (1985). The dynamics of the mouth channel of Verlorevlei: (Western Cape). Stellenbosch, *CSIR Report* T/SEA 8517. 18 pp.

GRINDLEY, J R (1979). *Zooplankton of the estuaries and lagoons of the west coast of southern Africa*. Fourth National Oceanographic Symposium, July 1979. Cape Town. (Abstract only).

GRINDLEY, J R and COOPER, K H (1979). *Proposals for the establishment of estuarine reserves*. Durban, Wildlife Society of South Africa. 35 pp.

GRINDLEY, J R, COOPER, K H and HALL, A V (1976). *Proposals for marine nature reserves for South Africa*. Johannesburg, Council for the Habitat. 16 pp.

GRINDLEY, J R and SAPEIKA, N (1960). The cause of mussel poisoning in South Africa. *S. Afr. med. J.* 43: 275-279.

HAUGHTON, S H (1926). On some new Mollusca from Tertiary beds in the West of the Cape Province. *Trans. R. Soc. S. Afr.* 13(2).

HAUGHTON, S H (1929). The palaeontology of the Namaqualand coastal deposits. *Trans. geol. Soc. S. Afr.* 31.

HAUGHTON, S H (1932). The Late Tertiary and Recent deposits of the west coast of South Africa. *Trans. geol. Soc. S. Afr.* 34.

HEINECKEN, T J E and BADENHORST, P (1985). Elandsbaai extensions 2 and 3. *Unpublished report*. Stellenbosch, National Research Institute for Oceanology, Council for Scientific and Industrial Research.

HENDEY, Q B (1983). Cenozoic geology and palaeogeography of the Fynbos region. *In:* Fynbos palaeoecology: a preliminary synthesis. Deacon, H J , Hendley, Q B and Lambrechts, J J N (eds). Pretoria, *S. Afr. Nat. Sci. Programmes Rep.* 75. 216 pp.

HEYDORN, A E F and TINLEY, K L (1980). Estuaries of the Cape Part I. Synopsis of the Cape coast. Natural features, dynamics and utilization. Stellenbosch, *CSIR Research Report* 380. 96 pp.

HOLTROP, V P (1981a). *The operation and construction of the horsemill at Verlorenvlei.* Cape Town, unpublished report.

HOLTROP, V P (1981b). *Factors leading to the decay of Verlorenvlei settlement buildings.* Cape Town, unpublished report.

JARMAN, M (ed.) (1986). Conservation priorities in the lowland region of the Fynbos Biome. Pretoria, *S. Afr. Nat. Sci. Programmes Rep.* 87. 55 pp.

JUBB, R A (1967). *Freshwater fishes of Southern Africa.* Cape Town, A A Balkema. 248 pp.

LANE, S B (1980). Interpretation of digital Landsat-1 imagery from Verlorenvlei, South Western Cape. University of Cape Town, *M.Sc. thesis.* 159 pp.

LLOYD, P H and MILLAR J C G (1983). A questionnaire survey (1969-1974) of some of the larger mammals of the Cape Province. *Bontebok* 3. 49 pp.

MACLEAN, G L (1985). *Robert's birds of Southern Africa.* Cape Town, The Trustees John Voelcker Bird Book Fund. 848 pp.

MANHIRE, A H (1981). Rock art of the Sandveld. University of Cape Town. *Honours thesis.*

MANHIRE, A H, PARKINGTON, J E and VAN RYSSEN, W J (1983). A distributional approach to the interpretation of rock art in the southwestern Cape. *S. Afr. Archaeol. Soc. Goodwin Ser.* 4: 29-33.

MEESTER, J A J (1976). South African red data book - small mammals. Pretoria. *S. Afr. Nat. Sci. Programmes Rep.* 11. 59 pp.

MIDGLEY, D C and PITMAN, W V (1969). Surface water resources of South Africa. Johannesburg. *Hydrological Research Unit Report* no. 2/69. 127 pp.

MILTON, S J (1978). Plant communities of Andriesgrond, Clanwilliam district. *Unpublished report.* Habitat Working Group, University of Cape Town.

MILTON, S J and LINDER, P (1980). The story of a dry mountain. *Veld and Flora* 66: 82-84.

MOLL, E J and BOSSI, L (1983). 1:250 000 scale map of the vegetation of 3218 Clanwilliam. Eco-lab, University of Cape Town.

MONTHLY RAINFALL AND EVAPORATION RECORDS OF EVAPORATION STATIONS up to SEPTEMBER 1967 (n.d.). Department of Water Affairs, Division of Hydrology. Pretoria. *Hydrographic Survey Publication* No. 9. 255 pp.

NOBLE, R G and HEMENS, J (1978). Inland water ecosystems in South Africa - a review of research needs. Pretoria, *S. Afr. Nat. Sci. Programmes Rep.* 34. 150 pp.

ORME, A R (1975). Late Pleistocene channels and Flandrian sediments beneath Natal estuaries: a synthesis. *Ann. S.Afr. Museum,* 71: 77-87.

PARKINGTON J E (1976a). Conservation of Verlorenvlei: archaeological implications. *Unpublished memorandum.* University of Cape Town, Department of Archaeology.

PARKINGTON, J E (1976b). Coastal settlement between the mouths of the Berg and Olifants rivers, Cape Province. *S. Afr. Archaeolog. Bull.* 31: 127-140.

