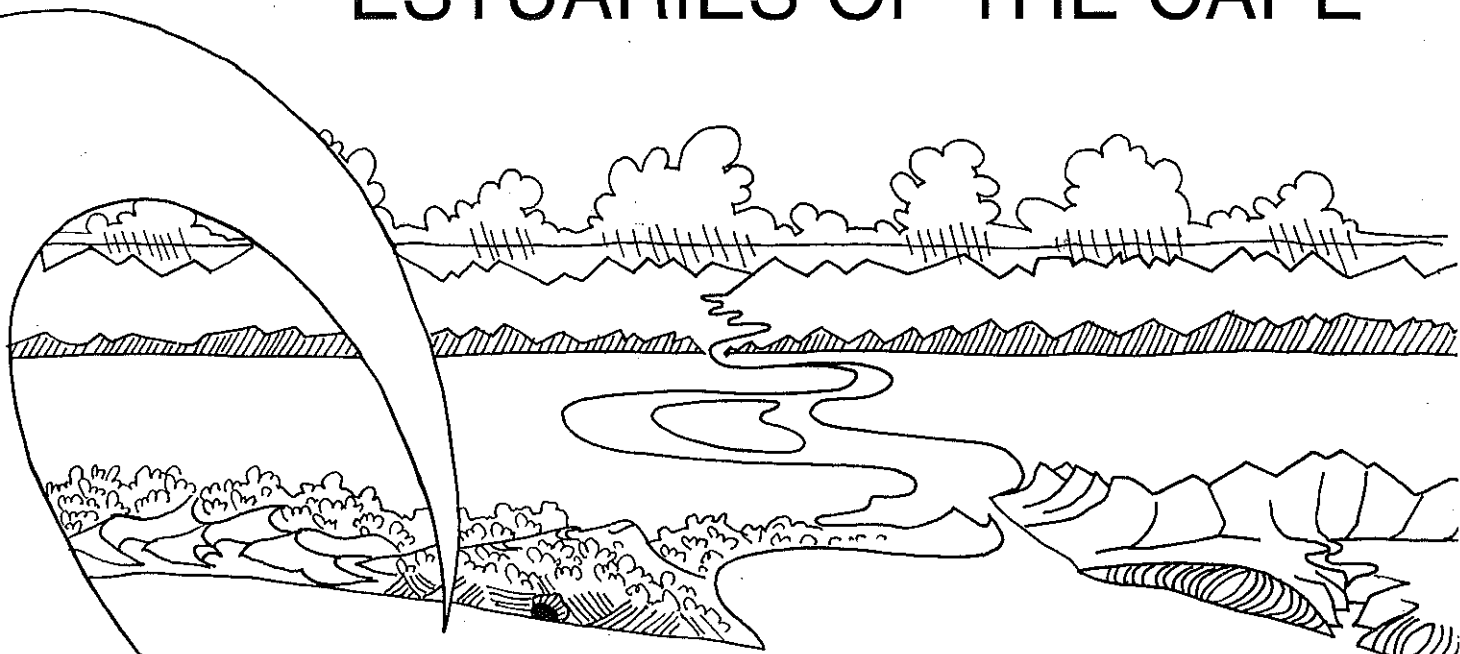


COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU



ESTUARIES OF THE CAPE



PART II

SYNOPSIS OF AVAILABLE INFORMATION
ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN
J R GRINDLEY

REPORT NO. 6

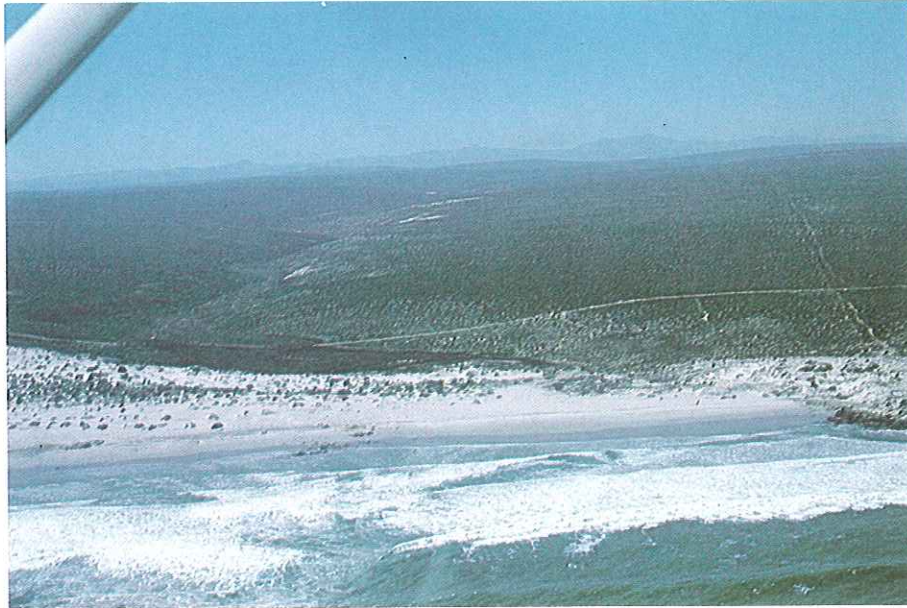
BITTER (CW6)

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 6: BITTER (CW6)

(CW6 — CSIR Estuary Index Number)



FRONTISPIECE: BITTER ESTUARY — ALT. 150 m, ECRU 79-08-14

COMPILED BY: I B BICKERTON

ECRU SURVEY : 19 OCTOBER 1980
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ESTUARINE AND COASTAL RESEARCH UNIT — ECRU
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COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

ISBN 0 7988 1812 3 (Set)
ISBN 0 7988 1813 1 (Part 2)
ISBN 0 7988 1829 8 (Rep. No.6)

Published in 1981 by :

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

Printed by :

CREDA PRESS, CAPE TOWN

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PREFACE

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

- to contribute information relevant to the development of a cohesive management policy for the South African coastline;
- to compile syntheses of all available knowledge on the 167 estuaries of the Cape between the Kei and the Orange rivers;
- to identify gaps in information and to stimulate research at Universities, Museums and other institutions to fill these.

