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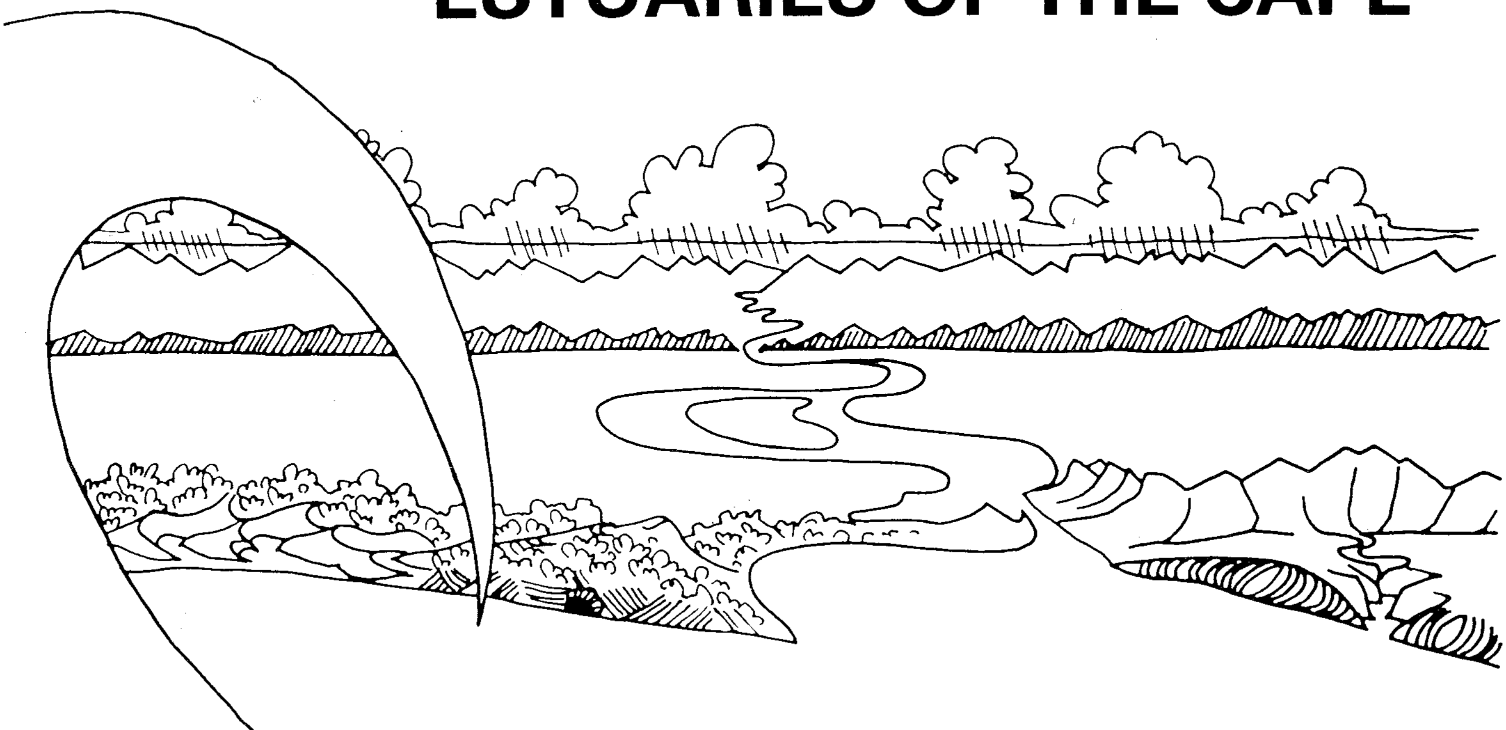
ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 42

NAHOON (CSE 44), QINIRA (CSE 45) AND GQUNUBE (CSE 46)

CSIR RESEARCH REPORT 441

Stellenbosch, South Africa
March 1993

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

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REPORT NO. 42:
NAHOON (CSE 44), QINIRA (CSE 45) AND GQUNUBE (CSE 46)

(CSE 44, 45 AND 46 - CSIR ESTUARY INDEX NUMBERS)

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DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY
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PLATE I: The Nahoon and Qinira estuaries (Photo: ECRU 04.05.90)

PLATE II: The Gqunube Estuary (Photo: ECRU 04.05.90)

PREFACE

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

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

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

In 1980 the Unit published its first report under the title "Estuaries of the Cape, Part 1 - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley, *CSIR Research Report* 380). The report is an overview of the Cape Coast dealing with aspects such as climate, geology, soils, catchments, run-off, vegetation, oceanography, and of course, estuaries. At the specific request of the Government, the report includes preliminary management recommendations.

The present report is one of a series on Cape Estuaries being published under the general title "Estuaries of the Cape, Part II". These reports summarize, in language understandable to the layman, all available information on individual estuaries. It was found, however, that much information is dated or inadequate and that the compilation of Part II reports is therefore not possible without brief prior surveys by the ECRU. These surveys are, however, not adequate to provide complete understanding of the functioning of estuarine systems under the variable conditions prevalent along the South African coastline. The ECRU therefore liaises closely with universities and other research institutes and encourages them to carry out longer-term research on selected estuarine systems. In this way a far greater range of expertise is involved in the programme and it is hoped that the needs of those responsible for coastal zone management in local, provincial and central government can be met within a reasonable period of time.

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

P D MORANT
COASTAL DEVELOPMENT PROGRAMME
<u>DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY</u>

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NAHOON, QINIRA AND GQUNUBE

INTRODUCTION

This report is a synthesis of recent research findings and available knowledge pertaining to the Nahoon, Qinira and Gqunube estuarine systems in the East London area. It provides the different groups and individuals involved with the management and utilisation of these estuaries with access to expert knowledge and published opinion that might otherwise be unavailable or of which they might otherwise be unaware.

The report provides a description of the abiotic characteristics of the river catchments and of the physical processes, current utilisation and recent changes in the estuaries. In addition, the flora and fauna of the estuarine systems are described, with particular reference to human influences on the status of those systems. A synthesis of these diverse data is then presented. The synthesis provides an account of the present state of the systems, the state of knowledge, the problems that exist or are likely to occur, and broad recommendations for the treatment of those problems.

1.1 Location

The Nahoon and Qinira estuaries are located in the East London Metropolitan Area. The location of the estuaries is shown in Figure 1 and in the Centrespread. The Nahoon River flows into the Indian Ocean approximately 6,8 km north-east of East London harbour. The Qinira River forms a predominantly closed estuarine lagoon about 1,5 km east of the Nahoon Estuary in the Beacon Bay Township. The Gqunube Estuary is located about 10 km east of the Nahoon Estuary, and is situated at the eastern border of the Gonubie township.

The co-ordinates of the river mouths are:

Nahoon	32° 59' 05" S; 27° 57' 05" E
Qinira	32° 58' 20" S; 27° 58' 00" E
Gqunube	32° 56' 00" S; 28° 02' 00" E

1.2 Accessibility

NAHOON: Junction 23 to East London off the N2 National Road leads to the north east bank of the estuary and to the eastern suburbs of East London on the west bank. In both these residential areas there are numerous access points to the estuary.

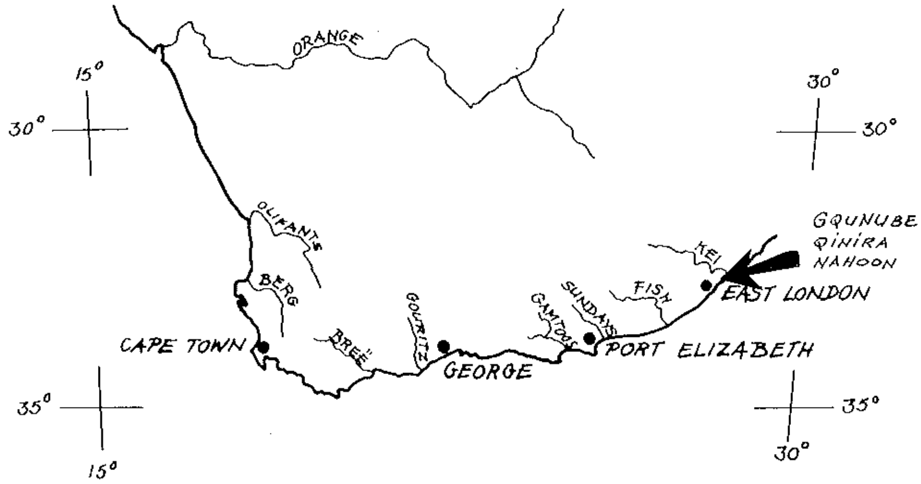

Figure 1: Locality map

QINIRA: Junction 23 to East London off the N2 National Road leads to the North East Expressway. Access to Beacon Bay is possible by branching off this road and crossing the Beacon Bay Bridge. There are numerous access points to the west side of the Qinira Estuary in Beacon Bay and Bonza Bay. The east side of the Qinira Lagoon is accessible via a minor road that branches off the main Gonubie access road (Centrespread).

GQUNUBE: Junction 22 off the N2 National Road leads to a tarred access road to Gonubie Township. In the township there are three main access points to the west bank of the estuary. The eastern bank of the estuary is accessible via a gravel road off the R102 which leads to the Mount Leisure Caravan Park in the middle reaches of the estuary (Centrespread).

The Ben Schoeman Airport, situated 10 km west of East London, is an all weather instrumented airport and handles scheduled flights from all parts of Southern Africa (Centrespread).

1.3 Managing authorities

NAHOON

Catchment: The entire Nahoon River catchment falls within the jurisdiction of the Amatola Regional Services Council. In addition, the Nahoon Estuary and river system fall within the East London, Komga and King Williams Town magisterial districts.

Estuary: The Nahoon Estuary forms part of the East London Metropolitan Area. The south bank of the estuary falls under the jurisdiction of the East London City Council, whereas the north bank above the High Water Mark falls under the Beacon Bay Municipality. Part of the north bank of the river mouth lies within the Nahoon State Forest Reserve which is under the jurisdiction of Cape Nature Conservation (Cape Provincial Administration). This Reserve extends inland for approximately 500 m from the shore.

Recreation activities on the Nahoon Estuary (see Section 3.2.6) are controlled by the Directorate: Cultural and Environmental Services of the East London City Council. A Beach Supervisor within the Amenities Department of this Directorate is responsible for ensuring that the provisions contained in the City Council's by-laws are adhered to. The Beacon Bay Municipality does not provide any similar law enforcement service, although no boat launching sites on the northern shore of the estuary have been permitted by the Municipality.

The Nahoon Trust is a collective of concerned ratepayers with a particular interest in the preservation of the Nahoon Estuary (Mr R Vos, Chairman of the Nahoon Trust, pers. comm., 1991). The Trust was initially formed in the early 1970s as a result of proposals to build a four lane National Road bridge across the Nahoon Estuary. This proposal arose as a result of the destruction of the Jack Batting Bridge by a major flood in 1970 (see section 3.1.7).

The Nahoon River Advisory Board was formed in 1980, under the auspices of the Nahoon Trust, although its members include representatives of user groups and conservation bodies, and a representative of the East London City Council. Beacon Bay Municipality have thus far declined to be represented on the Board (*in litt*). The Board performs an advisory function to the East London City Council in respect of the management of the Nahoon River, but as yet the Board has not officially adopted a constitution.

QINIRA

Catchment: The entire Qinira River catchment falls within the jurisdiction of the Amatola Regional Services Council. The Qinira Estuary and river catchment also fall within the East London, Komga and King Williams Town magisterial districts.

Estuary: The Qinira Estuary forms part of the East London Metropolitan Area. The north and south banks of the Qinira Estuary fall within the jurisdiction of Beacon Bay Municipality. The control of recreation activities on the estuary is administered by the

Town Clerk in terms of a municipal by-law (Cape of Good Hope, 1985). The municipality has no beach enforcement or control officers for the estuary. Disturbances or contraventions of the boating by-law are usually referred to the local Traffic Police (Mr M Symon, Town Clerk, Beacon Bay Municipality, pers. comm.). At present about 25 boat owners have permits entitling them to utilise the estuary (*ibid.*).

GQUNUBE

Catchment: The entire Gqunube River system falls under the jurisdiction of the Amatola Regional Services Council. In addition, the Gqunube Estuary and river catchment fall within the East London, Komga and King Williams Town magisterial districts.

Estuary: The township on the south bank of the estuary falls under the jurisdiction of the Gonubie Municipality. The Kwelera State Forest Reserve on the north bank of the estuary is under the jurisdiction of Cape Nature Conservation.

The control of recreation activities on the Gqunube Estuary is undertaken by Gonubie Municipality in terms of regulations made under the Sea Shore Act 21 of 1935 (South Africa, 1972 and 1975). The Municipality, however, has no beach enforcement or control officers for the estuary. Disturbances or contraventions of the regulations are referred to the police (Ms J Cooper, Gonubie Municipality, pers. comm., 1991).

2. HISTORICAL BACKGROUND

The official names of "Nahoon", "Qinira" and "Gqunube" are used for the rivers and estuaries addressed in this report since they conform to those shown on the 1:50 000 Topographical Sheets 3227 DD (for the Nahoon and Qinira rivers) and 3228 CC (for the Gqunube River). The Quenera Lagoon is the official name of the closed Qinira Estuary (1:50 000 Topographical Sheet 3227 DD).

2.1 Synonyms and derivations

NAHOON: The word "Nahoon" is a corruption of the Xhosa name *Nxaruni*, said to have been a chief who once lived there (Bulpin, 1980). However, Raper (1989) describes Nahoon as derived from a Khoekhoen word meaning "river of fighting". Other names given to the Nahoon River include Cahoon, Kahoon, Kahoona, Nagoerij and Nagoezij (Raper, 1989).

QINIRA: The name of the Qinira River is reportedly adapted from the Khoekhoen *!Kani!ab*, meaning "river of elands" (Bulpin, 1980; Raper, 1989). Bonza Bay at the mouth of the Qinira River, is said to have been so named by an admiring Australian (Bulpin, 1980). Other synonyms for the Qinira River are Qinirha, Caninga, Geneka, Kwinegha, Kwinera, Quenera, Quinega and Quinera (Raper, 1989).

GQUNUBE: The Gqunube River derives its name from the Xhosa word *Qunube*, referring to the wild bramble berries which grow along its banks (Bulpin, 1980). Another name given to the river is *Goadar* or "marsh river", after the nama word *!goa* which implies "mud" or "marsh" (Raper, 1989). Further details of the derivation of the name Gonubie, are discussed by Van Eeden (1985).

2.2 Historical aspects and archaeology

The town of East London was founded when the Buffalo River mouth (about 8 km to the south west of the Nahoon Estuary) was first used as a harbour, around 1836. The harbour was originally named Port Rex, but was renamed East London in 1847. East London is now the fifth largest port in South Africa, and the only river port of any significance (Bulpin, 1980).

The East London Museum has extensive collections including an exhibit of the first coelacanth to be caught in modern times and the only remaining dodo egg. The coelacanth was caught in 1938 near East London (Bulpin, 1980).

Several unusual biostratigraphic and geological aspects have been noted with respect to the Nahoon-Qinira-Gqunube coastline. The presence of key reptilian fossils, such as *Dicynodon grimbeeki, Oudenodon baini* and *Pristerodon* spp. have been discovered here within the so-called lower *Cistecephalus* horizon, and identify the sandstone as belonging to the Lower Beaufort Stage (Mountain, 1945 and 1974). Fossils of the fern *Dicroidium lancifolia* and several *Glossopteris* spp., common to the Upper and Lower Beaufort Stages respectively, have also been found here (Du Toit, 1926).

At Bats Cave near the Nahoon Estuary there is an unusual outcrop of calcareous sandstone, or aeolianite, which rests upon a pebble layer above dolerite. Middle Stone Age implements have been found in this layer, and casts of human footprints and tracks of hyena and birds have been found in one of the strata. On the basis of this evidence, Mountain (1966 and 1974) identified this deposit as belonging to the upper Pleistocene period. Primitive tools that are characteristic of the Early Stone Age occasionally have been found around East London, and there is also abundant evidence of Late Stone Age "strandlopers" in the many shell middens found in the coastal dunes (Hall, 1988).

Some of the shipwrecks that have occurred on the East London coastline have been documented by Bell-Cross (1983). These include the unconfirmed 16th century Portuguese wreck of the *Santo Alberto* at Sunrise On Sea near the Gqunube Estuary, and the *Santa Maria Madre de Deus* wrecked near the mouth of the Qinira Estuary in 1643.

3. ABIOTIC CHARACTERISTICS

3.1 Catchments

3.1.1 Catchment characteristics

Area

The catchment areas for each of the Nahoon, Qinira and Gqunube estuaries, as reported by various authors, are shown below.