PARKINGTON, J E (1980). Report on archaeological research in the Verlore Vlei 1976 - 9. *In: Verloren Vlei - a challenge to conservation.* Papers presented at a symposium on 'Conservation at Verloren Vlei' held in September 1980, organised by the School of Environmental Studies and the Department of Archaeology, Unviersity of Cape Town. Cape Town, University of Cape Town. 33 p.

ROBERTS, A (1936). Some unpublished field notes made by Dr (Sir) Andrew Smith between the years 1826 and 1831 in the Cape Colony (Cape Province of South Africa). Compiled from his manuscript notes. *Ann. Transv. Mus.* 18: 271-323.

ROBERTSON, H N (1980). An assessment of the utility of Verlorenvlei water. University of Cape Town, *Masters thesis.*

ROGERS, A W (1904). Geological survey of parts of the Division of Piquetberg, Clanwilliam, and Van Rhyn's Dorp: *A. Rep. Geol. Comm. CGH.* for 1903, Cape Town.

ROGERS, J (1980). First report on the Cenozoic sediments between Cape Town and Elands Bay. Pretoria. *Rep. Geol. Surv. S. Afr.* 165: 1-64 (Open file).

ROGERS, J (1982). Lithostratigraphy of Cenozoic sediments between Cape Town and Eland's Bay. In: *Palaeoecology of Africa and the surrounding islands.* Coetzee, J A and Van Zinderen Bakker, E M. (eds) Rotterdam, Balkema.

SCOTT, H A and HAMMAN, K C D (1984). Freshwater fishes of the Cape. *Cape Conservation Series* 5. Cape Town, Cape Department of Nature and Environmental Conservation. 24 pp.

SINCLAIR, S A (1980a). The rural settlement of Verlorenvlei in historical perspective: University of Cape Town. *Masters thesis.*

SINCLAIR, S A (1980b). Recent settlement at Verlorenvlei. *In: Verlorenvlei - a challenge to conservation.* Papers presented at a symposium on 'Conservation and research at Verlorenvlei' ... 51 pp.

SINCLAIR, S A (1985). Monitoring of change in the rural settlement of Verlorenvlei from 1979 to 1985. University of Stellenbosch, Department of Nature Conservation. *Unpublished report* with photographic collection.

SINCLAIR, S A (1986a). A synthesis of available research information on the Verlorenvlei estuary and coastal lake, with some preliminary recommendations. University of Stellenbosch, Department of Nature Conservation, *Honours project.*

SINCLAIR, S A (1986b). Historical review of the fauna and vegetation of Verlorenvlei. University of Stellenbosch, Department of Nature Conservation. *Unpublished report.*

SINCLAIR, S A (1986c). Interpretation of an archival map sequence for Verlorenvlei. Stellenbosch, *unpublished report*.

SINCLAIR, S A and HOLTROP, V P (1982). Horsemills of the Sandveld. *South African Panorama*. October 1982: 16-17.

SKEAD, C J (1980). *Historical mammal incidence in the Cape Province Vol. 1: The Western and Northern Cape*. Cape Town, Cape Department of Nature and Environmental Conservation. 903 pp.

SKELTON, P H (1977). South African Red Data Book - Fishes. Pretoria, *S. Afr. Nat. Sci. Programme Report* 14. 39 pp.

SKINNER, J D, FAIRALL, N and BOTHMA, J du P (1977). South African red data book - large mammals. Pretoria. *S. Afr. Natl. Sci. Programmes Rep*. 18. 29 pp.

SOUTH AFRICA (1935). Sea shore *Act* 21 of 1935.

SOUTH AFRICA (1956). Water *Act* 54 of 1956.

SOUTH AFRICA (1961). Disposal of State land *Act* 48 of 1961.

SOUTH AFRICA (1973). Sea Fisheries *Act* 58 of 1973.

SOUTH AFRICA (1973). Sea birds and seals protection *Act* 46 of 1973.

SOUTH AFRICAN SAILING DIRECTIONS (1979). Volume II. The coasts of South West Africa and the Republic of South Africa from the Kunene River to Cape Hangklip. 2nd Edition. Retreat, Cape. The Hydrographer, S.A. Navy. 219 pp.

SOUTH AFRICAN TIDE TABLES (1985). Tokai, C.P. The Hydrographer, South African Navy. 260 pp.

SOUTH AFRICAN WEATHER BUREAU (1975). Climate of South Africa. Part 12. Surface winds. Pretoria. *Weather Bureau Publication* No. WB38.

STUART, C T (1981). Notes on the mammalian carnivores of the Cape Province, South Africa. *Bontebok* 1:1-58.

SUMMERS, R W, PRINGLE, J S and COOPER, J (1976). *The status of coastal waders in the South-western Cape, South Africa*. Cape Town, Western Cape Wader Study Group. 162 pp.

SUMMERS, R W, COOPER, J and PRINGLE, J S (1977). Distribution and numbers of coastal waders (Charadrii) in the South-western Cape, South Africa. *Ostrich* 48: 85-97.

TANKARD, A J (1976a). Thermally anomalous Late Pleistocene molluscs from the south-west Cape Province, South Africa. *Ann. S. Afr. Mus*. 69: 17-45.

TANKARD, A J (1976b). Pleistocene history and coastal morphology of the Ysterfontein-Elands Bay area, Cape Province. *Ann. S.Afr. Museum*. 69(5): 73-119.