The Unit was established at the request of the Government, and the Department of Water Affairs, Forestry and Environmental Conservation contributes substantially to the running costs.

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

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

These surveys are however not adequate to provide complete understanding of the functioning of estuarine systems under the variable conditions prevalent along the South African coastline. The ECRU therefore liaises closely with Universities and other research institutes and encourages them to carry out longer-term research in 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, it has been attempted to write the Part II reports in language understandable to the layman. However it has been impossible to avoid technical terms altogether. A glossary explaining these is therefore included in each report.



F P Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

* CSIR Research Report 380

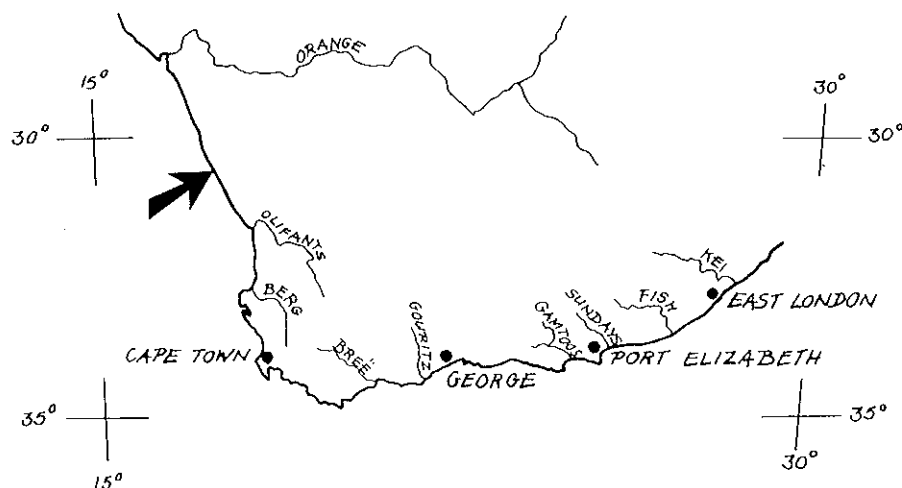
BITTER

1. SYNONYMS

No synonyms recorded.

2. LOCATION

30° 36' S 17° 27' E



The mouth of the Bitter is situated approximately 35 km south of Hondeklipbaai and 31 km north of the Groen River mouth.

2.1 Accessibility

Accessible via Soutfontein by 64 km of gravel roads and tracks from the main road between Garies and Kamieskroon (1:250 000 Topographical Sheet 3017). The turnoff is approximately 5 km north of Garies. There is access also by 48 km of tracks via Soutfontein from the Groen River mouth.

As the Bitter Estuary falls within the De Beers Consolidated Mines prospecting area, access to the general public is prohibited for security reasons.

3. ABIOTIC CHARACTERISTICS

3.1 Catchment :

Area

750 km² (Heydorn and Tinley 1980).

River length

The total river length from Speelmanshoek near the national road,

to the mouth of the Bitter is approximately 70 km (1:250 000 Topographical Sheet 3017).

Tributaries

Outeeprivier (1:500 000 Topographical Sheet SE 31/16 $\frac{1}{2}$).

Mean annual run-off

The topography and nature of the river suggests sporadic run-off.

The mean annual rainfall ranges from 76 to 100 mm at the mouth to 151 to 200 mm in the upper reaches of the catchment. (Le Roux and Ramsey 1979; Heydorn and Tinley 1980).

3.2 Flow :

Episodic. There is no recorded information, but as is the case with other Namaqualand rivers, peak flow is usually between April and September when 80 percent of the rainfall occurs (Heydorn and Tinley 1980). Rivers in this area rise rapidly after relatively little rain (A le Roux pers. comm.).

There was no flow at the time of the ECRU survey on 19 October 1980.

Flood history and level fluctuations

No data.

Driftwood, kelp and other floating debris deposited on the northern side of the estuary at the time of the ECRU survey, indicated that water must have extended approximately 300-400 m in from the point where the mouth opens onto the beach, through flooding or as a result of sea water penetration.

3.3 Obstructions :

(a) In the catchment

The access road to the Bitter mouth from the main road between Garies and Kamieskroon, crosses the riverbed in several places (1:250 000 Topographical Sheet 3017).