NAHOON

590 km^2	(Middleton *et al.*, 1981; Jezewski and Roberts, 1986)
625 km^2	(Heydorn and Tinley, 1980)
584 km^2	(CSIR, 1987)
547 km^2	(Reddering and Esterhuysen, 1986)

QINIRA

90 km^2	(CSIR, 1987; Jezewski and Roberts, 1986; Middleton *et al.*, 1981)

GQUNUBE

665 km^2	(CSIR, 1987; Jezewski and Roberts, 1986; Middleton *et al.*, 1981)
675 km^2	(Reddering and Esterhuysen, 1986)
500 km^2	(Heydorn and Tinley, 1980).

Tributaries

NAHOON: Numerous small, unnamed tributaries enter the Nahoon River from both the north and the south. Upstream of the Nahoon Dam, the Ngqkana and Kwetyana tributaries enter from the north, and the Rwantsa tributary joins from the west.

QINIRA: The Qinira River catchment contains a few small and unnamed tributaries (1:50 000 Topographical Sheet 3227DD).

GQUNUBE: The Gqunube River also has a number of small, unnamed tributaries in its catchment. The largest tributary is the Tanga River, which enters the Gqunube from the north. The Ngwevana, Ntena, Qolora, Ncweba and Mtyana tributaries enter the Gqunube River in its lower reaches.

River length and elevation

	River length km	Elevation of source m above MSL	Gradient	Reference
NAHOON	76,5 72 83	640 - -	1:120 - -	CSIR, 1987 Reddering and Esterhuysen,1986 Jezewski and Roberts,1986
QINIRA	20,5 21	320 -	1:64 -	CSIR, 1987 Jezewski and Roberts,1986
GQUNUBE	108,9 80 95	800 - -	1:136 - -	CSIR, 1987 Reddering and Esterhuysen,1986 Jezewski and Roberts, 1986.

3.1.2 Geology, topography and soils

The majority of the geological formations encountered within the catchments of the Nahoon, Qinira and Gqunube rivers belong to the Karoo system (Figure 2). The mud and sandstone deposits of the Beaufort Series predominate and are mainly of fluvial origin, having been laid down during the warmer Permian and Triassic periods following the Permo-Carboniferous glaciation (Truswell, 1977). Sandstones tend to prevail along ancient flow courses, while mudstones occur elsewhere (Rust, 1988).

Dolerite sills and dykes are evidence of post-Karoo (Jurassic) intrusions of igneous material. Examples of both forms of dolerite outcrops can be seen at Nahoon Point and at the Nahoon River mouth. Metamorphism of invaded sediments has occurred over a period of time, with some of the mudstones having been altered to lydianite and the sandstones, which principally contain quartz, having been altered to very hard quartzite (Mountain, 1974).

The hinterland and river catchments descend towards the coast in a series of steps at the 250 to 300 m, 180 to 200 m, 90 and 60 m contour intervals. The lower bench levels date to the Pleistocene glacial periods and are a result of sea level fluctuations. The major topographical features have been created by uplift and faulting during the Jurassic period when the seaward extension of the coastline caused the rivers to erode to new base levels (Nicol, 1988). The hilly and undulating topography within the coastal region has been created by the numerous unnamed tributaries of the major rivers, which established themselves during the glacial periods.

Incision of the river courses into the Beaufort deposits was initiated on the now elevated Tertiary coastal plain and proceeded during the Pleistocene Ice Age, when eustatic lowering of sea level took place. A phenomenon which is characteristic of most larger rivers in the region (including the Nahoon, Qinira and Gqunube rivers) is the disappearance of the valley rock base beneath varying depths of alluvium, some distance landward of the present coastline. This occurred after the rise in sea level during the Flandrian transgression when the mouths of the river valleys became flooded and shallow estuaries developed with the accompanying process of fluvial and marine sediment deposition (Reddering and Esterhuysen, 1986).

The soil types encountered within the catchment are largely determined by the underlying geological formations, with those derived from intrusive dolerite differing markedly from those associated with the Beaufort sedimentary rocks. A description of the regional soils is provided by Bader (in Board, 1962). Red doleritic clays predominate on the hotter northern, north-western and western aspects and are seldom found in valley beds or moist sites. The black doleritic clays, which are confined to the proximity of dolerite intrusions, occur mainly on the cooler, southern and eastern aspects, poorly drained areas and in the valley bottoms.

Grey sandy loams are derived from Beaufort sandstones and shales where dolerite is absent and differ markedly from the doleritic soils (in colour etc.). Climatic influences appear to have had a reduced differentiating influence on pedogenesis within this soil type and the soils are only slightly better developed on southern and western aspects than elsewhere.The sandy loams occur discontinuously along the coastal strip where they have not been overlain by aeolian or calcareous Tertiary deposits.

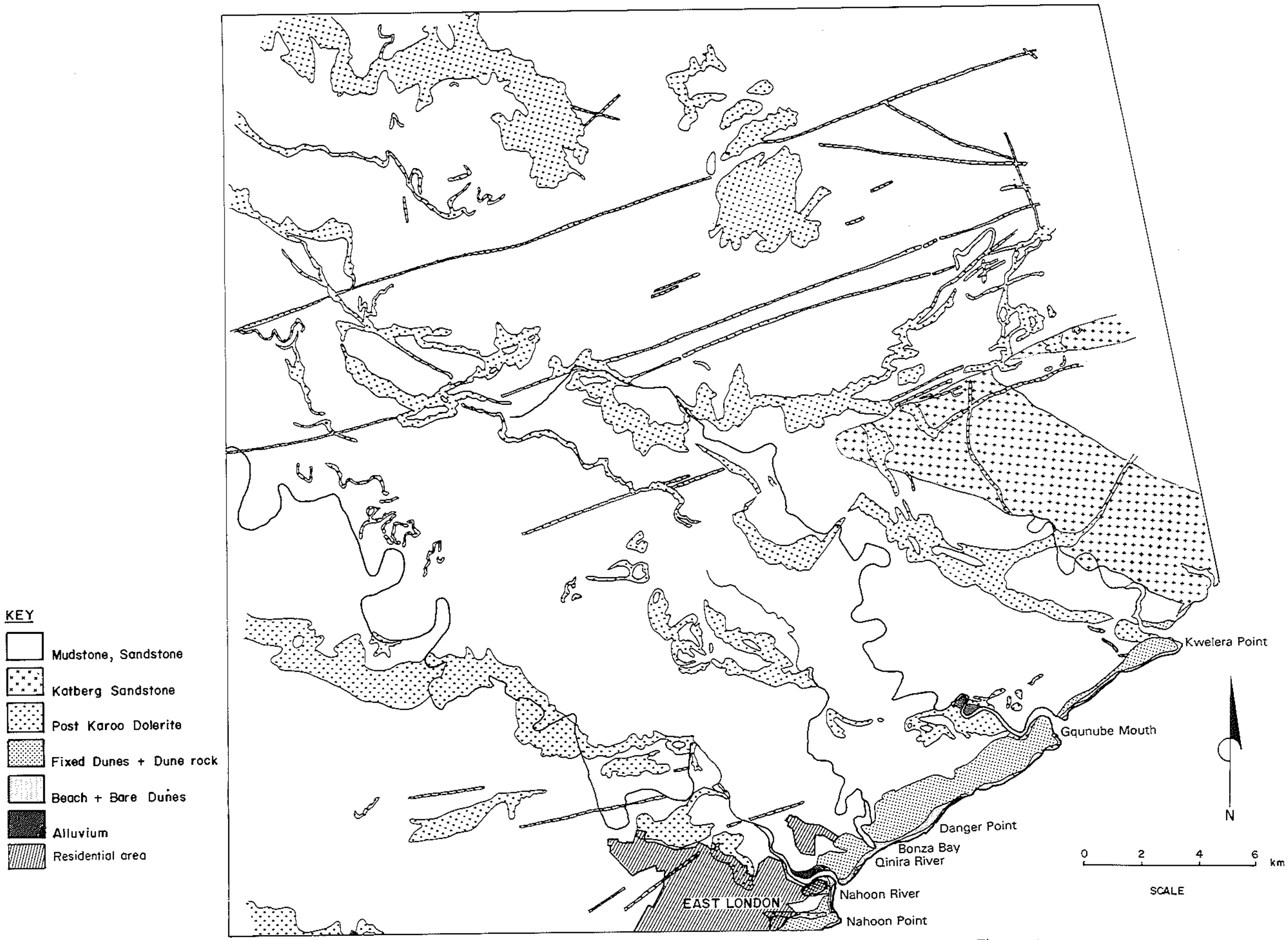

Figure. 2: Geology of the river catchments

Hartmann (1988) describes the soils of the East London coastal belt as being weakly developed and occurring on rock interspersed with black and brownish-black clay loams. They are derived predominantly from the argillaceous sediments of the Balfour and Middleton formations of the Beaufort Group and the dominant associated soil series are Williamson, Kanonkop, Mispah and Rutherglen. The doleritic topsoils are strongly structured and are characterized by the Msinsini, Mayo and Glengazi series. Reddering and Esterhuysen (1986) describe the catchment soils as being solonetzic and prone to erosion with lithosols occurring closer to the coast.

(Lithosols = shallow or skeletal soils less than 25 cm deep, often containing rock fragments, overlying weathering rock or gravel. Solonetzic = duplex soils with a friable, porous top soil overlying a hard clay sub-soil with columnar structure which is typically alkaline due to a high sodium content (Heydorn and Tinley, 1980)).

3.1.3. Climate and run-off

Climate

The climate of the south-east Cape has been described by a number of authors (Stone, 1988; Poynton, 1971; Tinley, 1985; Heydorn and Tinley, 1980; Walter and Leith, 1960). Schulze (1947) described the climate experienced at East London estuaries as humid and temperate, with "sufficient" rainfall in all seasons. He classified the East London climate as provincial sub-type Cfbl (C = warm, temperate climate, coldest months 18°C to -3°C; f = sufficient precipitation during all months; b = mean temperature of warmest month is below 22°C; and l = luke warm mean temperature of all months between 10°C and 22°C). In general, however, the coastal climate can be classified as warm and humid, tending towards sub-tropical, with a bimodal summer rainfall pattern (see Figure 3). The climate of the adjacent hinterland is somewhat more temperate.

The major climatic influences on the East London weather regime are the warm, offshore, southward flowing Agulhas Current, the coastline topography and, as for the whole sub-continent, the interaction between the east-moving cyclones of the circumpolar westerlies and the sub-tropical belt of anticyclonic cells of high pressure (Heydorn & Tinley, 1980; Tinley, 1985; Stone, 1988).

Precipitation

The bimodal (spring and autumn) pattern of rainfall distribution for East London and Gonubie is evident from Table 1. Rainfall data for King Williams Town are also shown in Table 1 and indicate the rainfall gradient between the coast and the approximate limit of the upper catchments of the Nahoon, Qinira and Gqunube rivers.

Table 1: Rainfall (mm) records for East London, Gonubie and King Williams Town. The numbers in brackets indicate the period, in years, for which records are available. (Source: Weather Bureau Records, *in litt.*)

	J	F	M	A	M	J	J	A	S	O	N	D	Yr (mm)
East London (67)	73	77	97	68	55	36	35	44	69	91	86	77	808
Gonubie (9)	74	76	105	72	41	28	10	38	48	107	74	72	745
King W. Town (14)	63	78	63	34	31	22	33	61	37	58	72	61	613

An important characteristic of rainfall in the East London region is the high variability both monthly and annually. Figure 4 shows the interquartile range of monthly rainfall measured at Southernwood (near East London Museum) for the period 1910 to 1990. It can be seen that monthly rainfall shows a markedly large range during spring and autumn. This characteristic can also be deduced from the flood history of the Nahoon River, discussed in section 3.1.7.

The mean annual precipitation recorded within the river catchments is shown below: (Source: Middleton *et al.*, 1981).

	Upper catchment (mm)	Lower catchment (mm)
Nahoon	662	777
Qinira	-	850
Gqunube	746-754	813

No data are available on the fog precipitation on the East London coastline.

Temperature

Lower-than-normal temperatures on the south-east Cape coast are associated with cyclonic activity, cloudy conditions and minimum insolation. Hotter-than-normal weather is associated with anticyclonic conditions with clear skies and maximum insolation.

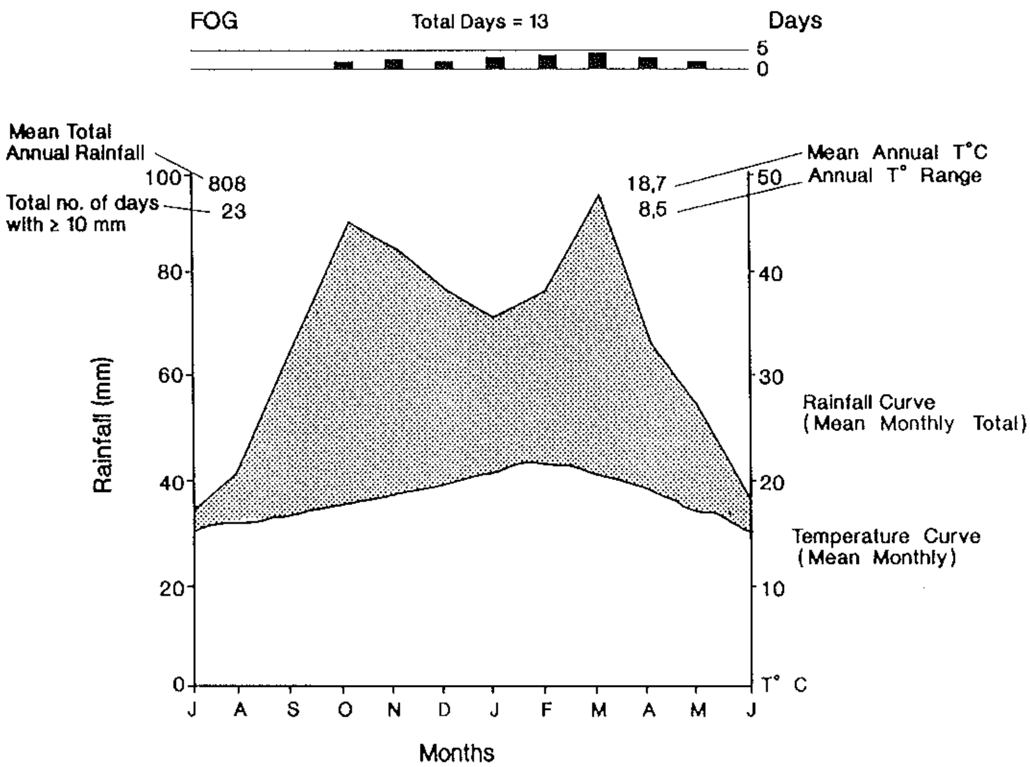

FIGURE 3: Coastal climograph for East London (Source Tinley, 1985).

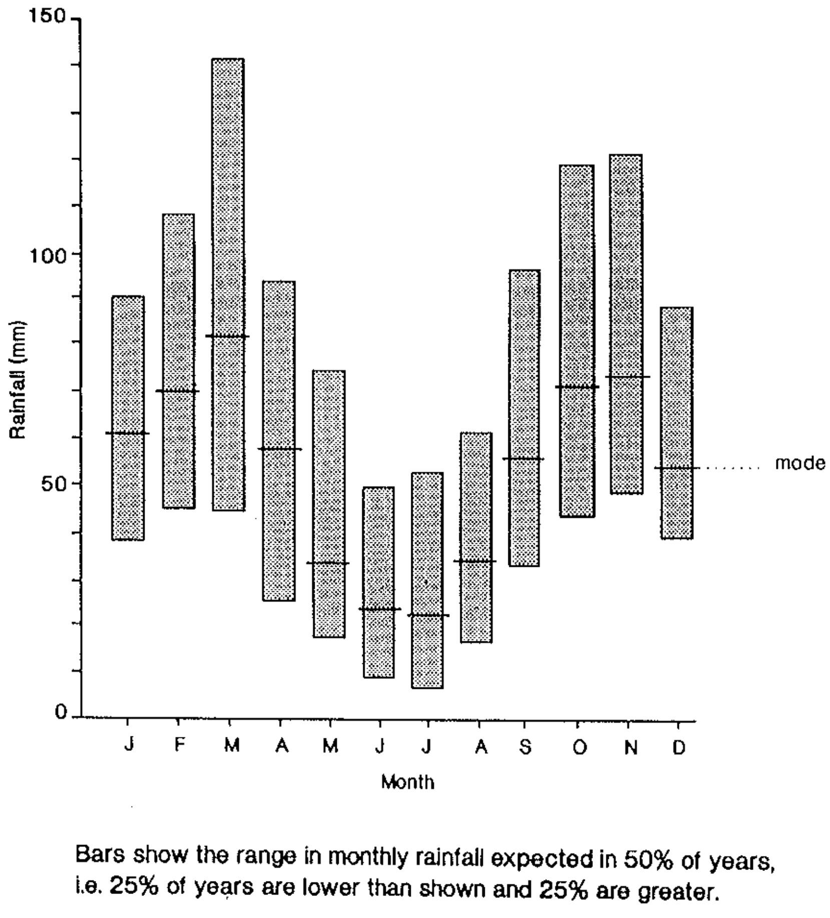

FIGURE 4: Interquartile range of monthly rainfall measured at Southernwood, East London (Data from East London Museum records.)