TAYLOR, H C (1978). Capensis. *In: Biogeography and ecology of Southern Africa*. Werger, M J A (ed.). The Hague, Junk: 171-230.

UNDERHILL, L G and COOPER, J (1983). Counts of waterbirds at coastal wetlands in southern Africa: estuaries 1979-1981. *Unpublished report*, interim version UWETLD. Cape Town, Western Cape Wader Study Group and Percy Fitz-Patrick Institute of African Ornithology.

UNIVERSITY OF CAPE TOWN (1978). Nutrient analysis - Verlorenvlei. *Unpublished Masters student project*. University of Cape Town, School of Environmental Studies.

UNIVERSITY OF CAPE TOWN (1980). Verlorenvlei recorded. *Unpublished student group project*, University of Cape Town, School of Architecture.

VAN RYSSEN, W J (1984). Southwestern Cape rock art - who painted what? *S. Afr. Archaeol. Bull.* 39: 125-129.

VILJOEN, A (1975). Die ploeg van nuwe grond in die Sandveld. *Unpublished memorandum*. Stellenbosch, Streeksadvieskomitee vergadering te Stellenbosch.

VISSER, H M and TOERIEN, D K (1971). Die geologie van die gebied tussen Vredendal en Elandsbaai. Toeligting van blaaie 3218C Doringbaai en 3218A Lambertsbaai. Pretoria, Department of Mines, *Geological Survey Publication* No. 62813-1. (Summary in English entitled: The geology of the area between Vredendal and Elandsbaai).

VISSER, J D (1984). Akkedisse van Suider-Afrika. *Landbouweekblad* reeks 65(319)-66(359).

VON HARMSE (1978). Schematic soil map of Southern Africa south of latitude 16°30'S. *In: Biogeography and ecology of Southern Africa*. Werger, M J A (ed.). The Hague, Junk: 71-76.

WALTON, J (1974). *Water mills, windmills and horsemills of South Africa*. Cape Town, Struik.

WERGER, M J A (1978). The Karoo-Namib region. *In: Biogeography and ecology of Southern Africa*. Werger, M J A (ed.). The Hague, Junk: 231-300.

WHITFIELD, A K, ALLANSON, B R and HEINECKEN, T J E (1983). Estuaries of the Cape. Part II: Synopsis of available information on individual systems. Report No. 22. Swartvlei (CMS11). Heydorn A E F and Grindley, J R (eds). Stellenbosch. *CSIR Research Report* 421. 62 pp.

YATES, R J, MILLER, D E, HALKETT, D J, MANHIRE, A H and PARKINGTON, J E (1986). A late mid-holocene high sea-level: a preliminary report on geoarchaeology at Elands Bay Western Cape Province, South Africa. *S. Afr. J. Sci.* 82: 164-165.

Maps

SOUTH AFRICA 1:50 000 Topographic Sheet 3218 AD Elandsbaai. 1st edition. Pretoria. Government Printer. 1966.

SOUTH AFRICA 1:50 000 Topographic Sheet 3218BC Redelinghuys. 1st edition. Pretoria. Government Printer. 1967.

SOUTH AFRICA 1:125 000 Geological Sheet 3118C - Doringbaai and 3218A - Lamberts Bay. Pretoria. Government Printer. 1969.

SOUTH AFRICA 1:250 000 Geological Sheet 3218 Clanwilliam. Pretoria. Government Printer. 1973.

SOUTH AFRICA 1:250 000 Topographic Sheet 3218 Clanwilliam. 2nd edition. Pretoria. Government Printer. 1979.

CAPE ARCHIVES. Nieuwe kaart van Caap der Goede Hoop in hare rechte jegenwoordige Staat vertoond door Francois Valentyn. ca:1700. (M1/1184).

CAPE ARCHIVES. Das Vorgebirg der Guten Hofnung. L S de la Rochette. 1789. (M1/1178).

Aerial Photography

Date	Job No.	Photos Nos	Scale	Colour	Source
1942	10/42	299, 337, 347-350, 394	28:000	B/W	Trig. Survey
Feb/March 1960	437	4263, 4264, 5404, 5405	40:000	B/W	Trig. Survey
23-01-1971	675	329, 393	41:000	B/W	Trig. Survey
12-05-1979	326	1007/5	10:000	Col.	University of Natal
01-04-1980	348	64	20:000	B/W	University of Natal

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: Amphibians and Reptiles likely to occur in the environs of Verlorenvlei (A L de Villiers, CDNEC, *in litt.*). (CDNEC = Cape Department of Nature and Environmental Conservation, Herpetological specimen collection (1972-1985))
X = recorded, L = likely to occur