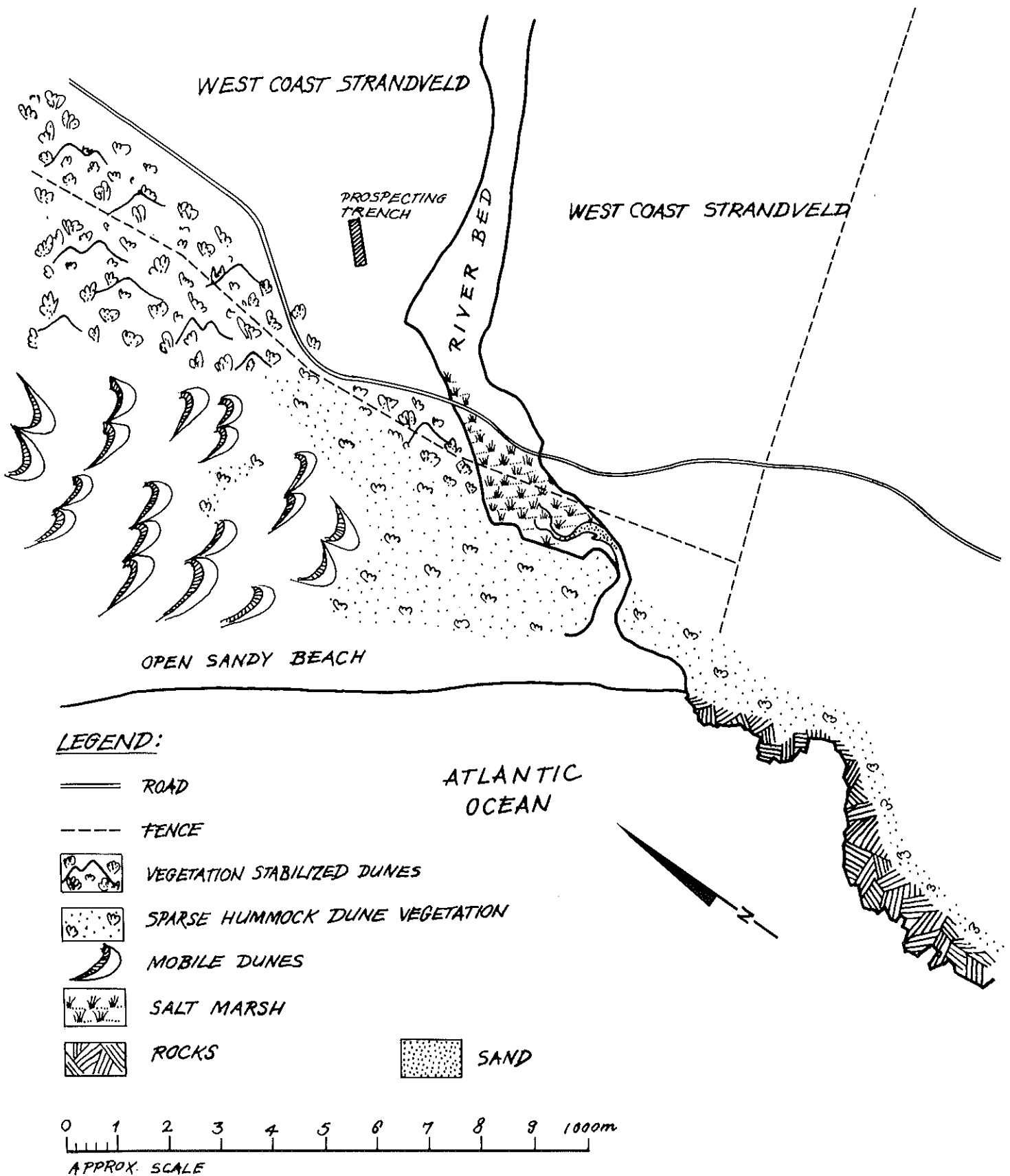
(b) Near the mouth

A gravel track and fence (Figs. 1 and 2) cross the riverbed approximately 500 m and 400 m respectively from the point where the mouth opens onto the beach.

3.4 Siltation :

Beach sand penetration of the mouth area extended approximately 200 m upstream from the point where the mouth opens onto the beach. The remaining bed of the estuary generally consisted of fine silt with encrusting salt and layers of decaying algal mat. (See Fig. 3 and Plate I for core profiles taken during the ECRU survey.)

FIG. 1 BITTER ESTUARY



3.5 Landownership/use :

(a) Catchment

Extensive sheep farming. Some of the farms in the catchment are owned by De Beers Consolidated Mines and are leased to the farmers.

(b) Around the estuary

The estuary falls within De Beers Consolidated Mines prospecting areas. However, at the time of the ECRU survey, there was no evidence of excavations in the immediate vicinity of the estuary. The area around the estuary is used for rough grazing of livestock by the local farmer.



FIG. 2 : Bitter Estuary showing fence and track crossing the dry riverbed. (ECRU 80-10-19).

3.6 Local authority :

Namaqualand Divisional Council.

3.7 Estuary uses :

Low intensity grazing.

3.8 Morphometry of the estuary :

Area

The area of the estuary bed (taken as the area from the mouth to just upstream of the road) is approximately 4,7 ha.

Shape (See Fig.1)

The main axis of the system is orientated in an east/west direction. The valley turns sharply south at the estuary and finally opens north-westwards across the beach. A spit of dunes

approximately 10 m high (Plate III) lies parallel to the estuary between it and the beach on the north bank.

Bathymetry

At the time of the ECRU survey, there was no water in the estuary, which consisted of a dry river channel (Fig. 2 and Plate III).

3.9 Geomorphology

Geology

The following description is based on information from Truswell (1977), Wagner and Merensky (1928) and the 1:1 000 000 Geological Map of S.A. as summarized by Coward (1981, unpublished).

The basement rocks fall under the Namaqualand-Natal belt of metamorphism and granitization.

Overlying the basement rocks are sedimentary deposits consisting of unconsolidated sands with fluvial and terrestrial gravels, shells, limestone and calcrete cappings. The sedimentary deposits are of Cenozoic¹ age and the basement rocks Precambrian² and approximately 1100 million years old.