The moderating influence of the sea and particularly of the Agulhas Current results in relatively stable minimum temperatures at East London. Maximum temperatures, however, can show large fluctuations due to the occurrence of berg (katabatic) wind conditions, the effects of cold fronts and high cloud cover variability (Schulze, 1965). The mean daily temperature range at East London is greatest in July when both hot berg winds and cold spells can occur. The mean daily maxima, minima and temperature ranges at East London are shown below.

Table 2: Mean daily temperature maxima, minima and ranges recorded for East London

	J	F	M	A	M	J	J	A	S	O	N	D
Mean daily maximum (°C)	25,2	25,6	24,7	23,5	22,6	20,9	21,0	21,3	21,4	21,6	22,8	24,0
Mean daily minimum (°C)	17,9	18,3	17,5	15,1	12,8	10,5	10,2	11,2	12,5	14,2	15,4	16,7
Mean daily range (°C)	7,3	7,3	7,2	8,4	9,8	10,4	10,8	10,1	8,9	7,4	7,4	7,3

Wind

Wind data obtained from Voluntary Observing Ships (VOS) are shown in Figure 17 (Section 3.2). The wind roses show that south-westerly winds predominate throughout the year. North-easterly and east-north-easterly winds are also common in the summer. Spring is usually the windiest season of the year at East London, while the calmest periods occur from January to March. The least windy months, in terms of wind speeds, are April to June. Berg winds can occur all year round but are most common during winter, when the synoptic conditions necessary for their formation develop more frequently.

Run-off and river flow patterns

Recorded catchment run-off volumes, which have been adjusted for missing or incorrect data, are available only for the Outspan gauging station on the Gqunube River. No actual run-off data are available for either the Nahoon or Qinira rivers.

The recorded run-off data from the Outspan gauging station (R3H001) on the Gqunube River covers the period 1972 to 1979. Middleton *et al.* (1981) used these data to determine a recorded mean annual run-off figure of 35,76 x 10^6 m^3 from the Gqunube catchment for that period.

The simulated mean annual run-off for the Nahoon, Qinira and Gqunube rivers is shown below:

	Noble & Hemens, 1978	Middleton *et al.*, 1981	CSIR, 1987
Nahoon	-	34 x 10^6 m^3	33,65 x 10^6 m^3
Qinira	-	9 x 10^6 m^3	9,02 x 10^6 m^3
Gqunube	35 x 10^6 m^3	47 x 10^6 m^3	47,09 x 10^6 m^3

The simulated annual run-off of the Nahoon, Qinira and Gqunube rivers for the hydro years[1] 1921 to 1976 are shown in Figures 5, 6 and 7 respectively (Source: CSIR, 1987 after Middleton *et al.*, 1981). An important characteristic of the three rivers is that years with below average run-off are more common than years with above average run-off. Figure 5, for example, shows that only 17 years having greater than the Mean Annual Run-off (MAR) of the Nahoon River occurred in the 55 years of simulated run-off data.

Similar drought and flood cycles can be seen for the Qinira and Gqunube rivers. It is evident that periodic river floods are an important hydrodynamic feature of the three estuaries. The significance of this feature for the sediment dynamics and hydraulic characteristics of the Nahoon, Qinira and Gqunube estuaries is discussed in Section 3.2.

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[1] Note: A hydro year extends from October of one year to September of the following year. For example, hydro year 1969 includes October, November, December of 1969 and January to September of 1970.

The simulated monthly run-off of the Nahoon, Qinira and Gqunube rivers is shown in the table below.

Table 3: Simulated monthly run-off (x 10^6 m^3) for the Nahoon, Qinira and Gqunube rivers. Source: Middleton *et al.*, 1981

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Nahoon	1,68	2,14	4,94	3,99	2,62	1,11	1,50	2,75	2,84	3,19	4,60	2,30	33,65
Qinira	0,45	0,57	1,32	1,07	0,70	0,30	0,40	0,74	0,76	0,85	1,23	0,62	9,02
Gqunube	2,35	2,99	6,91	5,58	3,67	1,56	2,10	3,85	3,97	4,46	6,43	3,22	47,0

The simulated monthly run-off of the three rivers shows a bimodal pattern, with peaks occurring in the spring and autumn. Reduced run-off periods occur in the summer and winter months, which agrees with the monthly rainfall patterns for the East London area.

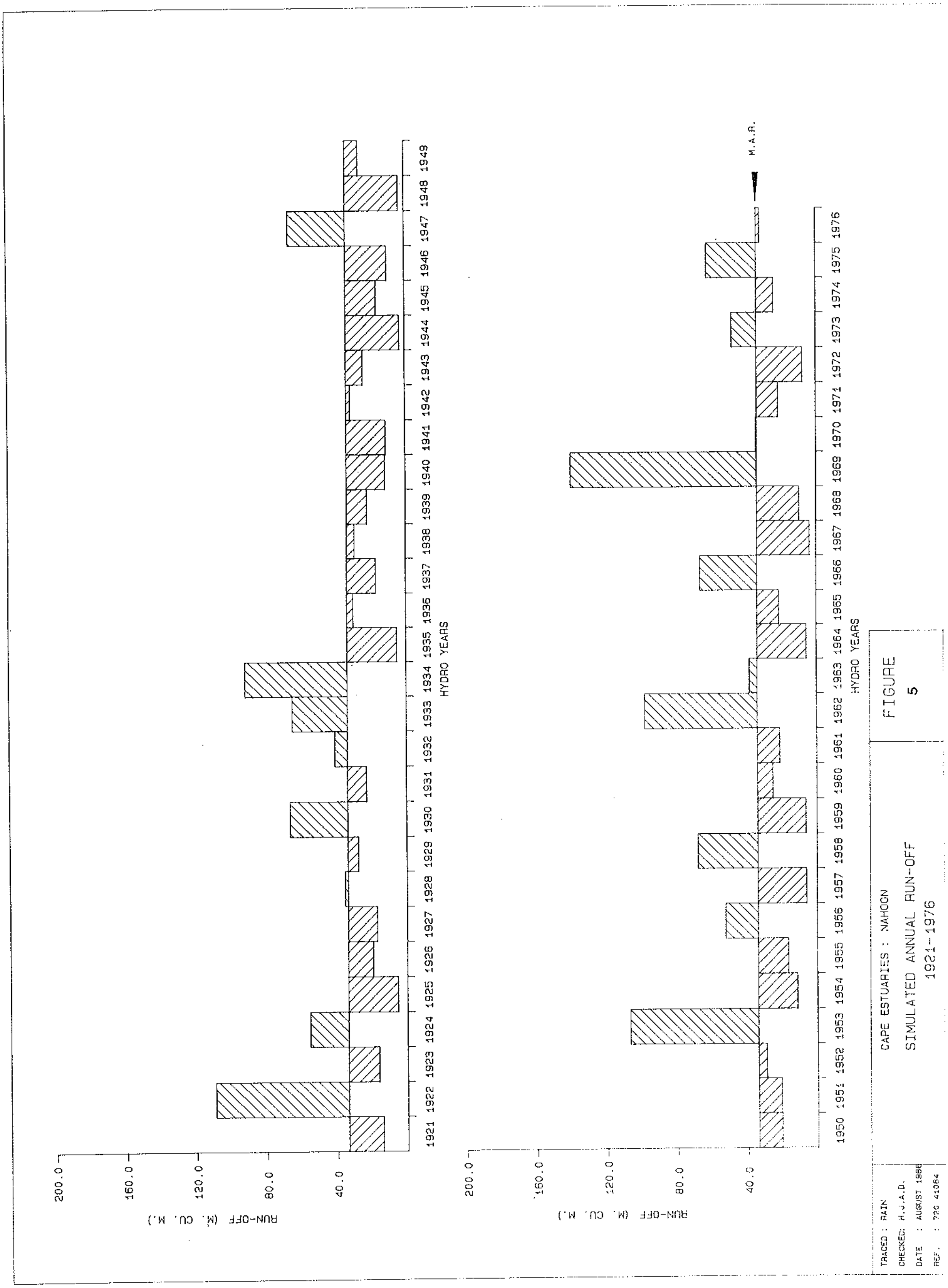
3.1.4 Land ownership and uses

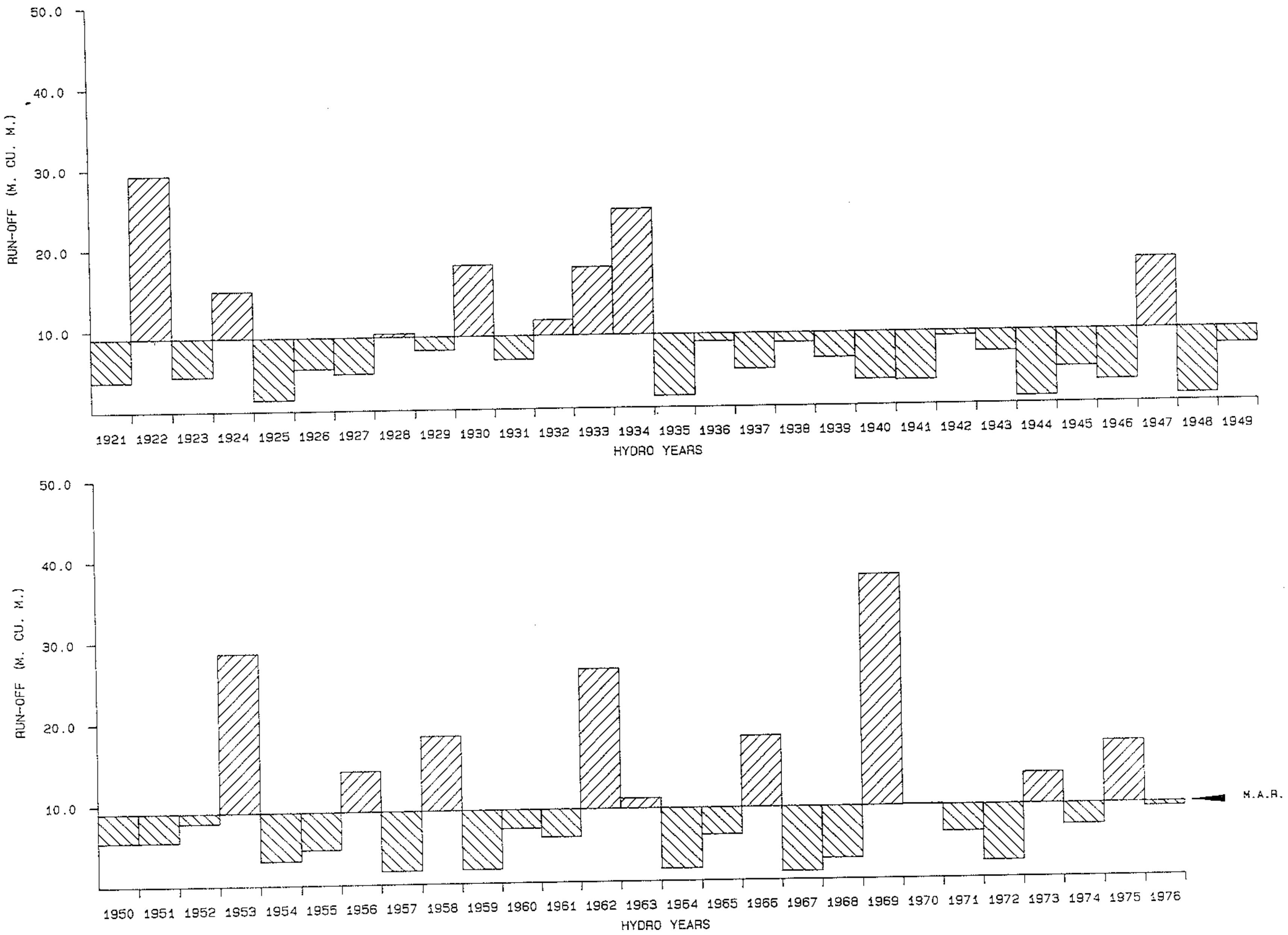
The Nahoon catchment has practically no forested area, but the Gqunube has about 12 km^2 of its catchment covered by forest (Reddering and Esterhuysen, 1986).

Domestic livestock farming is the most important agricultural activity in the Eastern Cape region. The most commonly kept livestock are cattle, of which two-thirds are beef cattle and the remainder dairy cattle, followed by sheep (wool), goats, pigs and poultry. Overall land use in the Eastern Cape region has been reported to include 87% devoted to extensive livestock farming, 10% arable land (of which 1% was irrigated land) and 3% other uses (Antrobus, 1986).

In the catchment of the Qinira River and to a lesser extent in the lower catchments of the Nahoon and Gqunube rivers, pineapple farming on irrigated land is widespread. The alluvial soils in the lower reaches of the Gqunube River are utilised for vegetable crops. Tomatoes are grown on irrigated land in the middle and lower reaches of the Qinira catchment.

The Nahoon, Qinira and Gqunube river catchments each occupy part of the East London, King Williams Town and Komga magisterial districts (see Section 1.3). Urban expansion within these districts is taking place rapidly as a result of both in-migration and natural population growth. The present and projected future population of each of the East London, King Williams Town and Komga districts is shown in Table 4.


RUN-OFF (M. CU. M.)
200.0
160.0
120.0
80.0
40.0
HYDRO YEARS
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949
1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
M.A.R.
CAPE ESTUARIES : NAHOON
SIMULATED ANNUAL RUN-OFF
1921-1976
FIGURE
5
TRACED : RAIN
CHECKED: H.J.A.D.
DATE : AUGUST 1986



TRACED : RAIN CHECKED: H.J.A.D. DATE : AUGUST 1986 REF. : 720 41064	CAPE ESTUARIES : CSE QINIRA SIMULATED ANNUAL RUN-OFF 1921-1976	FIGURE 6

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

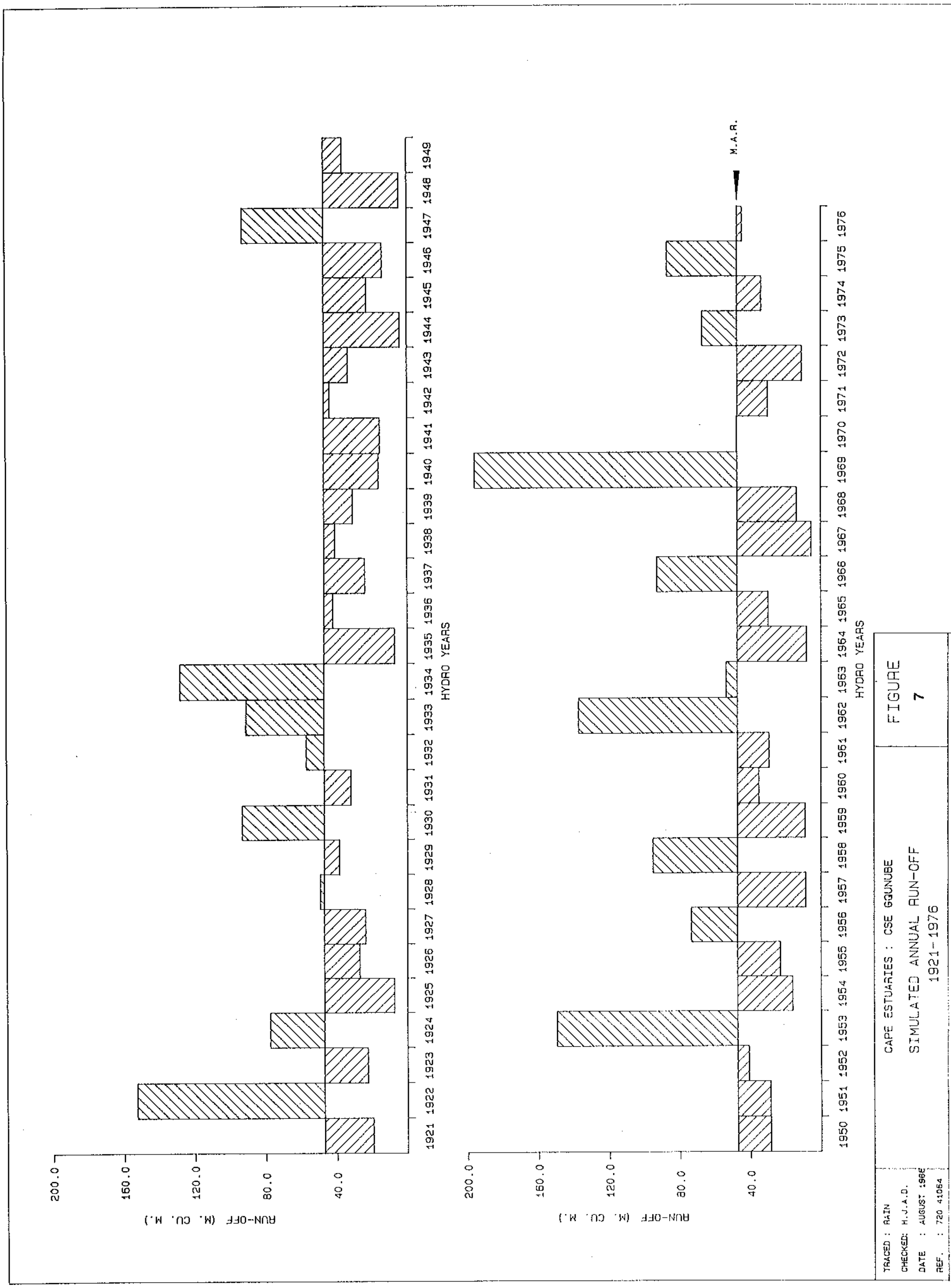

RUN-OFF (M. CU. M.)
200.0
160.0
120.0
80.0
40.0
HYDRO YEARS
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949
1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
M.A.R.
TRACED : RAIN
CHECKED: H.J.A.D.
DATE : AUGUST 1986
REF. : 720 41064
CAPE ESTUARIES : CSE GQUNUBE
SIMULATED ANNUAL RUN-OFF
1921-1976
FIGURE
7