		3218AD	REFERENCE
AMPHIBIANS			
Xenopus laevis	common platanna	L	
Bufo gariepensis	Karoo toad	L	
Bufo rangeri	raucous toad	L	
Breviceps namaquensis	Namaqua rain frog	L	
Breviceps rosei	sand rain frog	L	
Tomopterna delalandii	Cape sand frog	L	
Rana fuscigula	Cape river frog	L	
Rana grayii	spotted rana	L	
Cacosternum boettgeri	common caco	L	
TORTOISES AND TERRAPIN			
Chersina angulata	angulate tortoise	L	
Homopus signatus	Namaqualand padloper	L	
Pelomedusa subrufa	Cape terrapin	L	
SNAKES			
Typhlops lalandei	Delalande's blind snake	L	
Lamprophis inornatus	olive house snake	L	
Lamprophis guttatus	spotted house snake	L	
Lamprophis fuliginosus	common brown house snake	L	
Pseudaspis cana	mole snake	L	
Psammophylax rhombeatus	skaapsteker	X	CDNEC
Psammophis notostictus	whip snake	L	
Psammophis leightoni namibensis	Namib sand snake	X	Broadley (1983)
Psammophis crucifer	cross-marked grass snake	X	CDNEC
Homoroselaps lacteus	spotted harlequin snake	X	CDNEC
Prosymna sundevallii sundevallii	southern shovel-snout	L	
Crostaphopeltis hotamboeia	herald snake	L	
Dispholidus typus	boomslang	L	
Dasypeltis scabra	common egg-eater	L	
Hemachatus haemachatus	rinkhals	L	
Aspidelaps lubricus	coral snake	L	
Naja nivea	Cape cobra	L	
Bitis cornuta	many-horned adder	L	
Bitis arietans arietans	puff-adder	L	
LIZARDS			
Chrondodactylus angulifer	ground gecko	L	
Pachydactylus austeni	Austen's ground gecko	X	Visser (1984), CDNEC
Pachydactylus geitje	ocellated gecko	L	
Pachydactylus mariquensis	Marico gecko	L	
Pachydactylus rugosus formosus	striped rough-scaled gecko	L	
Pachydactylus weberi	Weber's gecko	L	
Pachydactylus capensis labialis	western Cape gecko	X	Visser (1984)

APPENDIX I: (Cont.)

		3218AD	REFERENCE
Pachydactylus bibronii	Bibron's gecko	X	Visser (1984), CDNEC
Phyllodactylus lineatus	dwarf leaf-toed gecko	X	Visser (1984), CDNEC
Phyllodactylus porphyreus	marbled gecko	L	
Bradypodion pumilum	Cape dwarf chameleon	L	
Bradypodion ventrale occidentale	Namaqua dwarf chameleon	L	
Agama atra	rock agama	X	CDNEC
Agama hispida	Cape spiny agama	L	
Scelotes bipes sexlineatus	striped didactyle sand skink	X	CDNEC
Scelotes kasneri	Kasner's didactyle sand skink	X	CDNEC
Scelotes caffer	Cape tridactyle skink	X	CDNEC
Acontias litoralis	west coast legless skink	X	Broadley and Greer (1969)
Acontias meleagris	golden legless skink	L	
Acontias lineatus	striped legless skink	L	
Typhlosaurus caecus	Cuvier's legless skink	X	Visser (1984, CDNEC
Mabuya capensis	Cape three-striped skink	X	CDNEC
Mabuya variegata	variegated skink	X	CDNEC
Gerrhosaurus typicus	Namaqua plated lizard	L	
Cordylosaurus subtessellatus	blue-tailed plated lizard	L	
Nucras tessellata	tiger lizard	L	
Eremias lineoocellata pulchella	ocellated sand lizard	L	
Meroles knoxii	Knox's ocellated sand lizard	X	Visser (1984)
Cordylus macropholis	large-scaled girdled lizard	X	Visser (1984)
Cordylus catephractus	armadillo lizard	X	CDNEC
Cordylus capensis	Smith's girdled lizard	L	
Cordylus polyzonus	smooth-backed girdled lizard	X	Visser (1984), CDNEC

APPENDIX II: Bird species observed present and observed breeding or suspected breeding at Verlorenvlei (from records for Elandsbaai and Redelinghuys, Percy FitzPatrick Institute of African Ornithology, University of Cape Town). Note: The "New Roberts numbers" are used (Maclean, 1985).

New Roberts number		3218BC Redelinghuys		3218AD Elandsbaai	
		Observed present	Breeding	Observed present	Breeding
3	Jackass Penguin			x	
6	Great Crested Grebe			x	x
7	Black-necked Grebe	x		x	
8	Little Grebe	x	x	x	
49	White Pelican	x		x	
53	Cape Gannet			x	
55	White-breasted Cormorant	x		x	x
56	Cape Cormorant			x	x
57	Bank Cormorant			x	
58	Reed Cormorant	x		x	x
59	Crowned Cormorant			x	
60	Darter	x		x	x
62	Grey Heron	x		x	x
63	Black-headed Heron	x		x	
65	Purple Heron	x		x	
66	Great White Egret	x		x	
67	Little Egret	x		x	
68	Yellow-billed Egret	x		x	
71	Cattle Egret	x		x	x
76	Night Heron	x		x	
81	Hamerkop	x			
84	Black Stork	x			
91	Sacred Ibis	x		x	
93	Glossy Ibis	x		x	
95	Spoonbill	x		x	x
96	Greater Flamingo	x		x	
97	Lesser Flamingo			x	
116	Spurwing Goose	x		x	
102	Egyptian Goose	x	x	x	
103	South African Shelduck	x	x	x	x
112	Cape Shoveler	x		x	x
104	Yellow-billed Duck	x		x	
108	Redbill Teal	x		x	
106	Cape Teal	x		x	x
113	Redeyed Pochard	x		x	
117	Maccoa Duck			x	
181	Rock Kestrel	x		x	
126	Yellow-billed Kite	x		x	
127	Black-shouldered Kite	x		x	
131	Black Eagle	x		x	x
136	Booted Eagle	x			
148	Fish Eagle			x	
152	Jackal Buzzard	x			
149	Buzzard	x		x	
165	African Marsh Harrier	x		x	

APPENDIX II: (Cont.)