The Bitter, as is the case with other Namaqualand rivers, has been incised into granite bedrock and can be seen as a small water course running down a shallow valley. Rounded granite boulders occur in places and in the lower reaches, the valley floor is filled with alluvium. Granite outcrops can be seen along much of the adjacent shoreline.

From observations made during the ECRU survey, calcrete occurs in small quantities in association with damp interdune slacks to the north of the Bitter mouth, indicating freshwater seepage.

¹Cenozoic : era in geological time scale from 65 million years ago to 2 million years ago.

²Precambrian : all geological time and the associated rocks before about 570 - 600 million years ago and extending back for more than 4000 million years.

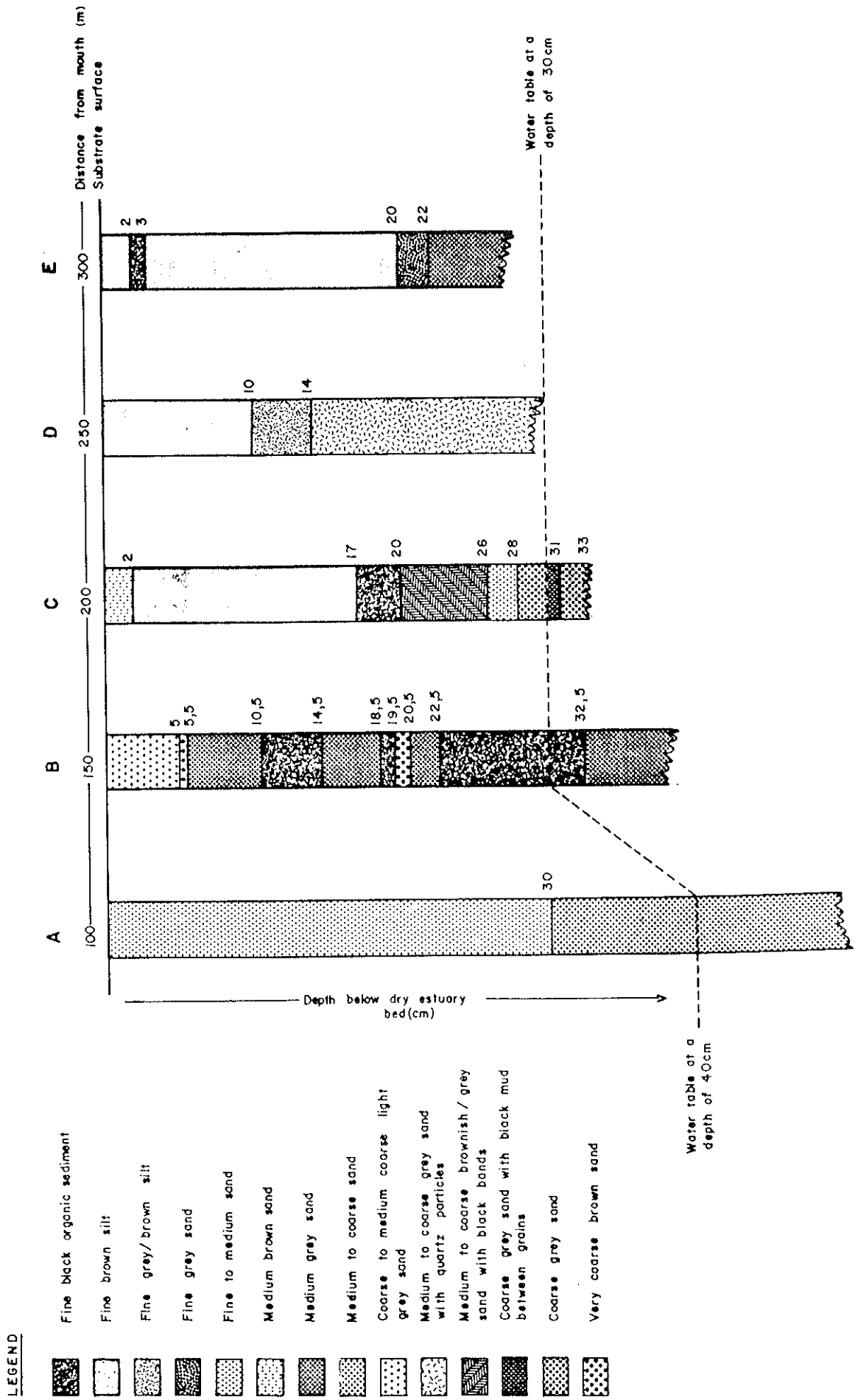
Nature of bottom materials

At the time of the ECRU survey, the dry bed of the estuary was made up of fine silt with encrusting salt and layers of decaying algal mat.

Using a prawn pump, five cores were taken to a depth of 0,5 m at 50 m intervals along the length of the estuary bed, from 100 m upstream of the mouth to 300 m upstream of the mouth (See Fig. 3 and Plate I for core profiles).

The cores indicate alternating periods of fluvial deposition (silt and organic sediment) and marine and wind-blown sediment input (fine to coarse-grained sand).

FIG 3: Core profiles taken to a depth of 0,5m in the bed of the Bitter Estuary. As a prawn pump was used for sampling some of the cores are compressed to a lesser length.



Major features of the cores are layers of exceedingly fine organic sediment of grease-like consistency, as found at the Swartlinter Estuary lying to the north (Heineken 1981). This organic sediment indicates layers of decomposed algae originating from periods of inundation. With drying out during periods of low rainfall the algae would have died off leaving a layer of organic sediment to be overlain by further deposits. The organic sediment was capped by sand in the lower reaches of the estuary (Core B) and silt higher up (cores C and E).