Table 4: The present and projected future population of the East London, King Williams Town and Komga districts. Source: Kassier *et al.*, 1988 as modified by Fabricius and Heath, 1988

District	Black		Coloured & Asian		White		Total	
	1985	2010	1985	2010	1985	2010	1985	2010
East London								
Urban	29 204			64 659			119 252	
Non-urban	44 256			4 297			48 252	
Total	73 460	135 528	-	-	68 956	83 532	167 992	253 522
King W. Town								
Urban	6 793	6 111	-	8 418	-	21 322		
Non-urban	3 810	242	-	453	-	4 505		
Total	10 603	19 562	6 353	8 560	8 871	10 746	25 827	38 868
Komga								
Urban	3 799	-	360	-	1 038	-	4 197	
Non-urban	8 031	-	32	-	559	-	9 622	
Total	11 830	21 825	392	528	1 597	1 935	12 819	24 288

3.1.5 Obstructions

Dams

A number of small farm dams exist on the tributaries of the Nahoon, Qinira and Gqunube rivers (1: 50 000 Topographical Sheets 3227 DD Cambridge and 3228 CC Gonubie). The only major impoundment in the study area of this report, however, is the Nahoon Dam, situated about 27 km from the mouth of the Nahoon Estuary.

The Nahoon Dam was completed in 1966 and is the property of the Department of Water Affairs (Tow, 1981). The dam has a catchment area of 473 km^2 and its original functions were to supply water to a local textile factory and to stabilise the water supply to irrigators downstream (South Africa, Department of Water Affairs, 1963).

As a result of the then predicted increases in the demand for water in the East London - King Williams Town area, the Department of Water Affairs (South Africa, 1975) undertook to raise the dam to the full potential of the site. This increased the gross capacity of the Nahoon Dam from 5,9 x 10^6 m^3 to 22,1 x 10^6 m^3, and the water surface area from 0,82 km^2 to 2,38 km^2 at full supply level (South Africa, Department of Water Affairs, 1975). The dam now supplements urban and industrial water supplies to the East London Metropolitan Area and adjoining townships, including Mdantsane and Potsdam, from the Laing and Bridle Drift dams on the Buffalo River. Construction of the raised Nahoon Dam wall was completed in 1979 (Tow, 1981).

Further hydrological analyses subsequent to the raising of the Nahoon Dam are reported to have shown a considerably greater quantity of water than originally estimated may be available at the dam (Tow, 1981). Preliminary designs and economic analyses reportedly show that a further 3 m raising of the Nahoon Dam would be optimal (Tow, 1981; South Africa, Department of Water Affairs, 1976).

The CSIR (1985) report that by comparing the MAR of the Nahoon River with the capacity of the raised Nahoon Dam, the dam can be classified as medium-sized in relation to the MAR. It is therefore clear that whereas the original Nahoon Dam would have had little effect on the flow downstream and hence on the estuary, the raised dam is likely to have a considerable effect. Small or intermediate floods, particularly those following dry periods, will be considerably attenuated by the dam. Nevertheless, major floods such as that of 1970 (see section 3.1.7) will not be significantly affected by the dam and will still scour large amounts of accumulated sediment from the estuary (CSIR, 1985). An effect of the dam is, therefore, to reduce the frequency with which large floods scour the river mouth, causing a greater accumulation of sand in the estuary between floods.

Other obstructions to river flow

NAHOON: Both river and tidal flow in the Nahoon Estuary are affected by the Abbotsford Causeway (Figure 8) (or De Waal Bridge), which is located just upstream of the National Road bridge, about 5 km from the river mouth. The Abbotsford Causeway constricts natural water flow in the river and confines estuarine conditions, including tidal effects, to the river downstream of its position. However, this artificial tidal head lies close to the natural position of the tidal head and has a negligible effect on the overall tidal dynamics of the estuary (Rust *et al.*, 1985).

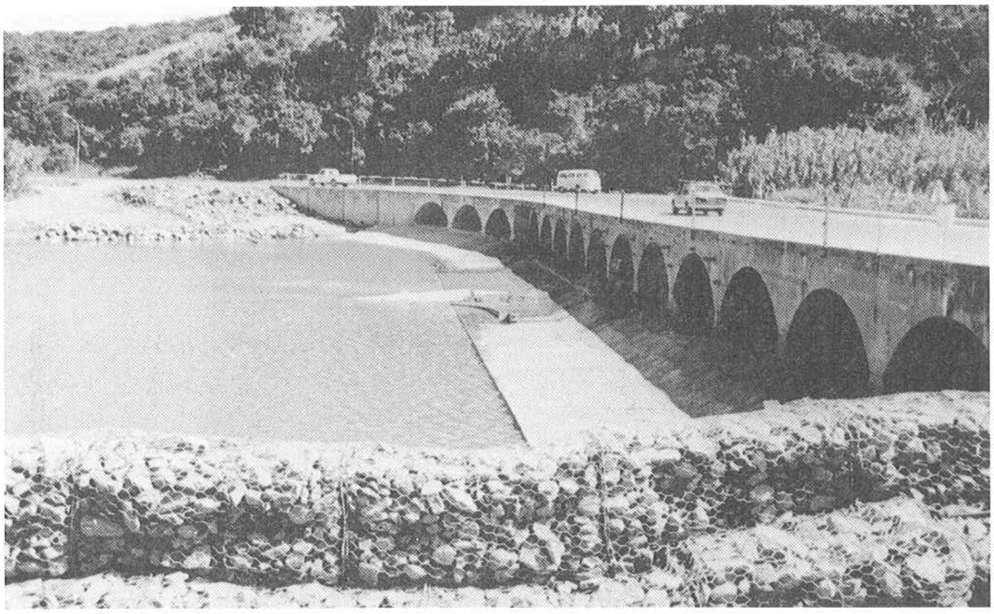


Figure 8: The Abbotsford Causeway on the Nahoon River. (Photo: ECRU 21.01.86).

Three other large bridges cross the Nahoon River in its lower reaches, but do not create any significant obstruction to the natural water flow. They are the National Road bridge (which also crosses the Qinira and Gqunube rivers), the North East Expressway bridge, which links the National Road to an interchange on the east bank of the Nahoon River, and the Jack Batting Bridge, situated two and a half kilometres from the river mouth. The Jack Batting Bridge provides a direct link between Beacon Bay and East London.

QINIRA: The National Road bridge and three other small bridges cross the Qinira River in its middle to upper reaches, but do not create any significant obstruction to the natural river flow (Raal, 1993). There are no bridges on the lower reaches of the Qinira River, but a weir located at the head of the Quenera Lagoon retains river flow during low-flow periods (Figure 9). The weir also creates an artificial limit to tidal ebb-and-flow in the estuary when the mouth is open.

GQUNUBE: The National Road bridge and other small bridges that exist in the middle reaches of the river do not appear to create any significant obstruction to the natural river flow (Raal, 1993). There are no bridges or other river crossings in the lower reaches of the river.

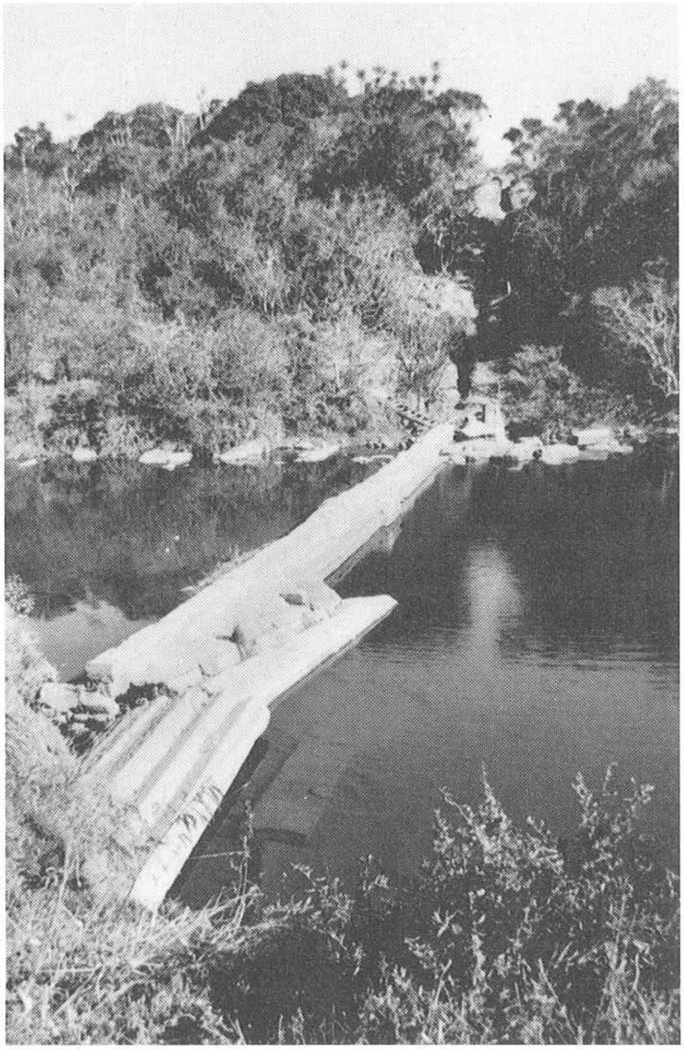


Figure 9: Weir at the head of the Qinira Estuary (Photo: ECRU 18.07.91)

3.1.6 Siltation

Extensive sedimentation has taken place in the Nahoon and Qinira estuaries as a result of erosion in the catchment. The catchment soils are moderately to highly erodible, with an estimated maximum sediment yield of 400 tonnes/km^2/year under extreme conditions (Rooseboom, 1975 in Middleton *et al.*, 1981). Estimates of the average catchment sediment yield for the three rivers are shown below. However, due to the fine-grained nature of the eroded material, most of it is transported as a suspended load within the river flow (Esterhuysen and Reddering, 1985).

Average catchment sediment yield		
River	tonnes/yr	tonnes/km^2/yr
Nahoon	201 000	344
Qinira	15 300	170
Gqunube	226 100	340

Source: CSIR, 1987.

Erosion in the Nahoon, Qinira and Gqunube catchments is also aggravated by the variable characteristics of the regional climate. In particular, the periodic droughts and floods of the region, combined with reduced vegetation cover due to intensive grazing and the inherently low moisture percolation capacity of clayey soils, lead to high rates of erosion and sedimentation. Hartman *et al.* (1981) have estimated that approximately 18 percent of the land under cultivation in the Eastern Cape has soils of high to very high erosion hazard ratings on slopes exceeding six percent, and that 34 percent of the land comprises soils with a moderate erosion hazard rating on slopes exceeding 12 percent. Much of the cultivation on sloping terrain can be ascribed to pineapple crops, which are unsuited to sites having impeded drainage and prefer conditions in which excess surface water can drain off rapidly.

Increased erosion and sedimentation as a result of the factors described above is likely to most significantly affect the Qinira River due to the large extent of irrigated lands in its catchment (see Section 3.1.4). From an examination of recent aerial photographs and from *in situ* observations, it appears that much of the riparian vegetation will tend to reduce the impact of siltation in the lower reaches and estuary, although this does little to alleviate the long term effects of soil loss from the catchment.

3.1.7 Floods

The recorded variability of monthly rainfall for East London (Figure 4) and the simulated virgin run-off for the Nahoon, Qinira and Gqunube rivers (Figures 5, 6 and 7) show that floods, separated by droughts, are characteristic of the East London region. Table 5 shows the recorded incidence of floods for the Nahoon River.

Simulated virgin run-off data for the three rivers in the hydro years 1921 to 1976, show the following characteristics:

NAHOON: Major flood flows exceeding nine times the maximum average monthly flow of 4,94 x 10^6 m^3 occurred in November 1922, May 1935, October 1953, March 1963 and August 1970 (Figure 5).

Table 5: Recorded floods in the Nahoon River. (Source: Raal, 1993).

Month	Year	Rainfall	Source
October	1989	180 mm	Daily Dispatch
October/November	1985	400+mm in 9 days	*Daily Dispatch*
April	1978	257 mm	Measured at Southernwood
September	1975	265 mm	Measured at Southernwood
November	1973	251 mm	Measured at Southernwood
August	1970	853 mm in 7 days	*Daily Dispatch*
April	1967	354 mm	Measured at Southernwood
March	1963	561 mm	Measured at Southernwood
April	1961	256 mm	Measured at Southernwood
October	1953	312 mm in 2 days 435 mm for month	Measured at Southernwood
September	1952	261 mm	Measured at Southernwood
April	1948	219 mm	Measured at Southernwood
May	1941	252 mm	Measured at Southernwood
May	1935	270 mm	Measured at Southernwood
July	1931	284 mm	Measured at Southernwood
November	1922	457 mm	Measured at Southernwood
October	1905	300 mm in 3 days	*Daily Dispatch*
August	1887	200 mm in 6 days	*Daily Dispatch*

QINIRA: Major flood flows exceeding nine times the maximum average monthly flow of 1,32 x 10^6.m^3 occurred in May 1935, October 1953, March 1963 and August 1970 (Figure 6).

GQUNUBE: Major flood flows exceeding nine times the maximum average monthly flow of 6,91 x 10^6 m^3 occurred in May 1935, October 1953, March 1963 and August 1970 (Figure 7).

Major floods that have occurred in recent years include those of November 1985 and of August 1970. The flood of November 1985 removed almost all the accumulated marine sand deposits from the mouth of the Nahoon Estuary (Reddering and Esterhuysen, 1986 and 1987). Approximately 0,4 x 10^6 m^3 of sediment was scoured from the Nahoon Estuary, although 94% of this was marine sand scoured from the river mouth (Reddering and Esterhuysen, 1987). The peak flood discharge in the Nahoon River was 1 400 m^3/s (*ibid.*) Reddering and Esterhuysen (1986) estimated that a period of ten to fifteen years without major floods would allow the estuary to return to the state it was in before November 1985. Nevertheless, the reduced incidence of smaller floods as a result of the raising of the wall of the Nahoon Dam in 1981 could accelerate this natural process.