New Roberts number		3218BC Redelinghuys		3218AD Elandsbaai	
		Observed present	Breeding	Observed present	Breeding
169	Gymnogene	x			
190	Greywing Francolin	x			
195	Cape Francolin	x		x	x
200	African Quail	x		x	
203	Crowned Guineafowl	x		x	
210	Water Rail	x		x	
213	Black Crake	x		x	
217	Red-chested Flufftail	x			
223	Purple Gallinule	x		x	
226	Moorhen	x		x	
228	Red-knobbed Coot	x	x	x	
239	Black Korhaan	x		x	
244	Black Oystercatcher			x	x
262	Turnstone			x	
245	Ringed Plover			x	
246	White-fronted Sandplover			x	
247	Chestnutbanded Sandplover			x	
248	Kittlitz's Sandplover	x		x	x
249	Three-banded Sandplover	x		x	
251	Great Sandplover			x	
254	Grey Plover			x	
255	Crowned Plover	x		x	x
258	Blacksmith Plover	x	x	x	
286	Ethiopian Snipe	x	x	x	x
272	Curlew sandpiper	x		x	
274	Little Stint	x		x	
281	Sanderling			x	
284	Ruff	x		x	
264	Common Sandpiper	x		x	
269	Marsh Sandpiper	x		x	
270	Greenshank	x		x	
266	Wood Sandpiper	x		x	
272	Curlew sandpiper			x	
294	Avocet	x		x	
295	Stilt	x		x	
298	Water Dikkop			x	
297	Cape Dikkop	x		x	
312	Kelp Gull	x		x	
315	Grey-headed Gull	x		x	
316	Hartlaub's Gull			x	
322	Caspian Tern			x	
327	Common Tern	x		x	
329	Antarctic Tern			x	
328	Arctic Tern			x	
326	Sandwich Tern			x	
324	Swift Tern			x	x
339	White-winged Black Tern	x		x	
338	Whiskered Tern			x	
344	Namaqua Sandgrouse	x		x	

APPENDIX II: (Cont.)

New Roberts number		3218BC Redelinghuys		3218AD Elandsbaai	
		Observed present	Breeding	Observed present	Breeding
348	Feral Pigeon	x		x	
349	Rock Pigeon	x		x	
352	Redeyed Turtle Dove	x		x	
354	Turtle Dove	x		x	
355	Laughing Dove	x	x	x	
356	Namaqua Dove	x		x	
386	Diederik Cuckoo	x		x	
391	Burchell's Coucal	x			
401	Spotted Eagle Owl			x	
412	Black Swift	x		x	
415	White-rumped Swift	x		x	
417	Little Swift	x	x	x	
418	Alpine Swift	x		x	
424	Speckled Mousebird	x		x	
425	White-backed Mousebird	x		x	
426	Redfaced Mousebird	x		x	
428	Pied Kingfisher	x		x	
429	Giant Kingfisher	x		x	
431	Malachite Kingfisher	x		x	
438	European Bee-eater	x		x	
451	Hoopoe	x	x	x	
465	Pied Barbet	x		x	
474	Greater Honeyguide	x		x	
502	Karoo Lark			x	
512	Thickbilled Lark	x		x	
495	Clapper Lark	x			
500	Long-billed Lark	x		x	
516	Greybacked Finchlark	x		x	
507	Redcapped Lark	x		x	
518	European Swallow	x		x	
520	White-throated Swallow	x	x	x	
523	Pearl-breasted Swallow	x	x	x	
526	Greater Striped Swallow	x		x	
529	Rock Martin	x		x	
532	African Sand Martin	x		x	
534	Banded Sand Martin			x	
548	Pied Crow	x		x	
547	Black Crow			x	
550	White-necked Raven	x		x	
551	Grey Tit	x		x	
566	Cape Bulbul	x		x	
577	Olive Thrush	x			
581	Cape Rockthrush	x			
586	Mountain Chat	x		x	
592	Karoo Chat			x	
587	Capped Wheatear	x		x	
589	Familiar Chat	x		x	
591	Sicklewing Chat			x	
595	Anteating Chat	x		x	

APPENDIX II: (Cont.)