Sandbar characteristics

The beach at the mouth (Plate II) is fairly flat, being 100 m wide and rising with a slope of 1:30 to the crest of the sandbar which was 1 m above MHWS level at the time of the ECRU survey.

The sandbar, with scattered kelp and rounded stones extends 100 m from its crest to the first Sarcocornia beds at the mouth of the estuary.

Rounded boulders were accumulated in the southern corner of the beach with smaller ones spread over the mouth region, at the time of the ECRU survey.

Configuration of adjacent shore (See Fig. 1)

The rocky promontory south of the mouth, protects the estuary mouth and the sandy beach extending northwards from it.

A large plume of mobile sand dunes extends northwards from the mouth area. The area inland of these dunes is well stabilized by vegetation, but plant cover is minimal in the main dune field.

Hummock dunes close to the mouth are fixed predominantly by the grass Eragrostis cyperoides. The northward extending dune plume is maintained by the prevailing south-westerly winds.

Isolated rock clusters occur at intervals of several hundred metres along the beach.

3.10

Oceanography

Major currents

The Namaqualand coastline is under the influence of the northward-flowing Benguela Current and the characteristic upwelling of nutrient-rich water. Upwelling is enhanced during summer, by the prevalence of southerly to south-easterly winds, which tend to move inshore surface water away from the coast, thereby making room for the deeper-lying cooler water (Heydorn and Tinley 1980).

The influence of the cold Benguela Current, combined with predominantly southerly winds, results in a cool climate at the coast. Fog is prevalent during the nights and in the mornings.

Waves

The prevailing swells are generated in the South Atlantic and approach the West Coast, predominantly from a south-westerly or south south-westerly direction. They reach a height of over 1,6 m for 50 percent of the time in the nearshore area, as

measured at Oranjemund, approximately 250 km to the north of the Bitter (J Rossouw pers. comm.). Wave frequency at Buchu Bay, approximately 220 km to the north of the Bitter is 10 - 15 seconds for 95 percent of the waves (Ashby, Harper and Van Schaik 1973).

The wave and swell patterns of the West Coast play a major role in the longshore distribution of marine sediments, erosion and deposition phenomena and hence also in beach and dune formation (Tankard and Rogers 1978).

Surf zone currents

Rip current circulation cells were present at the time of the ECRU survey. However a net water movement northwards or southwards could not be discerned, except in the southern corner (Fig. 1), where water was moving southwards before being taken seawards by a rip current running out past the rocky promontory.

Aerial Photography Job No. 326 of 1979 indicates the occurrence of several rip currents emanating from the straight sandy beach just to the north of the Bitter mouth.

Waves breaking on the beach are straight and tend to dump due to its shelving nature.

Tides

The ECRU survey was carried out on 19 October 1980 approximately midway between neap and spring tides.

The tidal range between MLWS and MHWS for Port Nolloth (160 km to the north of the Bitter mouth) as given in the South African Tide Tables 1980, is 1,57 m.

3.11 Physico-chemical characteristics :

No data are available other than the salinity data collected by the ECRU on 19 October 1980. As the estuary was dry at the time the data are minimal.

Sub-surface water salinity at core points (30-40 cm below the riverbed) varied from 35 parts per thousand, 100 m from the mouth to 45 parts per thousand, 300 m from the mouth.

Surface water was present in the riverbed in isolated pools (Fig. 4) approximately 10 km from the mouth near the farm Sarrisaam (1:250 000 Topographical Sheet 3017). The salinity of this water was 120 parts per thousand but a few kilometres upstream of this point, the salinity was 45 parts per thousand. This indicates that there is considerable leaching of salts from the sediments in the catchment.

3.12 Pollution :

No data.



FIG. 4 : Riverbed in catchment approximately 10 km from the mouth of the Bitter showing isolated pool (salinity 120 parts per thousand). (ECRU 80-10-19)

3.13 Public health aspects :

No data.

As human utilization is minimal, public health aspects are negligible.

4. BIOTIC CHARACTERISTICS

No previous information on the plant and animal life of the estuary could be found. The observations below were made by ECRU during a brief visit.

4.1 Flora

Phytoplankton/diatoms

A dried mat of decaying filamentous algae was found in the bed of the estuary during the ECRU survey indicating its occurrence during the last floods.

Aquatic vegetation

(a) Estuary

The estuary being dry at the time of the ECRU survey, no aquatic vegetation was found.

(b) Adjacent shoreline

Marine algae found on the rocks of the southern promontory included Ecklonia maxima, Porphyra capensis, Ulva sp., Cladophora capensis and Champia lumbricalis.

Semi-aquatic vegetation

Species found around the estuary during the ECRU survey were Sarcocornia pillansii, and Limonium scabrum.

Terrestrial vegetation

(Contribution by Miss R Parsons, Botanical Research Institute, and Miss A le Roux, C.P.A. Department of Nature and Environmental Conservation).

This region falls into Acocks' Veld Type 34 (b), Strandveld Proper, which is an open semi-succulent scrub (Acocks 1975).