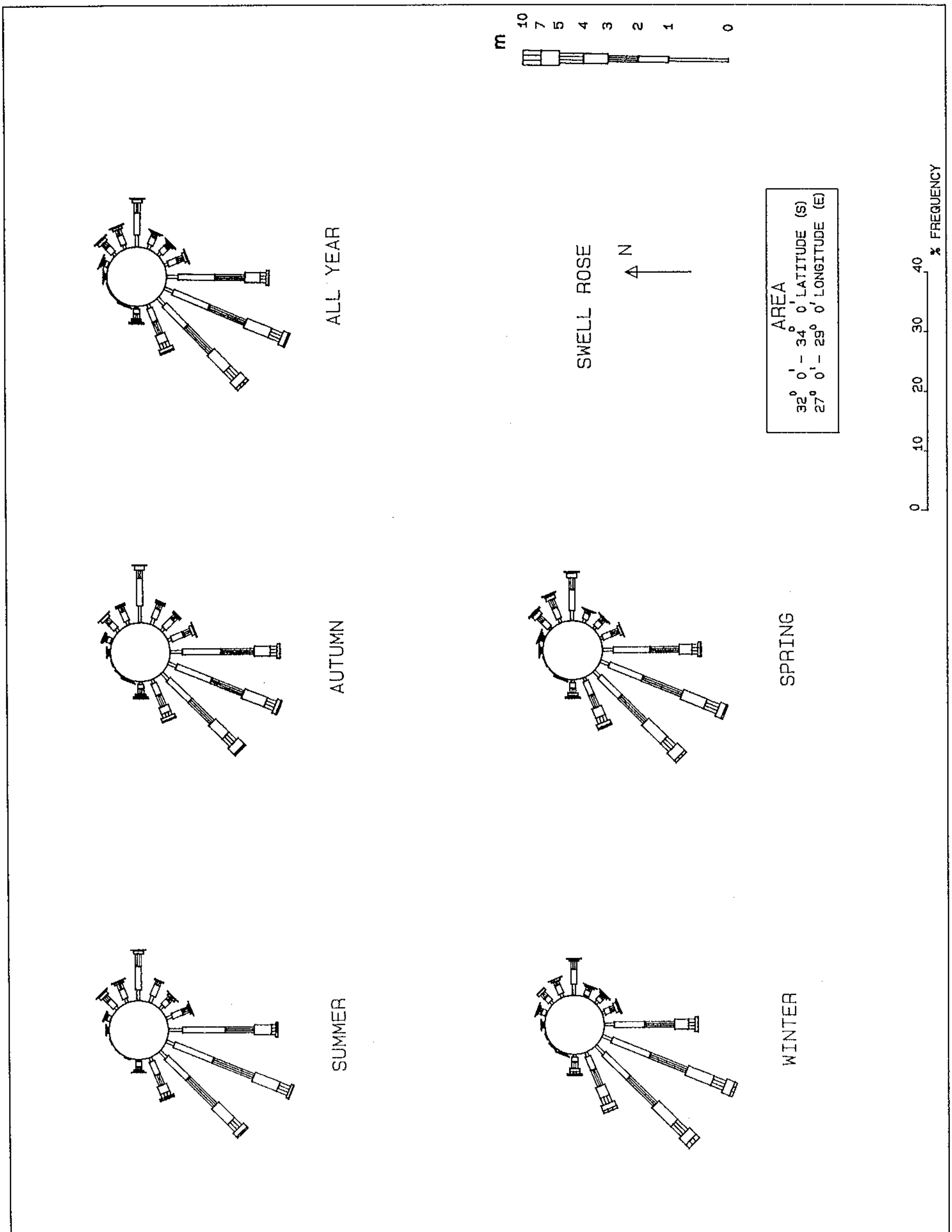
Severe flood damage to properties in low-lying areas of the Nahoon Estuary during the flood in August 1970 has also been reported (Rust *et al.*, 1985). The Jack Batting Bridge (about five metres above MSL) was completely destroyed by the flood. Although no river flow data are available for the estuary, river inflow records for the Nahoon Dam show that the monthly inflow during August 1970 was 171 x 10^6 m^3. This can be compared to the average monthly inflow for August in the four years preceding 1970, which was 2,9 x $10^4 m^3$ (Rust *et al.*, 1985). The flood flow was about 6 000 times greater than the average flow for that month.

3.2 Estuaries

3.2.1 Coastal hydraulics

Geomorphological features, such as Nahoon Point to the south-west and Kwelera Point to the north-east, influence deep sea swells entering the area off the estuary mouths. Owing to this fact only swells between 67,5° and 202,5° can enter the area unaffected. Data obtained from Voluntary Observing Ships (VOS) show that swells from the south-west predominate during winter, spring and summer whereas there is an increase in southerly swells in autumn (Figure 10; Swart and Serdyn, 1981).

Waves approaching the coast at an oblique angle are responsible for the generation of longshore sediment movement. Since swells mainly occur from the south-western sector, the longshore sediment movement generally is in a north-easterly direction. The growth of the sandspits at the three estuaries from the south-western sides of their mouths under normal conditions is indicative of this.



NAHOON , QINIRA AND GQUNUBE

VOS SWELL ROSES

FIGURE 10

CSIR-EMATEK

3.2.2 Estuarine hydraulics

NAHOON: Aerial photographs from 1970 onwards show the presence of sediment in the form of flood tide deltas within the estuary. Rust *et al*., (1985) have shown that during periods of prolonged drought, marine sediments may be deposited in the lower portion of the estuary up to a distance of 1,2 km from the inlet.

The estuary consists of a shallow permanently open inlet. However, on two occasions, during the severe drought in 1947 and again for five days in 1969 (Rossouw, 1969), it closed. Rust *et al.* (1985) calculated, from aerial photographs, the width of the inlet to be between 30 and 40 m. The shallow inlet channel has a rocky northern bank which restricts migration of the inlet channel further to the north east. A sandspit, formed as a response to wave and tidal action, constitutes the western bank of the inlet. The one kilometre-long Nahoon Beach adjoins the estuary to the south. A slow accumulation of sand normally takes place in the river mouth and along the adjacent western bank of the estuary. This sand is removed periodically during floods.

QINIRA: The study of available aerial photographs indicates that a gradual accumulation of sediment in the form of flood tide deltas within the Qinira Estuary occurs during times of low river flow, resulting in a closure of the river mouth. These sediments are removed periodically during floods. The river mouth is opened artificially to reduce the risk of flooding properties and to remove polluted water (see Section 5.1).

Sandy pocket beaches adjoin the estuary on both sides. When the estuary is open, the inlet is usually pushed towards the eastern side by the growing western sandbank which is a direct result of the north-easterly moving longshore current. The open inlet usually varies between 20 to 70 m in width. The system is flood-tide dominated and the 1987 aerial photograph shows that a sandbank, visible during low tide, was present 150 to 300 m up the estuary.

GQUNUBE: Similar to the Nahoon and Qinira estuaries, the Gqunube is microtidal (coastal spring tidal range = 1,6 m) and flood tide-dominated and as a result the system has a shallow, constricted tidal inlet and well developed flood-tidal deltas (Wooldridge, 1986). The estuary deepens from the flood-tidal deltas upstream towards the head of tidal effect. The northern bank consists of rock and prevents the inlet from migrating. To the south the adjacent 300 m wide beach merges laterally into the flood-tidal delta of the estuary.

A study of available aerial photographs from January 1939 to 1990 indicates that the mouth always stays open on the eastern side of the mouth area and that the flood-tidal delta on the western side extends into the estuary for nearly one kilometre. The width of the inlet channel varies between 30 to 60 m.

3.2.3 Estuarine sediments

Sediment grain size classification

NAHOON: Sand samples were taken on 23-01-90 at the mouth and the adjacent beach. Analysis shows that the median grain size diameter (D50) tends to increase closer to the mouth and falls within the medium to coarse sand limits (0,25 - 1,0 mm) of the Shore Protection Manual grain size classification. (Shore Protection Manual Vol. I, 1973).

QINIRA: Analysis of the sand samples taken at the mouth on 22-01-90 shows that the median grain size, varying between the fine to medium sand limits (0,125 - 0,5mm), seems to decrease closer to the mouth.

GQUNUBE: Sand samples were taken near the mouth on 24-01-90. Analysis shows that the median grain size diameter (D50) of all the samples falls within the medium sand limits (0,25 - 0,5 mm).

The longshore variation of the samples shows that grain size tends to increase further away from the mouth.

Sediment accumulation and dispersal

Sediment enters each of the Nahoon, Qinira and Gqunube estuaries in the form of silt from the river catchments, and as marine sand transported by tides, waves and wind. Most of the finer, clayey sediments from the catchment are transported out to sea by normal river flow as a suspended load, although some is deposited in the middle and upper reaches of the estuaries. Surveys of the cross-sectional profiles of each of the three estuaries have been made at their mouths and 200 - 400 m upstream (Figures 11-16). The profiles at the mouths tend to reflect short term variations whereas the upstream profile shows the longer term effects of the flow regime.

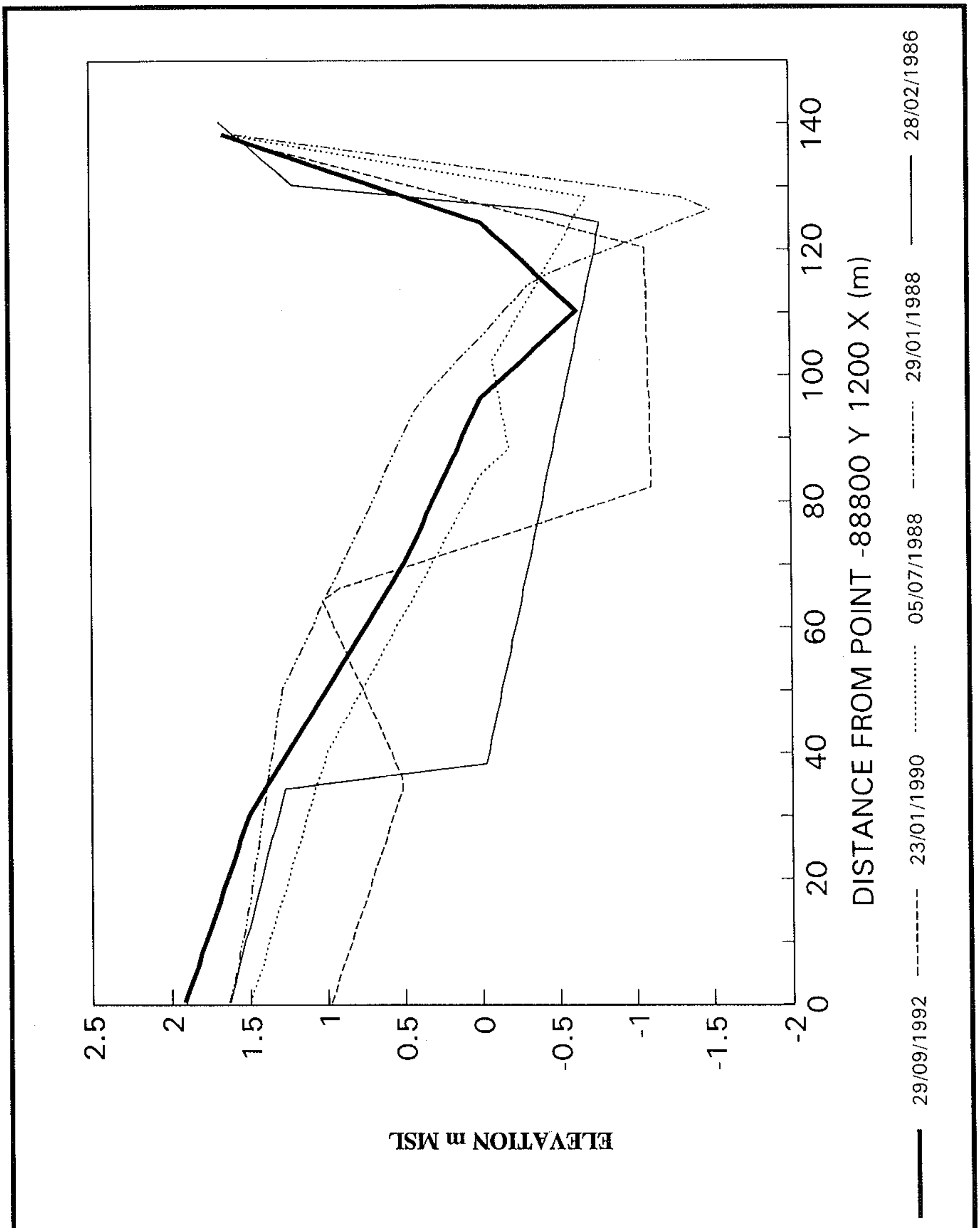
NAHOON: Reddering and Esterhuysen (1987) in an analysis of the effect of the 1985 flood, found that the flood scoured a total of 0,4 x 10^6 m^3 of sediment from the Nahoon Estuary. However, only six percent of the sediment removed was from the intertidal zone (middle and upper reaches of the estuary) whereas 94 percent was marine sediment removed from the subtidal zone (estuary mouth). The variation in erosive action of the flood in different parts of the estuary was attributed to differences in cohesion of the sediment from the middle and upper estuary to that of the lower estuary. Reddering and Esterhuysen showed that sand mixed with interstitial mud (middle and upper estuary) was much more erosion resistant than the matrix-free, i.e. pure, sand in the river mouth. As a result, the mud/sand mixture in the middle and upper reaches tends to show a net accumulation, whereas the sand shoals in the river mouth are scoured by larger floods. Reddering and Esterhuysen calculated that marine sand accumulates in the lower Nahoon Estuary at a rate of about 58 m^3/day (21 170 m^3 per annum), and that sediment consisting mainly of clastic sand accumulates in the middle and upper estuary at a rate of 6,0 x $10^3 m^3$ per annum, or 16,5 m^3/day.

Five bathymetric surveys of the Nahoon Estuary were undertaken by the CSIR during the period 28-02-86 and 29-09-92. The cross-section of the mouth in February 1986 (Figure 11) shows that the flood in November 1985 scoured out a wide flat-bottomed channel. During the following period of low flow, i.e. when the system was flood-tide dominated, sediment gradually accumulated on the western sandspit. At the same time the estuary was forced towards the rocky eastern shore forming a narrow V-shaped channel (Figure 11, sections surveyed on 29-01-88 and 05-07-88). This pattern of accretion during dry periods and erosion by floods is typical of many South African estuaries. In the case of the Nahoon Estuary the cycle is more pronounced because the Nahoon Dam captures smaller floods thus severely reducing the amount of erosion occurring between major floods.

Cross-sections of the Nahoon Estuary 300 m from the mouth showed that silt deposited by the November 1985 flood was eroded to a depth of one metre by the subsequent flood in the winter of 1988 (Figure 12, sections 28-02-86 and 05-07-88). Similar to the mouth, cycles of erosion and accretion occur throughout the estuary. The most recent survey (29-09-92) shows the largest accumulation of sediment recorded during the survey period. This accretion probably is the consequence of the extremely low flows during the recent protracted drought.

QINIRA: Only two surveys have been undertaken at the Qinira Estuary. The profiles at the mouth and 400 m upstream show that the sediment volumes have not changed significantly during the period 28-02-86 and 29-09-92. At the mouth, the channel has moved from the eastern (1986) to the western shore (1992) (Figures 13 and 14).

GQUNUBE: This estuary functions as a closed sedimentary circuit within a pocket beach (CSIR, 1992). Marine sediment entering the estuary accumulates in the lower estuary within a flood tidal delta, from where it is washed out to sea from time to time by river floods. The sandy beach and incipient foredunes in the mouth area and along the southern section of the beach are also washed away by flood waters. The sediment

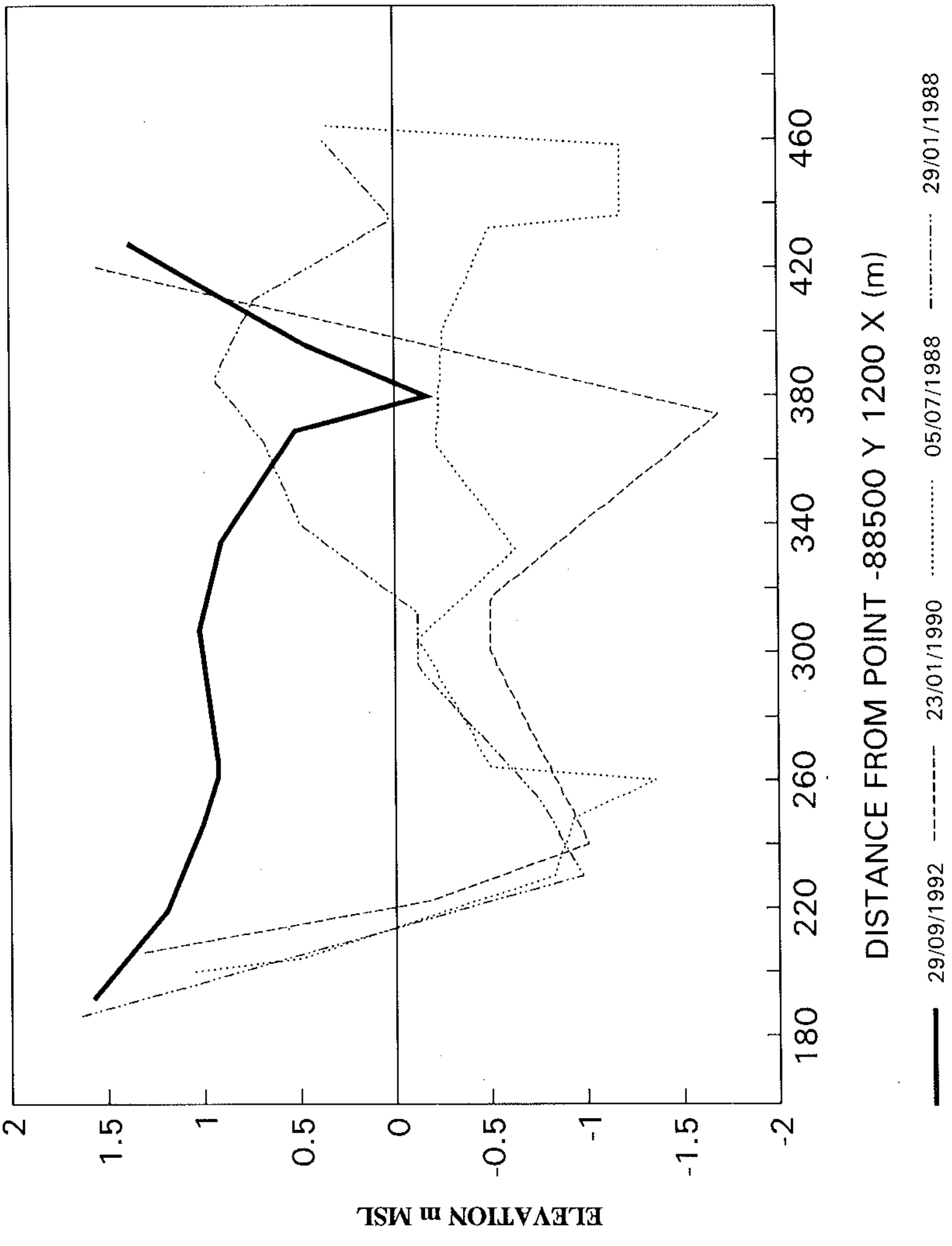


NAHOON ESTUARY

SECTIONS TAKEN IN ESTUARY MOUTH

FIGURE: 11

CSIR - EMATEK



NAHOON ESTUARY

SECTIONS 300m UPSTREAM OF ESTUARY MOUTH

FIGURE: 12

CSIR - EMATEK

is deposited as an offshore delta, and is gradually returned to the beach by low energy wave action.