New Roberts number		3218BC Redelinghuys		3218AD Elandsbaai	
		Observed present	Breeding	Observed present	Breeding
596	Stone Chat	x		x	
601	Cape Robin	x	x	x	
614	Karoo Scrub Robin	x		x	
635	Cape Reed Warbler	x		x	
631	African Marsh Warbler	x		x	
638	African Sedge Warbler	x		x	
651	Crombec	x		x	
645	Barthroated Apalis	x		x	
664	Fantail Cisticola	x			
669	Grey-backed Cisticola	x		x	
677	Le Vaillant's Cisticola	x		x	
686	Karoo Prinia	x		x	
621	Titbabbler	x		x	
622	Layard's Titbabbler	x		x	
697	Chat Flycatcher			x	
698	Fiscal Flycatcher	x		x	
706	Fairy Flycatcher	x		x	
713	Cape Wagtail	x		x	
716	Richard's Pipit	x		x	
727	Orange-throated Longclaw	x		x	
732	Fiscal Shrike	x		x	
746	Bokmakierie	x		x	
757	European Starling	x		x	
760	Wattled Starling	x		x	
769	Red-winged Starling	x		x	
759	Pied Starling	x	x	x	x
773	Cape Sugarbird	x			
775	Malachite Sunbird	x		x	
783	Lesser Double-collared Sunbird	x		x	x
796	Cape White-eye	x		x	
801	House Sparrow	x	x	x	
803	Cape Sparrow	x	x	x	x
813	Cape Weaver	x	x	x	x
814	Masked Weaver	x	x	x	
824	Red Bishop	x	x	x	x
827	Cape Widow	x		x	
846	Common Waxbill	x		x	
860	Pintailed Whydah	x		x	
874	Cape Siskin	x			
872	Cape Canary	x		x	
876	Blackhead Canary	x			
879	White-throated Seedeater	x	x	x	
878	Yellow Canary	x		x	
881	Streaky-headed Seedeater	x			
887	Larklike Bunting	x			
885	Cape Bunting	x		x	

APPENDIX III: Mammal species which occur or are likely to occur in the environs of Verlorenvlei, 1:50 000 Topographic sheets 3218 AD and 3218 BC (P H Lloyd, CDNEC, *in litt.*).

Species recorded as occurring in the relevant grid squares

INSECTIVORA
- *Crocidura cyanea*
- RDB *Cryptochloris wintoni*

ARTIODACTYLA
- *Sylvicapra grimmia*

RODENTIA
- *Otomys irroratus*
- RDB *Tatera afra*
- *Gerbillurus paeba*
- *Desmodillus auricularis*
- *Aethomys namaquensis*
- *Mus minutoides*
- *(Rattus rattus)*
- *Hystrix africaeaustralis*

CARNIVORA
- *Otocyon megalotis*
- *Herpestes pulverulentus*
- *Atilax paludinosus*
- RDB *Proteles cristatus*

Additional species occurring around he relevant grid squares

INSECTIVORA
- *Myosorex varius*
- *Chrysochloris asiatica*
- RDB *Eremitalpa granti*

RODENTIA
- *Otomys unisulcatus*
- *Otomys saundersae*
- *Parotomys brantsii*
- *Dendromus melanotis*
- *Dendromus mesomelas*
- *Rhabdomys pumilio*
- *(Mus musculus)*

CARNIVORA
- *Vulpes chama*
- *Ictonyx striatus*
- *Genetta genetta*
- *Cynictis penicillata*
- *Suricata suricatta*
- *Felis lybica*

CHIROPTERA
- *Miniopterus schreibersii*
- *Eptesicus hottentotus*
- *Eptesicus melckorum*
- *Eptesicus capensis*
- *Myotis tricolor*
- *Rhinolophus capensis*
- *Rhinolophus clivosus*
- *Nycteris thebaica*

PRIMATES
- *Papio ursinus*

TUBULIDENTATA
- RDB *Orycteropus afer*

HYRACOIDEA
- *Antidorcas marsupialis*
- *Raphicerus campestris*

LAGOMORPHA
- *Lepus saxatalis*
- *Lepus capensis*

Possible/probable* species not yet recorded

INSECTIVORA
- **Suncus varilla*
- *Crocidura flavescens*
- RDB *Cryptochloris zyli*
- *Macroscelides proboscideus*
- *Elephantulus rupestris*
- *Elephantulus edwardi*

ARTIODACTYLA
- *Raphicerus melanotis*
- *Pelea capreolus*

RODENTIA
- RDB *Acomys subspinosus*
- RDB *Graphiurus ocularis*
- *Bathyergus suillus*
- *Cryptomys hottentotus*
- *Georychus capensis*

CARNIVORA
- *Canis mesomelas*
- RDB *Mellivora capensis*
- *Aonyx capensis*
- *Felis caracal*

CHIROPTERA
- *Myotis lesueuri*
- *Sauromys petrophilus*
- *Tadarida pumila*
- *Tadarida aegyptiaca*

CETACEA (records are incomplete)
- *Mesoplodon mirus*
- *Hyperoodon planifrons*
- *Kogia breviceps*
- *Grampus griseus*
- *Globicephala melaena*
- **Delphinus delphis*
- *Stenella coeruleoalba*
- *Tursiops aduncus*
- *Balaenoptera acutorostrata*
- **Eubalaena glacialis australis*

RDB = Species listed in Red Data Book (Skinner *et al.*, 1977; Meester, 1976).

APPENDIX IV: Legal restrictions on the recreational use of Verlorenvlei as at 1980 (from Robertson, 1980)

Fishing
Fishing at Verlorenvlei must comply with the Cape Nature Conservation Ordinance (No. 19 of 1974), and with any Proclamations and Regulations made in terms of that Ordinance.

In terms of the Ordinance, Verlorenvlei is a "tidal water", defined as "that part of any inland waters which, owing to the influence of the sea, becomes saline at any time or the level of which rises at any time owing to the influence of the sea".

The use of all nets, except landing nets, in tidal waters requires a licence. At Verlorenvlei only riparian owners are granted netting licences. The licence costs R3,00 and is valid for one year. It allows each owner to use a single gill net in an area between the mouth and an imaginary direct line connecting beacons PA 90 and PA 91 (on the left and right banks respectively). The net used may not be more than thirty metres in length or two metres in depth when hanging wet and must carry an identification token issued and affixed by the Department of Nature and Environmental Conservation. The riparian owner can fish only in the waters adjacent to his property and the fish may only be caught for his own domestic use (Proclamation 357 of 1972).