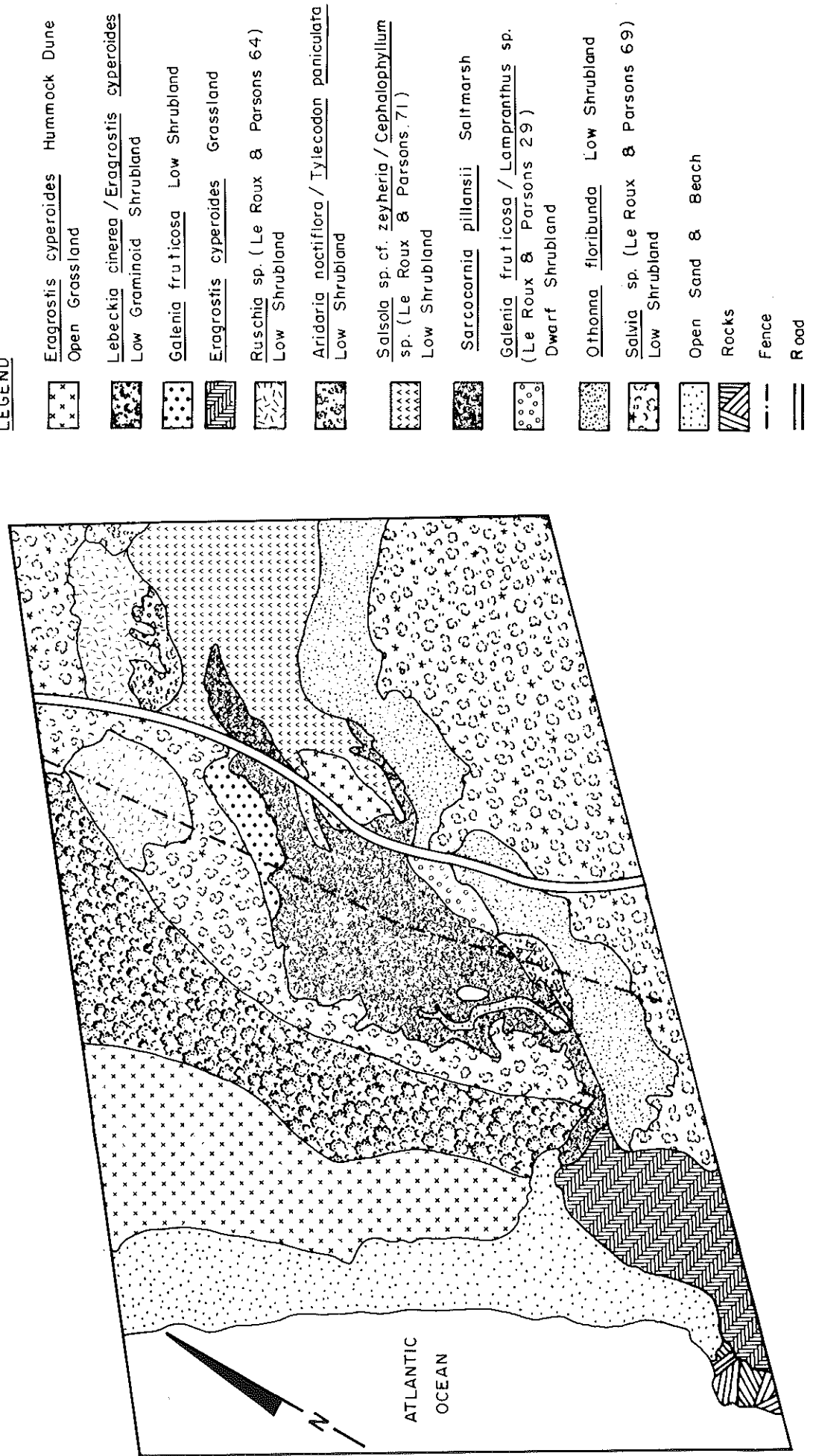
Eleven main vegetation mapping units were identified, their structure, species composition and area are shown in Appendix I and their spatial distribution in Fig. 5. The Sarcocornia pillansii Saltmarsh had the highest cover (85 percent) and the Eragrostis cyperoides Hummock Dune Open Grassland had the lowest (5 percent). This vegetation mapping unit also had the lowest species diversity (2 spp.) while the Salvia sp. (Le Roux and Parsons 69)¹ Low Shrubland had the highest species diversity with 19 species recorded. The height of the communities varied from 1,0 m (Aridaria noctiflora/Tylecodon paniculata Low Shrubland) to the 0,20 m of the Galenia fruticosa / Lampranthus sp. (Le Roux and Parsons 29) Dwarf Shrubland.

The main vegetation mapping units can be consolidated into four main plant formations namely, grassland, low shrubland (0,25 - 1,0 m), dwarf shrubland (0,25 m) and saltmarsh, the most extensive being low shrubland which covers an approximate area of 20 ha,² followed by grassland (6,4 ha), saltmarsh (3,5 ha) and dwarf shrubland (0,19 ha) of the total area of 35 ha studied.

¹ *Le Roux and Parsons species numbers e.g. Le Roux and Parsons 69, refer to specimens unidentified by the B.R.I. at the time of writing.*

² *As the accuracy of measurement of the botanical areas given in this section and Appendix I was estimated to be approximately within 5 percent, decimals are given only where they are greater than 5 percent of the area in question.*

FIG. 5 : Vegetation mapping units of the Bitter Estuary
 Approximate scale — 1 : 5000



No open water was found and only very small areas that were not covered by vegetation. Sarcocornia natalense appeared to be dying in places and this could be due to lack of moisture.

The Galenia fruticosa Low Shrubland and the Galenia fruticosa / Lampranthus sp. (Le Roux and Parsons 29) Dwarf Shrubland appear to be disturbed and are probably ruderal (pioneer) communities. If they are left undisturbed they will probably recover completely. The vegetation is however, in a relatively undisturbed and good condition.

4.2

Fauna

Note : Only cursory observations were possible during the ECRU survey and the following lists are incomplete.