After large floods, such as that of 1985, the beach builds up significantly. During extended droughts, however, the beach becomes severely denuded of sand and only an exposed rocky intertidal area is left. During these periods, the toe of the primary dune is subject to erosion, feeding sand to the beach. Although the dune does not contribute significantly to the sediment budget, it is important as a sediment source during droughts and is thus extremely sensitive to disturbance (CSIR, 1992).

The Gqunube Estuary underwent rapid sedimentation between 26-02-86 and 30-01-88 (Figure 15). At the transect approximately 200 m upstream of the mouth up to 5 m of sedimentation occurred in the central channel. However, the winter 1988 flood scoured 1-2 m of sediment after which further sediment accretion has taken place (Figure 16).

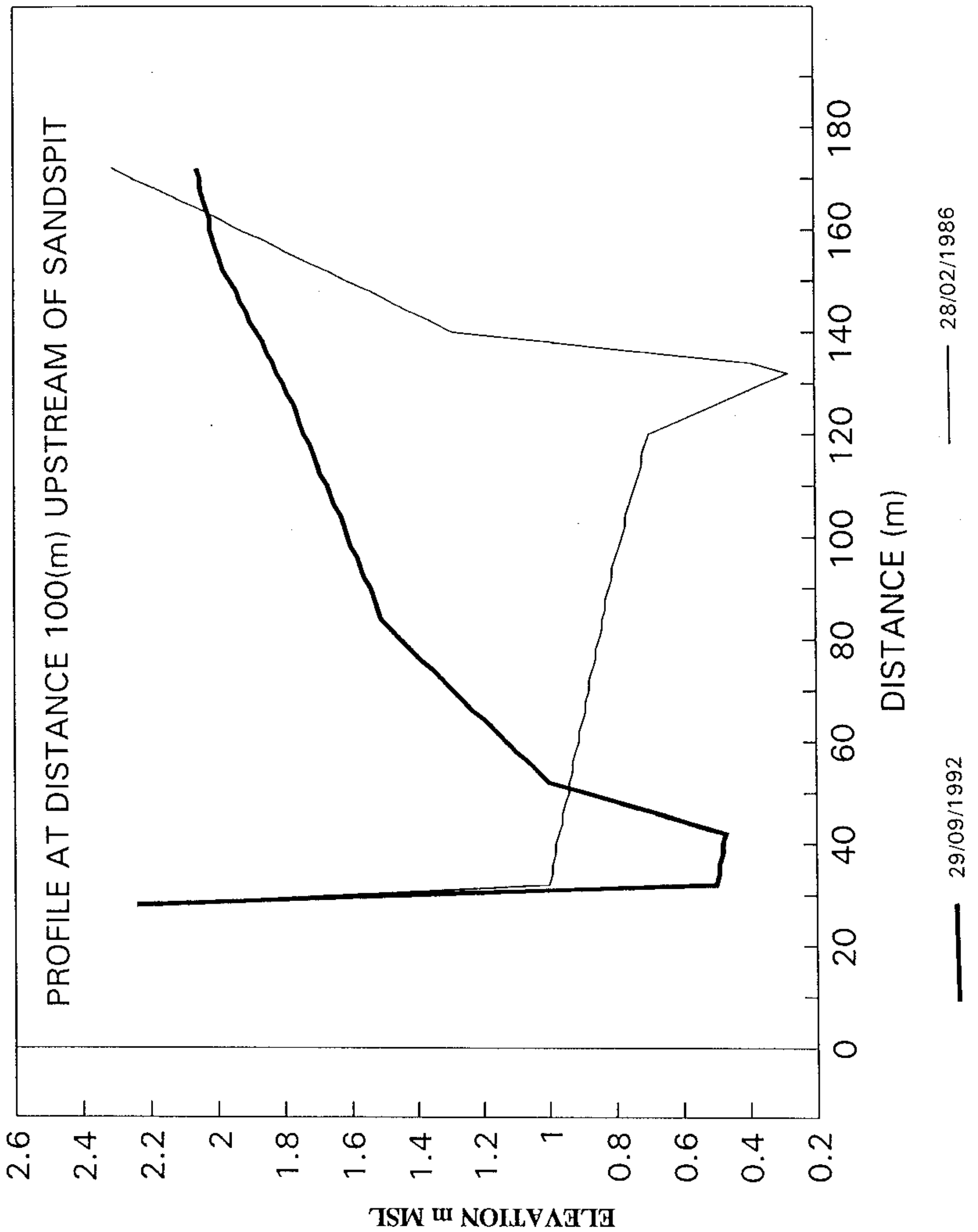
Wind and Aeolian Sand Transport

Wind data obtained from Voluntary Observing Ships (VOS), (Figure 17), indicate that south-westerly winds predominate throughout the year. The wind predominates in alongshore directions i.e. from the south-west and north-east. Strong north-east winds may occur at any time during the year. During winter a small component is from the north-west while during the summer months a south-easterly component is present.

The VOS data were analysed and an aeolian creep diagram (Figure 18) produced (Swart, 1986). The diagram indicates how wind-blown sand would approach from different directions towards the centre of an imaginary circle on the ground. From the "all year" diagrams the potential aeolian sand transport rate (cubic metres per year per metre perpendicular to the wind) can be calculated for the various wind directions.

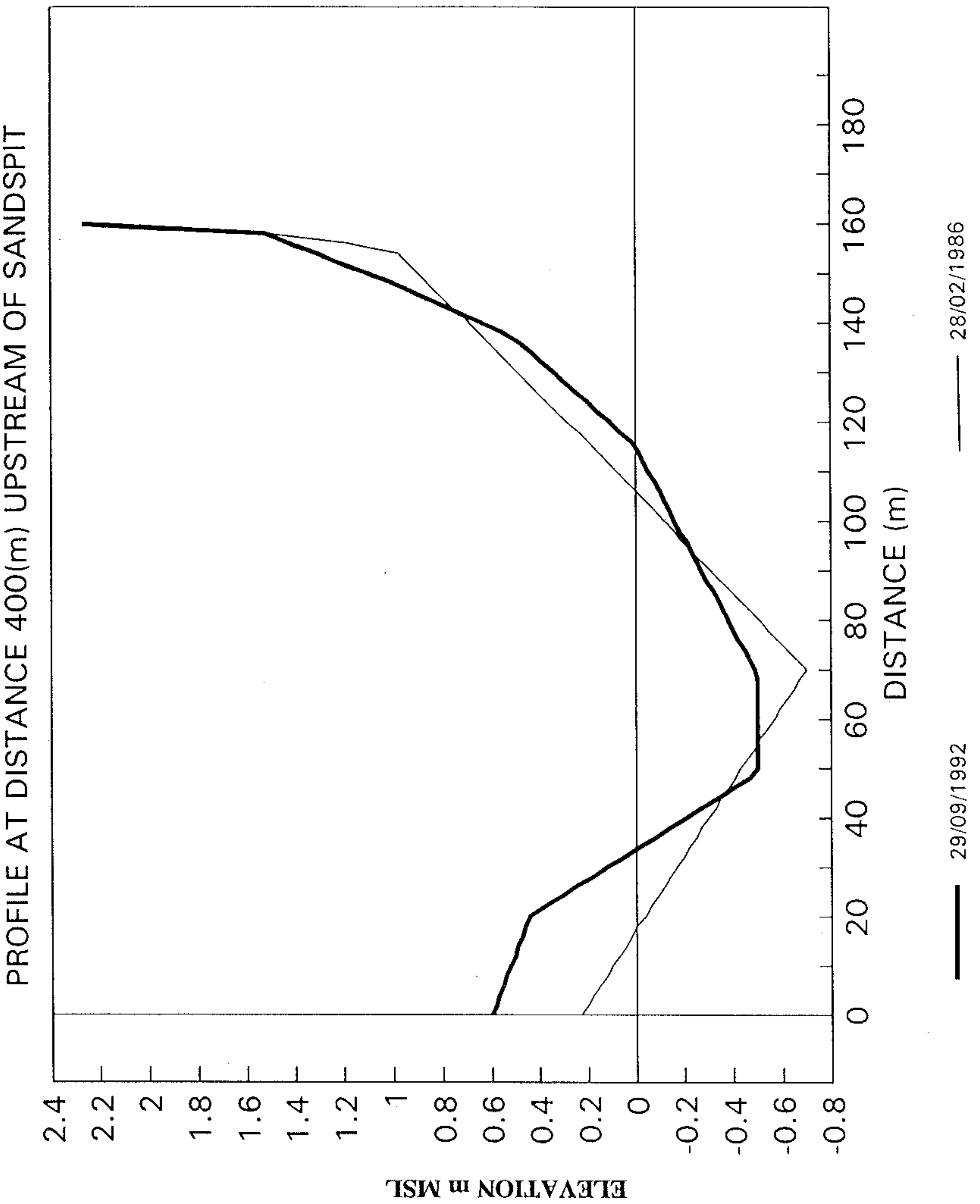
The diagram indicates aeolian sediment movement from the south-west towards the north. The "all year" diagram shows that a net movement of sand takes place towards the north-east. The fact that the inlets of the three estuaries are usually trapped on the north-eastern side, while the sandspits grow from the south-western side, is confirmation of this.

Table 6 gives the potential annual aeolian sand transport rates for the Nahoon, Qinira and Gqunube estuaries. Since sand grain size and wind conditions are similar at the three estuaries, one set of creep rates is representative of all three.