Angling is allowed in tidal waters without a licence. Where inland waters are not tidal, an angling licence, costing R2,00 is required. At Verlorenvlei, because of its brackishness, it is difficult to define the boundary between the "tidal" and non-tidal or fresh-water area. Therefore the beacons PA 90 and PA 91 were established to define this boundary. However, their location could not be established except that they are in the upper region of the vlei. According to the Nature Conservation Officer in the region they are probably overgrown and difficult to see, except from the water. This is unacceptable. The beacons should be kept visible from both land and water so that no excuses for breaking the law may be made. There appears to be uncertainty as to whether an angler who has no licence and is fishing legally in the "tidal" area, but catching freshwater fish, is contravening any regulation.

Certain methods of catching fish in inland waters are prohibited, for example by snatching or spearing, or with more than two lines (Nature Conservation Ordinance, Section 56).

Animal collection
Aquatic animals caught in inland waters may not be transferred from one inland water to another, or to the sea, nor may they be bought or sold unless the collector has a permit authorizing him to do so. Bait collected in inland waters may not be removed more than ten metres from the edge of the inland water, and therefore can be used only for angling in that inland water (Nature Conservation Ordinance, Section 59). Proclamations Nos. 357 of 1972, 326 of 1974 and Provincial Notice 955 of 1975 contain provisions relating to the size and numbers of aquatic animals that can be caught in inland waters.

Bird shooting
With the exception of the Cape Widow, Cape Weaver and Red Bishop, all the birds listed in Appendix II are protected in terms of the Nature Conservation Ordinance 1974. The exceptions are considered pests because they feed on grain crops, thereby causing considerable economic loss. Protected birds cannot be

APPENDIX IV: (Cont.)

kept in captivity (Section 31) or poisoned (Section 32). Shooting is allowed only in the hunting season and a licence is required (Section 27). A landowner, or his relative or full-time employee acting with the owner's permission, may hunt protected birds on his land without a licence but only during the hunting season (Section 27). Birds in or on inland waters may not be hunted using a boat (Section 29).

In South Africa waterfowl shooting has not gained the popularity it has in other countries.

Boating
In the area between the mouth of Verlorenvlei and an imaginary direct line connecting beacons PA 90 and PA 91 (on the left and right banks respectively) no person may use a boat or other craft propelled by an engine unless he has a permit (Proclamation 357 of 1972). Because these beacons are apparently in the upper region of the vlei (see under fishing) the deeper areas suitable for power boating are included in the restricted area. In the shallower upper and lower areas where *Myriophyllum spicatum* grows it hampers rowing. Canoeing is less restricted by *Myriophyllum*. Windsurfing has been taking place in the lower reaches, and is not specifically covered in the regulation, as it is a recent sport.

Penalties
The penalties for a person found guilty of an offence under the Nature Conservation Ordinance, except where a penalty is specifically prescribed by regulation, are:

(i) a fine not exceeding R200 or imprisonment for a period not exceeding 6 months on a first conviction;

(ii) a fine not exceeding R400 or imprisonment for a period not exceeding 12 months on a second or subsequent conviction.

In the three years before 1980 there were two court cases involving the use of nets without licences at Verlorenvlei. Four people were charged, a total of R100 and six nets were forfeited to the Provincial Administration. The approximate cost of a net less than thirty metres in length is R150. The total penalty in this case may be considered to be R1 000 (Van Rooyen, CDNEC, pers. comm.).

APPENDIX V: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: VERLORENVLEI

Guide to available information

		Sources of information	Acocks	Africa Pilot	Boucher	Boucher	Boucher and Jarman	Broadley	Broadley and Greer	Brooke	Buchanan et al	Burger	Burgers	Burgers	Burgers	Cape of Good Hope Ordinance 19	Cape of Good Hope Proclamation 17	Cape of Good Hope Proclamation 357	Cape of Good Hope Proclamation 326	Cape of Good Hope Provin Notice 955
		YEAR (DATE OF INFORMATION)	1975	1977	1980	1981	1977	1983	1969	1984	1984	1975	1978	1980	1984	1974	1969	1972	1974	1975
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																		

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																	MANAGEMENT				
		Physiography			Geology			Physics				Salinity	Chemistry			Microbiology	Flora					Fauna								Food webs/Ecosystems								
VERLORENVLEI		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing		General Chemistry	Eutrophication	Pollution		Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals		Water	Legislation	Management/Planning	Conservation/Utilization	Historical
Sources of information		Guide to available information																																		
Cape Provincial Administration	1968																																*			
Clancey	–																												*							
Cooper	1976																												*							
Cooper et al	1976																												*							
Ellis	1976				*																															
Flemming	1977						*																													
Fromme	1985									*																						*		*		
Grindley	1979																					*														
Grindley and Cooper	1979																																		*	
Grindley et al	1976																																		*	
Grindley and Sapeika	1960																								*											
Haughton	1926					*																			*											
Haughton	1929					*																														
Haughton	1932					*																														
Heinecken and Badenhorst	1985																																	*		
Hendey	1983				*	*																														
Heydorn and Tinley	1980			*					*	*																								*	*	
Holtrop (a)	1981																																			*