Zooplankton

No information. There was no water in the estuary at the time of the ECRU survey.

Fauna on

(a) hard substrates

The following intertidal animals were found to be present on the rocks on the adjacent shoreline.

Cape Reef Worm	<u>Gunnarea capensis</u>
Ribbed Mussel	<u>Aulacomya ater</u>
Black Mussel	<u>Choromytilus meridionalis</u>
Limpets	<u>P. granularis</u>
	<u>P. argenvillei</u>
	<u>P. granitina</u>
	<u>Helcion pectunculus</u>
Blue Periwinkle	<u>Littorina africana</u>
Snail	<u>Oxysteles variegata</u>
Whelk	<u>Argobuccinum argus</u>

(b) soft substrates

No information.

(c) vegetation

On kelp, Patella compressa.

Insects

No information.

Other invertebrates

Dried shells of terrestrial snails and millipedes were seen around the estuary during the ECRU survey.

Fish

No information.

Reptiles and Amphibians

A lizard Meroles ctenodactyla (Family : Lacertidae) was collected on the sand dunes lying to the north of the estuary mouth, during the ECRU survey.

Birds

The following species were recorded in and around the estuary during the ECRU survey.

1	Ostrich (tracks and excretions)	
169	Black Harrier	2
235	White-fronted Sandplover	12
275	Dikkop	1
287	Southern Black-backed Gull	6
289	Hartlaub's Gull	1
307	Namaqua Sandgrouse	10
543	Cape Bulbul	1
566	Karoo Chat	1
570	Familiar Chat	1
576	Stone Chat	1
686	Cape Wagtail	3
722	Bokmakierie	1
751	Malachite Sunbird	1
760	Lesser Double-collared Sunbird	1
873	Cape Bunting	4

During an ornithological survey of North-western Cape estuaries in January 1980, no birds were recorded at the Bitter, which was dry at the time (J Cooper pers. comm.).

Mammals

Tracks of Water Mongoose (Atilax paludinosus), Bat-eared Fox (Otocyon megalotis) and Steenbok (Raphicerus campestris) were seen around the estuary at the time of the ECRU survey. Porcupine Hystrix africae-australis) quills indicated their occurrence. A Caracal (Felis caracal) was sighted in the riverbed during the ECRU survey.

Stuart, Lloyd and Herselman (1980) have recorded the Bush Karoo Rat (Otomys unisulcatus) as occurring in the vicinity of the Bitter Estuary.

5.

SYNTHESIS

The state of knowledge of the Bitter is extremely poor. This is probably due to the remoteness of the lower reaches, being situated in a prohibited area under the control of De Beers Consolidated Mines.

According to Tankard and Rogers (1978) the plume of mobile sand dunes to the north of the mouth of the Bitter, is fed by surf erosion of older dunes at the coast giving rise to sediments deposited along the shore from the mouth northwards. These

sediments are then blown by southerly to southwesterly winds, northwards from the shore which is orientated in a north-west/southeast direction. Sand accumulation on the dune plume would be most prevalent in the summer months when the southerly to south-westerly winds predominate on the Namaqualand coast (Heydorn and Tinley 1980).

The nature of the surface sediments in the mouth region suggest that the river flows intermittently but probably only for short periods. This is to be expected from the nature of the rainfall and the small size (750 km²) of the catchment. Sediments originating from the sea tend to build up the sand bar at the mouth of the Bitter, whilst the river would tend to breach it at times of flow, particularly in the winter months. Sea water probably only overtops the sandbar during exceptionally high tides combined with heavy seas and onshore winds.

Although the Bitter falls within the areas controlled by De Beers Consolidated Mines, no mining has as yet taken place around it, although a prospecting trench has been excavated. Exhaustion of diamond resources in areas presently being worked will, however, result in concentration of mining effort in areas south of Hondeklipbaai, in which case the Bitter will be threatened.

The Bitter is probably of limited value as an estuary in the true sense, due to the episodic nature of its flow. However, being as yet relatively undisturbed by man's activities, this scenic section of coast has high aesthetic value and is part of the last remaining stretch of Namaqualand coastline as yet unaffected by mining operations.

6. ACKNOWLEDGEMENTS

The collection of field data for this report was essentially a team effort and the assistance of the other members of the ECRU survey team is acknowledged. De Beers Consolidated Mines granted permission for the survey to be carried out in areas under their jurisdiction and this is greatly appreciated.

Thanks are due to Mr J C Greig of the Cape Department of Nature and Environmental Conservation for identifying the dune lizard.

The report cover is based on one designed by Dr K L Tinley for Part I of the Cape Estuaries series. Thanks are also due to Miss Ronel Nel and the girls of the NRIO drawing office for the preparation of the figures, Mrs S Armbruster for typing this report and Mrs H Heydorn for literature reviews and proof-reading.

The survey was carried out at the request and with the financial support of the Department of Water Affairs, Forestry and Environmental Conservation. The encouragement of this Department, the Cape Estuaries Steering Committee and the S A National Committee for Oceanographic Research is gratefully acknowledged.

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

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

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

episodic: sporadic and tending to be extreme.

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

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

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

fluvial (deposits): originating from rivers.

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

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

geomorphology: the study of land form or topography.

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

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

halophytes: plants which can tolerate salty conditions.

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

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

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

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

indigenous: belonging to the locality; not imported.

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

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

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

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

limpid: clear or transparent.