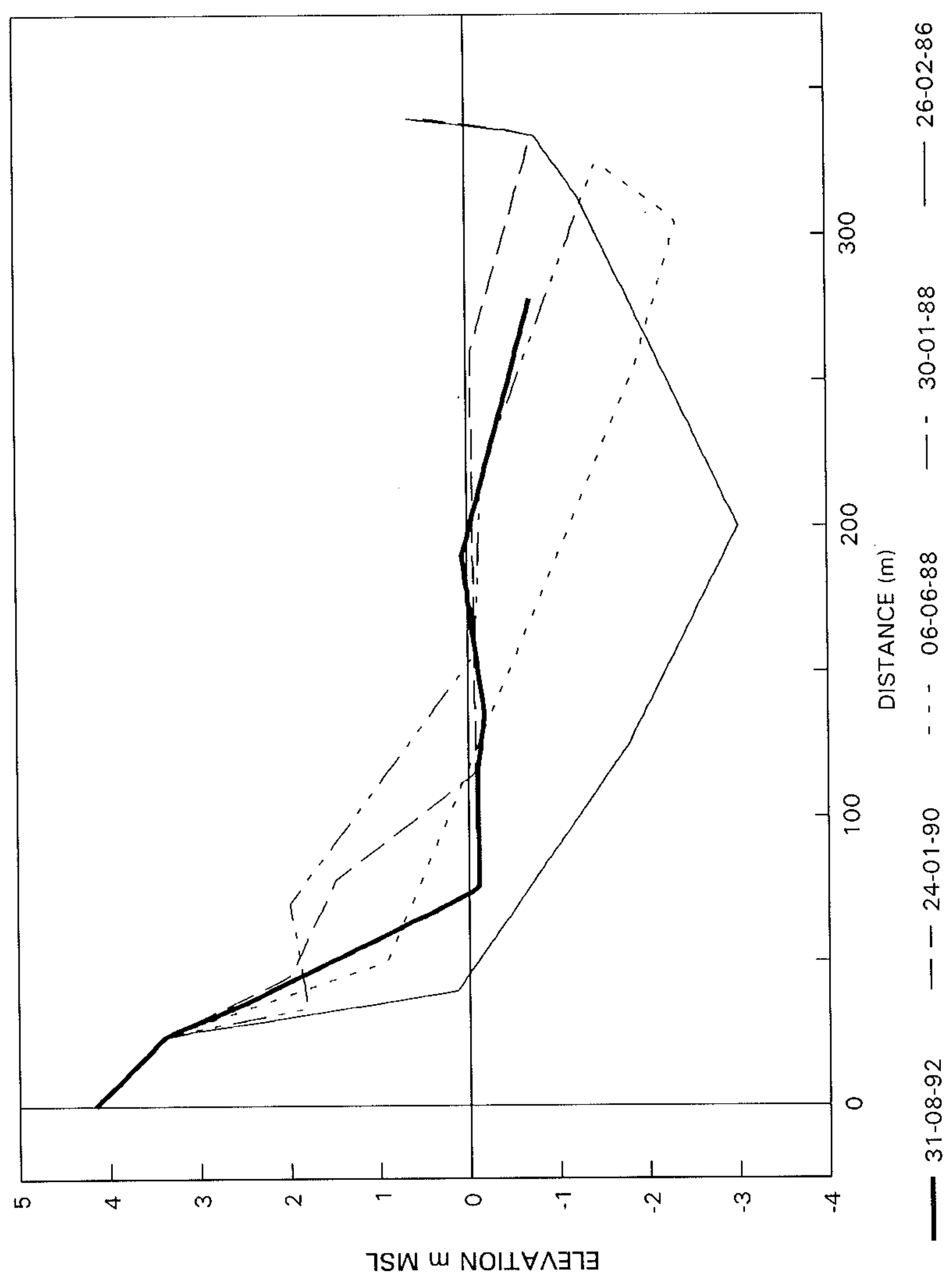
	QINIRA ESTUARY **SECTIONS TAKEN IN ESTUARY MOUTH**	**FIGURE:** **13**

CSIR - EMATEK



	QINIRA ESTUARY SECTIONS 400m UPSTREAM OF ESTUARY MOUTH	FIGURE: 14

CSIR - EMATEK

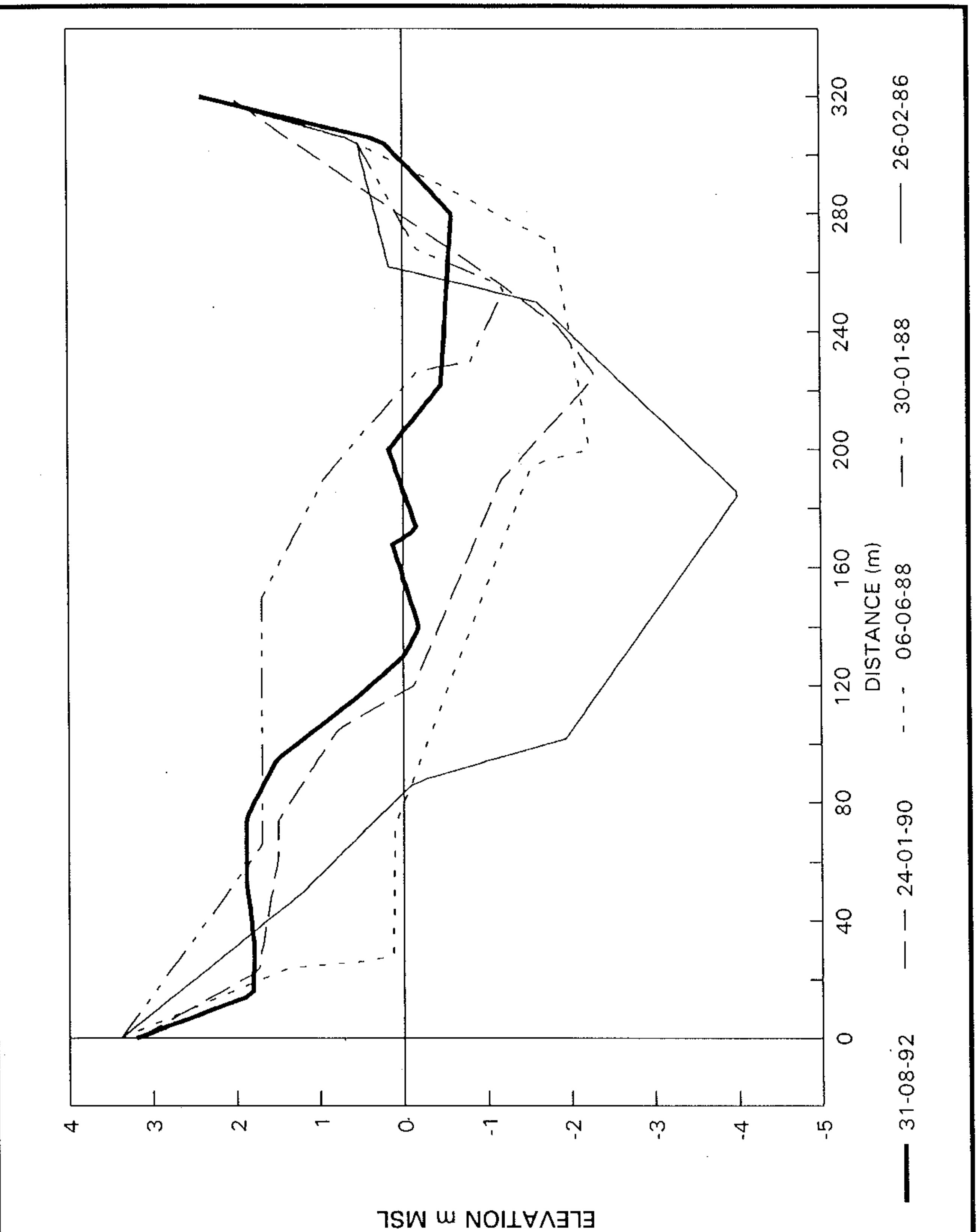


GQUNUBE ESTUARY

SECTIONS TAKEN IN ESTUARY MOUTH

FIGURE: 15

CSIR - EMATEK

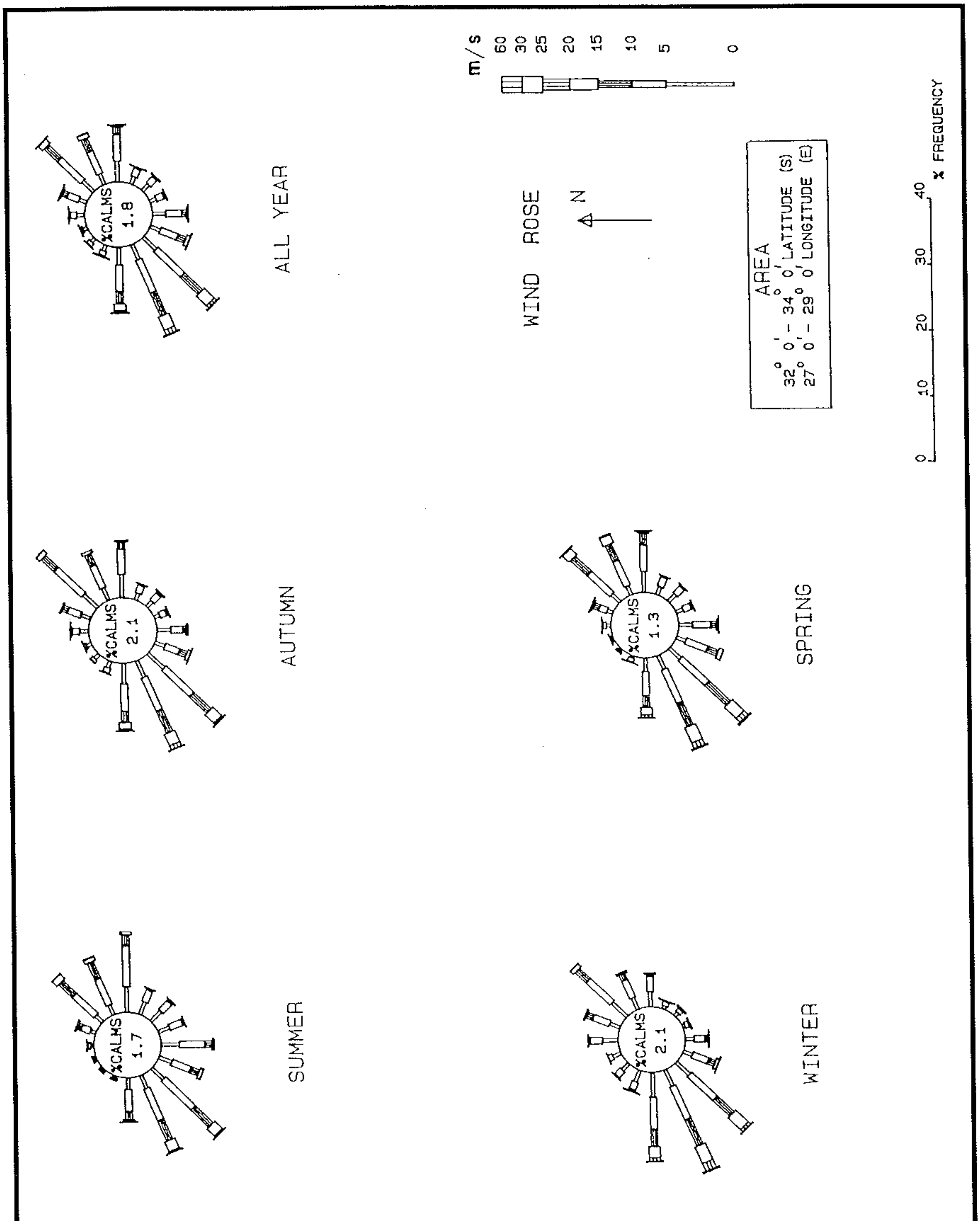


GQUNUBE ESTUARY

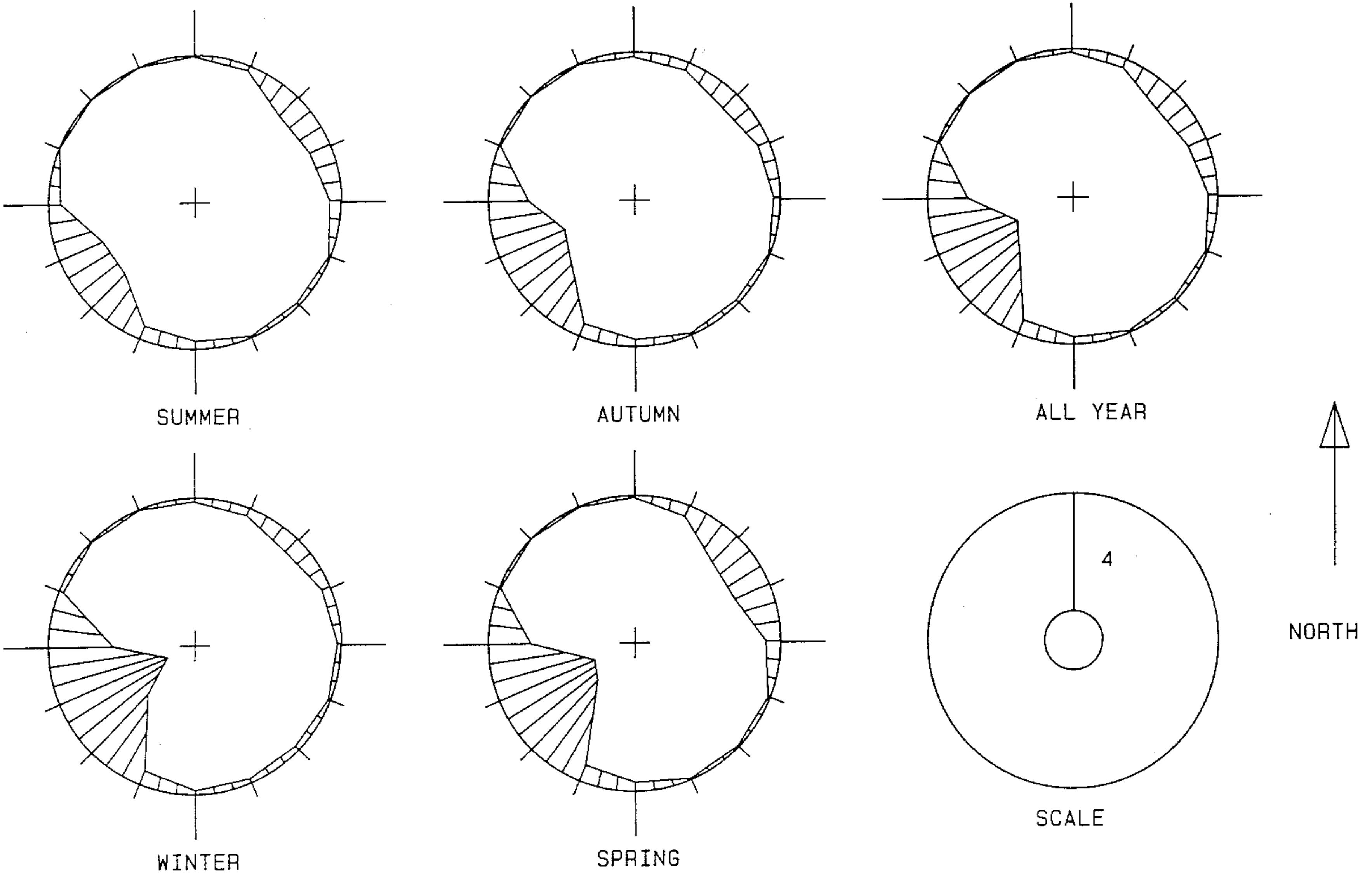
SECTIONS 200m UPSTREAM OF ESTUARY MOUTH

FIGURE: 16

CSIR - EMATEK



	NAHOON, QINIRA AND GQUNUBE **VOS WIND ROSES**	**FIGURE:** **17**
	CSIR - EMATEK	



AEOLIAN CREEP DIAGRAM (NAHOON, QINIRA AND GQUNUBE)
AEOLIAN TRANSPORT RATES ARE GIVEN IN CUB. METRES/YEAR/METRE WITH DUE COGNIZANCE FOR FREQUENCY OF OCCURRENCE OF WIND EVENTS

FIGURE 18

CSIR - EMATEK

Table 6: Potential aeolian sand transport rates

ANNUAL AEOLIAN WIND TRANSPORT RATE	
Direction of Wind-Blown Material	m^3/metre/year
Southbound	14
South-West bound	22
Westbound	20
North-West bound	12
Northbound	40
North-East bound	74
Eastbound	66
South-East bound	26

3.2.4 Bathymetry

NAHOON: The almost permanently open mouth of the Nahoon River has been classified as Type A: a single sandspit with rock on the opposite bank (Heydorn and Tinley, 1980). The mouth usually consists of an extensive sandspit on the western side with rock lining the eastern bank.

The mouth was surveyed by the CSIR on 29 September 1992. The channel at the mouth was at a depth of 0,54 m below mean sea level (MSL), increasing to *ca.* -1,0 m, both upstream and downstream towards the sea. The beach consists of a flat sandy area at a height that averages between +1,5 m to +2,0 m MSL and slopes upwards towards small hummock dunes at +5,0 m MSL. A contour plan of the river mouth is shown in Figure 19.

QINIRA: Heydorn and Tinley (1980) classified the Qinira River mouth as Type D: a double sandspit which is constantly changing in form as a result of sediment transport by wave action, river run-off and tidal action.

The CSIR surveyed the estuary mouth on 27 September 1992. The mouth was closed; the lagoon was up to -0,5 m MSL deep and averaged 150 m in width (Figure 20).

GQUNUBE: The mouth of the Gqunube Estuary is permanently open and classified by Heydorn and Tinley (1980) as Type A: a single sandspit with rock on the opposite bank. A sandy beach is situated on the south-western side of the mouth while the north-eastern side consists of rock.

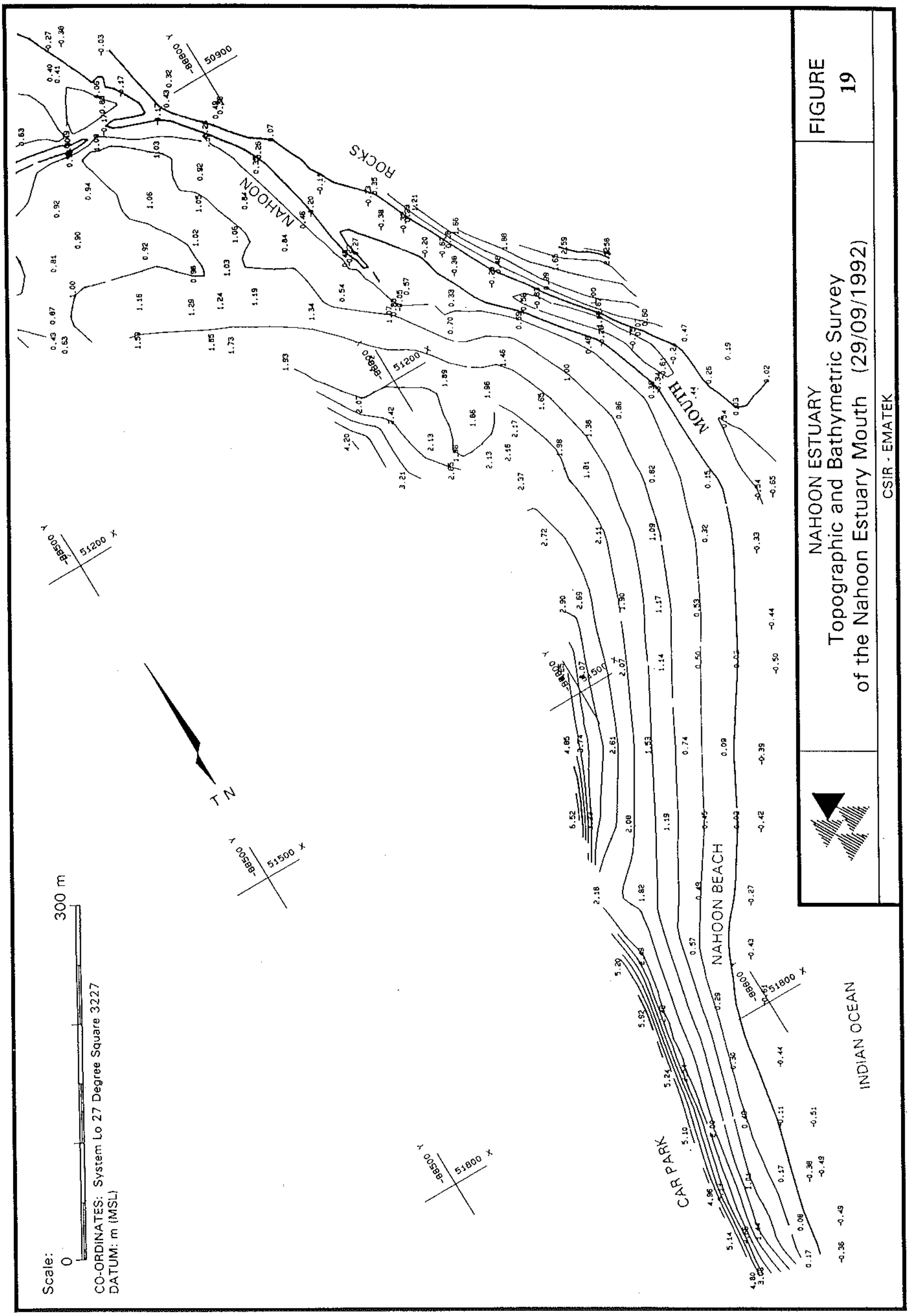


FIGURE 19

NAHOON ESTUARY
Topographic and Bathymetric Survey of the Nahoon Estuary Mouth (29/09/1992)

The estuary mouth was surveyed by the CSIR on 31 August 1992. The beach was very flat and only reached a height of +1,5 m MSL. A flood-tidal delta extended north-westward into the estuary, and is usually covered with water during high tide. The deepest section of the channel was -3,00 m MSL and the shallowest part -0,22 m MSL. A contour plan of the estuary mouth is shown in Figure 21.