APPENDIX V: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: VERLORENVLEI

Guide to available information

	Sources of information	Holtrop (b)	Jarman	Jubb	Lane	Lloyd and Millar	Maclean	Manhire	Manhire **et al**	Meester	Midgley and Pitman	Milton	Milton and Linder	Moll and Bossi	Monthly Rainfall and Evap Records	Noble and Hemens	Orme	Parkington (a)	Parkington (b)
	YEAR (DATE OF INFORMATION)	1981	1986	1967	1980	1983	1985	1981	1983	1976	1969	1978	1980	1983	n.d.	1978	1975	1976	1976
MANAGE-MENT	Historical	*						*	*										
MANAGE-MENT	Conservation/Utilization	*	*																
MANAGE-MENT	Management/Planning															*			
MANAGE-MENT	Legislation																		
MANAGE-MENT	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 V: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: VERLORENVLEI

Guide to available information

Category	Subcategory	Topic	Parkington	Roberts	Robertson	Rogers	Rogers	Rogers	Scott and Hamman	Sinclair (a)	Sinclair (b)	Sinclair	Sinclair (a)	Sinclair (b)	Sinclair (c)	Sinclair and Holtrop	Skead	Skelton	Skinner et al	S.A. Sea Shore Act
YEAR (DATE OF INFORMATION)			1980	1936	1980	1904	1980	1982	1984	1980	1980	1985	1986	1986	1986	1982	1980	1977	1977	1935
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											*							

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																		MANAGEMENT			
		Physiography			Geology			Physics				Salinity	Chemistry			Microbiology	Flora				Fauna										Food webs/Ecosystems								
VERLORENVLEI		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing		General Chemistry	Eutrophication	Pollution		Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals		Water	Legislation	Management/Planning	Conservation/Utilization	Historical
Sources of information		Guide to available information																																			
S.A. Water Act	1956																																*			
S.A. Disposal of State Land Act	1961																																*			
S.A. Sea Fisheries Act	1973																																*			
S.A. Sea birds and seals protect Act	1973																																*			
S.A. Sailing Directions	1979								*																												
S.A. Tide Tables	1985								*																												
S.A. Weather Bureau	1975							*																													
Stuart	1981																														*						
Summers et al	1976																												*								
Summers et al	1977																												*								
Tankard (a)	1976					*																			*												
Tankard (b)	1976			*		*																															
Taylor	1978																				*																
Underhill and Cooper	1983																												*								
University of Cape Town	1978												*																								
University of Cape Town	1980																																				*
Van Ryssen	1984					*																															*
Viljoen	1975																																	*	*		

APPENDIX V: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: VERLORENVLEI

Guide to available information

Category	Group	Topic	Visser and Toerien	Visser	Von Harmse	Walton	Werger	Whitfield et al	Yates et al
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							
YEAR (DATE OF INFORMATION)			1971	1984	1978	1974	1978	1983	1986

Sources of information: Visser and Toerien; Visser; Von Harmse; Walton; Werger; Whitfield et al; Yates et al

PLATE I:

Baboon Point/Cape Deseada, with Elands Bay in the foreground, and the coastline running towards the south. (Photo: P D Morant, October 1980)

PLATE II:

Driftsands to the north of the Verlorenvlei Estuary mouth in August 1979. (Photo: ECRU 79-08-14)

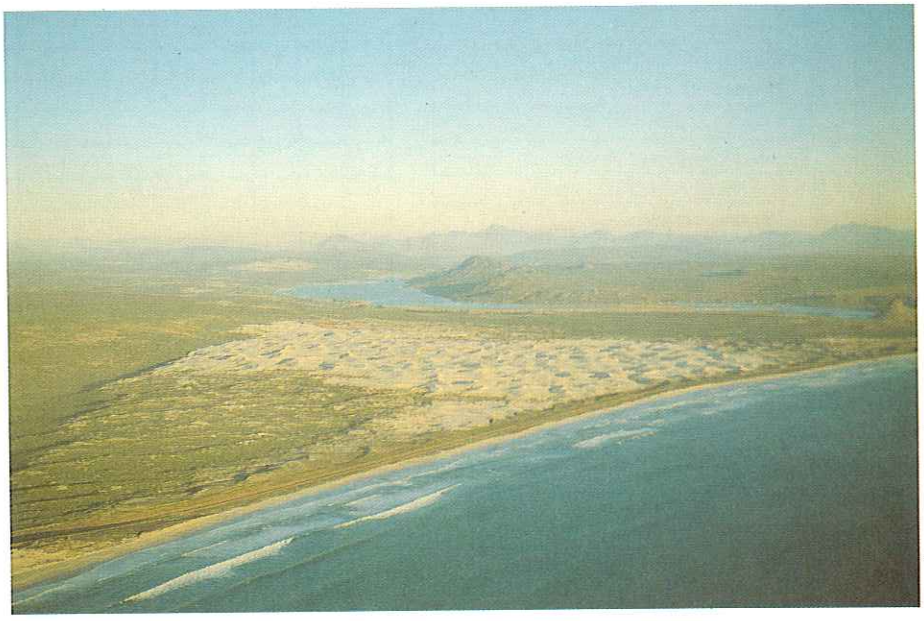


PLATE III:

Aerial view of Verlorenvlei from the northwest. (Photo: ECRU 79-08-14).