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

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

macrophyte: any large plant as opposed to small ones. Aquatic macrophytes may float at the surface or be submerged and/or rooted on the bottom.

marls: crumbly mixture of clay, sand and limestone, usually with shell fragments.

matrix: medium in which a structure is embedded.

meiofauna: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the macrofauna, or benthos.

metamorphic: changes brought about in rocks within the earth's crust by the agencies of heat, pressure and chemically active substances.

MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23° , of the height of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of MLWS is the average height obtained by the two successive low waters during the same periods (South African Tide Tables 1980).

morphometry: physical dimensions such as shape, depth, width, length etc.

osmoregulation: the regulation in animals of the osmotic pressure in the body by controlling the amount of water and/or salts in the body.

pathogenic: disease producing.

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

phytoplankton: plant components of plankton.

piscivorous: fish-eating.

plankton: microscopic animals and plants which float or drift passively in the water.

quartzite: rock composed almost entirely of quartz re-cemented by silicon. Quartzite is hard, resistant and impermeable.

riparian: Adjacent to, or living on, the banks of rivers, streams or lakes.

rip current: the return flow of water which has been piled up on the shore by waves, especially when they break obliquely across a longshore current.

salinity: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand, written $34,5^\circ/\text{‰}$.

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 cartilagenous fishes).

trophic level: a division of a food chain defined by the method of obtaining food either as primary producers, or as primary, secondary or tertiary consumers.

trough: a crescent shaped section of beach between two cusps.

wetlands: areas that are inundated or saturated by surface or ground water frequently enough to support vegetation adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

zooplankton: animal components of plankton.

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APPENDIX I

Species composition and physical features of the vegetation mapping units of the Bitter Estuary.

	5	55	25	60	35	50	40	85	25	40	50	Road	Beach and Open Sand	99) Low Shrubland	Total
Total Cover (%)	0-0,50	0-0,75	0-0,30	0-0,75	0-0,50	0-1,0	0-0,75	0-0,75	0-0,20	0-0,75	0-0,75			0-0,75	
Height (m)	4,7	4,7	0,36	1,7	1,5	0,38	2,6	3,5	0,19	3,2	7,5	0,48	4,0	7,5	0,22
Area (ha)	13,4	12,4	1,0	4,9	4,3	1,1	7,4	10,0	0,5	9,1	21,4	1,4	11,4	21,4	0,6
% of Studied Area															99,9
<i>Fragrostis cyperoides</i> Hummock Dune Open Grassland															
<i>Lebeckia cinerea</i> / <i>Fragrostis cyperoides</i> Low Graminoid Shrubland															
<i>Galenia fruticosa</i> Low Shrubland															
<i>Fragrostis cyperoides</i> Grassland															
<i>Ruschia</i> sp. (Le Roux & Parsons 64) Low Shrubland															
<i>Aridaria noctiflora</i> / <i>Tylectodon paniculata</i> Low shrubland															
<i>Salsola</i> sp. cf. <i>zeyheri</i> / <i>Cephalophyllum</i> sp. (Le Roux & Parsons 71) Low Shrubland															
<i>Sarcocornia pillansii</i> Saltmarsh															
<i>Galenia fruticosa</i> / <i>Lampranthus</i> sp. (Le Roux & Parsons 29) Dwarf Shrubland															
<i>Orthona floribunda</i> Low Shrubland															
<i>Drosanthemum</i> sp. (Le Roux & Parsons 4) / <i>Tetragonia</i> sp. (Le Roux & Parsons 70) / <i>Orthona floribunda</i>															
<i>Zygophyllum megerana</i> / <i>Asparagus capensis</i> var. <i>littoralis</i> / <i>Osteospermum oppositifolium</i> / <i>Ruschia</i> sp. (Le Roux & Parsons 64) / <i>Pteronia</i> sp. (Le Roux & Parsons 57) / <i>Asparagus fascicularis</i> / <i>Berkheya fruticosa</i>															
<i>Aridaria noctiflora</i> / <i>Tylectodon paniculata</i> / <i>Cephalophyllum spongiosum</i> / <i>Ruschia frutescens</i> / <i>Tetragonia fruticosa</i>															
<i>Cephalophyllum</i> sp. (Le Roux & Parsons 71) / <i>Salsola</i> sp. cf. <i>zeyheri</i> / <i>Sarcocornia pillansii</i> / <i>Sarcocornia natalense</i> / <i>Limonium equisetinum</i> / <i>Eragrostis sabulosa</i> / <i>Chaetobromus dregeanus</i> / <i>Lampranthus</i> sp. (Le Roux & Parsons 29) / <i>Psilocalon</i> sp. (Le Roux & Parsons 56) / <i>Nemesia</i> sp. (Le Roux & Parsons 55) / <i>Crassula mucosa</i> var. <i>mucosa</i> / <i>Didelta carnosa</i> var. <i>tomentosa</i> / <i>Ruschia</i> sp. (Le Roux & Parsons 68) / <i>Arctotis decurrens</i> / <i>Helichrysum</i> sp. (Le Roux & Parsons 52) / <i>Salvia</i> sp. (Le Roux & Parsons 69)															

PLATE I :

Cores taken to a depth of 0,5 m in the Bitter Estuary bed approximately 150 m from the mouth (c.f. Core B in Fig. 3). The upper parts of the cores are on the left of the plate. (ECRU 80-10-19)



PLATE II :

Sandbar and beach at the mouth of the Bitter. The intrusion of marine sediments into the mouth can be seen. (ECRU 80-10-19)



PLATE III :

Dry estuary bed of the Bitter, showing prolific saltmarsh vegetation. The 10 m high spit separating the estuary from the beach can be seen in the left background. (ECRU 80-10-19)