3.2.5 Historical changes

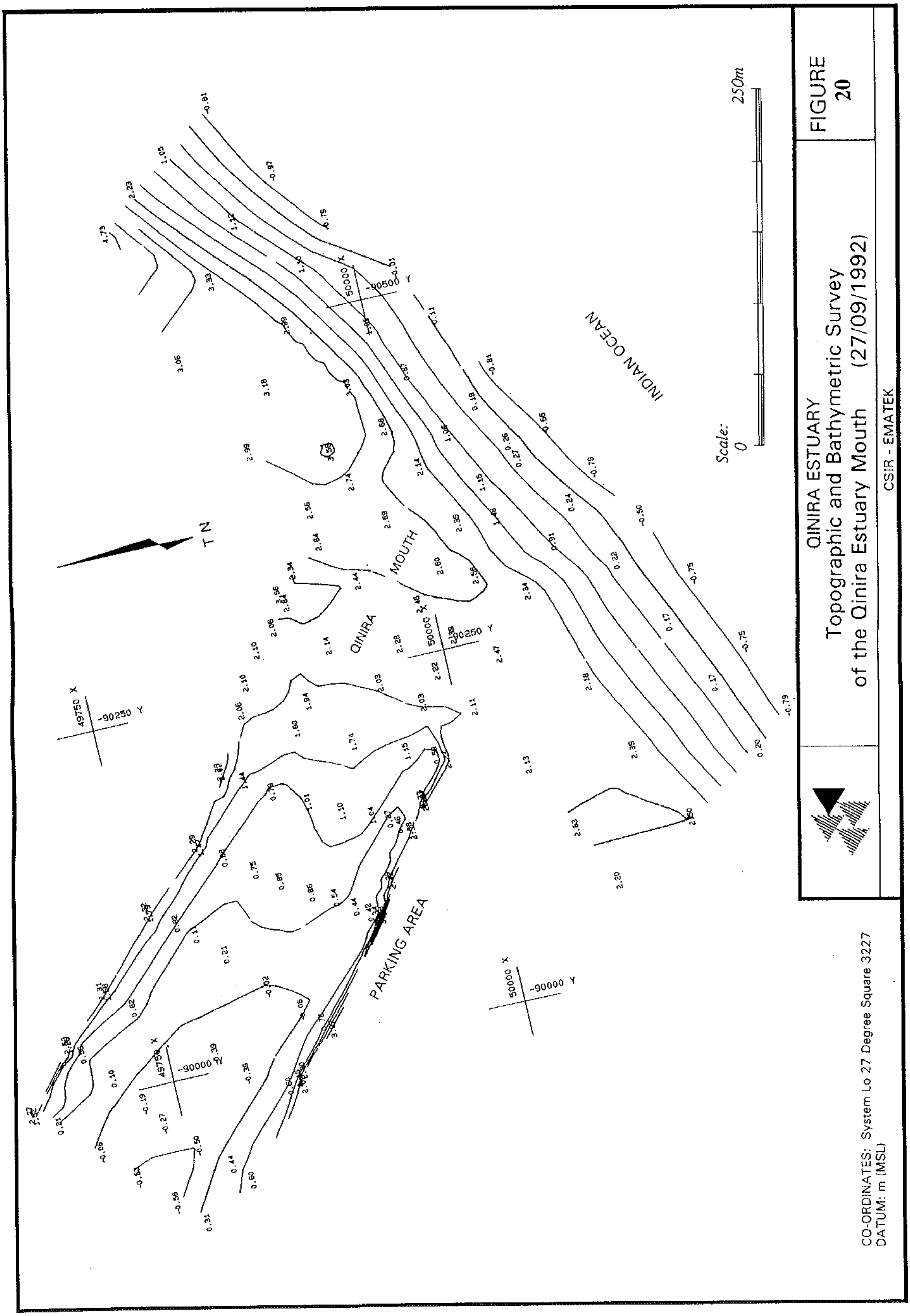
Aerial views of the Nahoon and Qinira estuaries in January 1939 are shown in Figure 22, and the Gqunube Estuary as it was in 1939 is shown in Figure 23.

NAHOON: An analysis of aerial photographs from 1939 to 1987 (Figure 24) shows that the present configuration of the sand bodies in and around the inlet have undergone various changes during the last 48 years.

On each of the aerial photographs a 30 - 40 m wide inlet channel can be recognised. The dominant longshore current flowing north-eastward tends to move the inlet in that direction. This is apparent on the photographs, except in 1939 when the submarine extension of the inlet into the surf zone trended westward. This channel drift effect is probably a meander phenomenon. Meander sinuosity is a result of the interplay between bank material properties, wavelength and channel width. (Zeller, 1987; Richards, 1982).

Considerably more sediment is present in the lower estuary on the 1939 photograph than in the 1954 and 1972 photographs. On the 1972 aerial photograph sand shoals are almost entirely absent in the lower estuary and only a small flood-tidal delta is present. This can be attributed to a river flood during August 1970 (South Africa, Department of Water Affairs, 1978). This flood removed nearly all the unconsolidated sediment from the lower estuary out to sea. Discharge data from the Nahoon River indicate that between 1970 and 1985 no flood occurred that could have produced any significant sediment scouring (Esterhuysen and Reddering, 1985) (See section 3.1.7).

The 1954 aerial photograph shows residential development on the western side of the estuary. By 1987 nearly all the available land on the western bank had been developed. The Beacon Bay side (eastern side) of the estuary was still undeveloped in 1954. By 1972 development had started on the eastern side and in the 1987 aerial photograph a well established residential area was visible.



QINIRA ESTUARY
Topographic and Bathymetric Survey of the Qinira Estuary Mouth (27/09/1992)

FIGURE 20

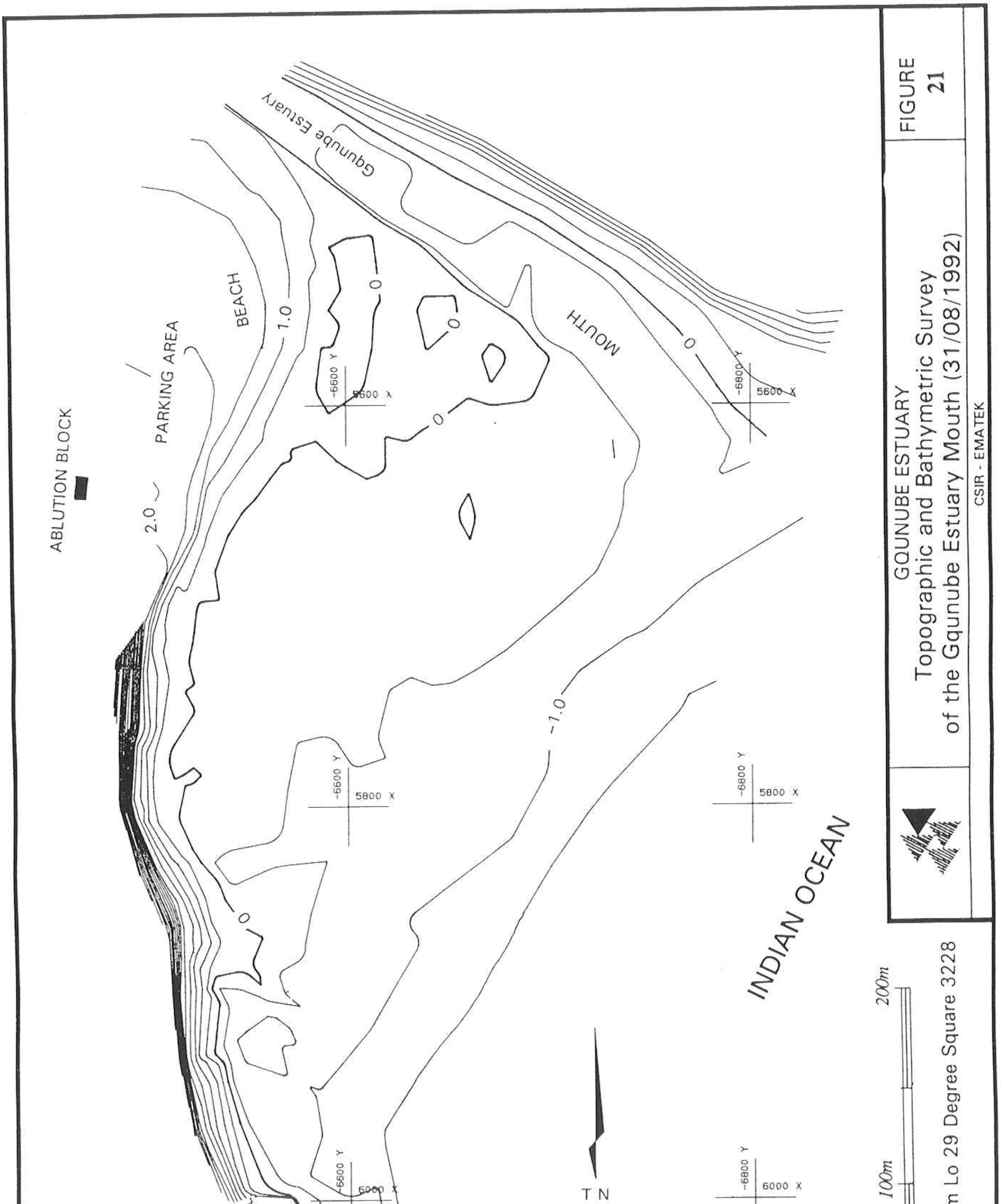


FIGURE 21

GQUNUBE ESTUARY
Topographic and Bathymetric Survey of the Gqunube Estuary Mouth (31/08/1992)

Figure 22: Aerial view of the Nahoon and Qinira estuaries. (Photo: Trig. Survey, January 1939.)

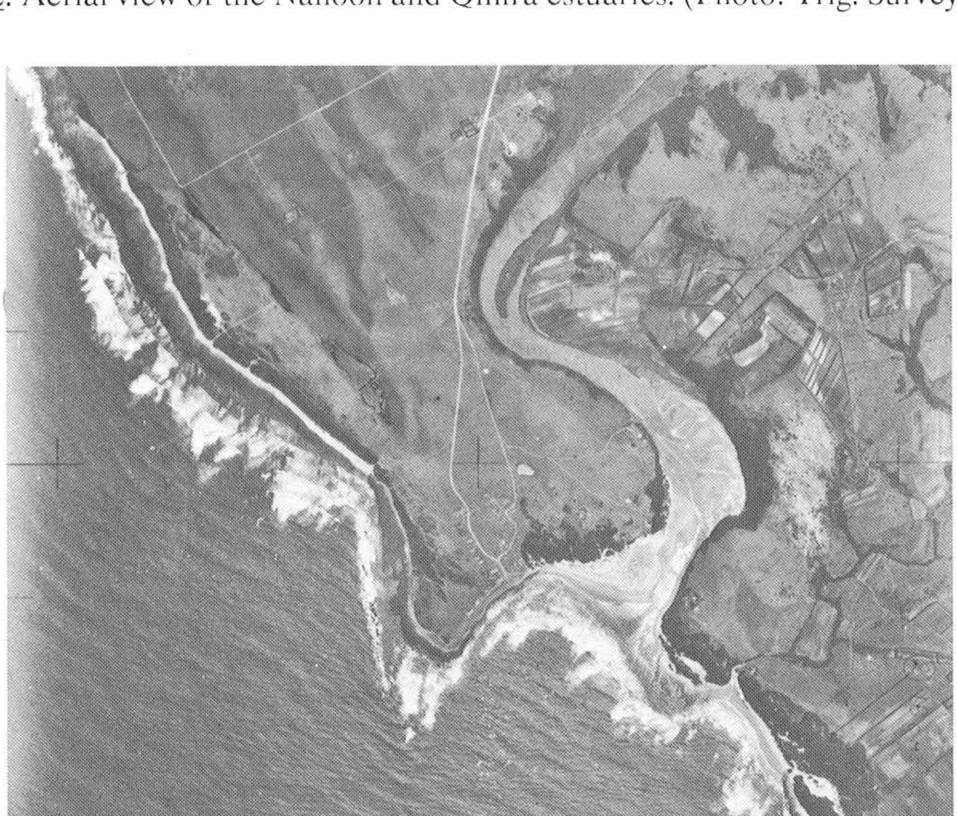


Figure 23: 1939 aerial view of the Gqunube Estuary. (Photo: Trig. Survey, January 1939).

QINIRA: Aerial photographs from 1967 to 1987 show that the inlet channel, when open, is usually situated on the eastern side of the mouth. However, in 1987, the seaward part of this channel flowed in a westerly direction into the sea. Of the five photographs studied (1967, 1968, 1970, 1972 and 1987), the mouth was open only during 1968 and 1987. (Figure 25).

Although the mouth was open in 1968 the photograph shows a large flood tidal delta stretching into the estuary. In 1972 this delta had taken on a new formation and could be a result of the flood in August 1970 when the run-off exceeded 35 x 10^6 m^3. (Hydrological Research Unit, 1981, *in litt.*).

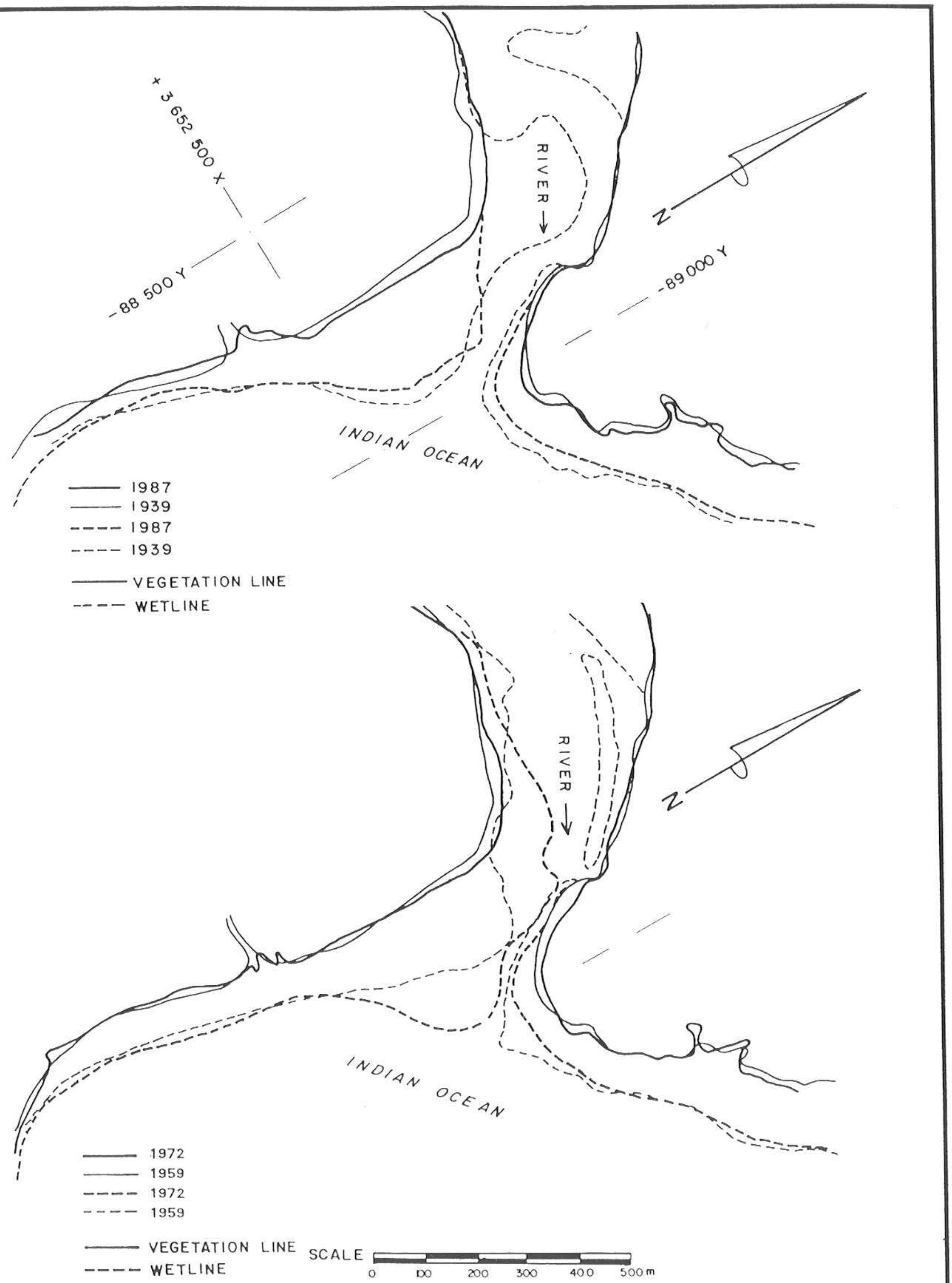
Intensive residential development in the area surrounding the estuary has occurred during the last 20 years. The township of Bonza Bay on the west bank, was already established in 1967. Further development has taken place and by 1987 nearly the whole west bank was developed.

Development on the west bank has caused considerable sedimentation in the estuary. The disturbance of soils by construction vehicles and excavation has particularly affected areas of saltmarsh in the west of the estuary (see Figure 34). In some areas, one metre depth of sediment has accumulated since 1960. Very little development has taken place on the eastern bank, except for a few holiday cottages.

GQUNUBE: The series of aerial photographs from 1939 to 1987 show the inlet channel permanently open and occupying the easternmost position of the estuary system. Continued eastward movement of the inlet is prevented by bedrock exposed on the eastern bank. The flood-tidal deltas, on the western side, presently stretching as far as one kilometre up the estuary, were already present in the 1939 aerial photograph.

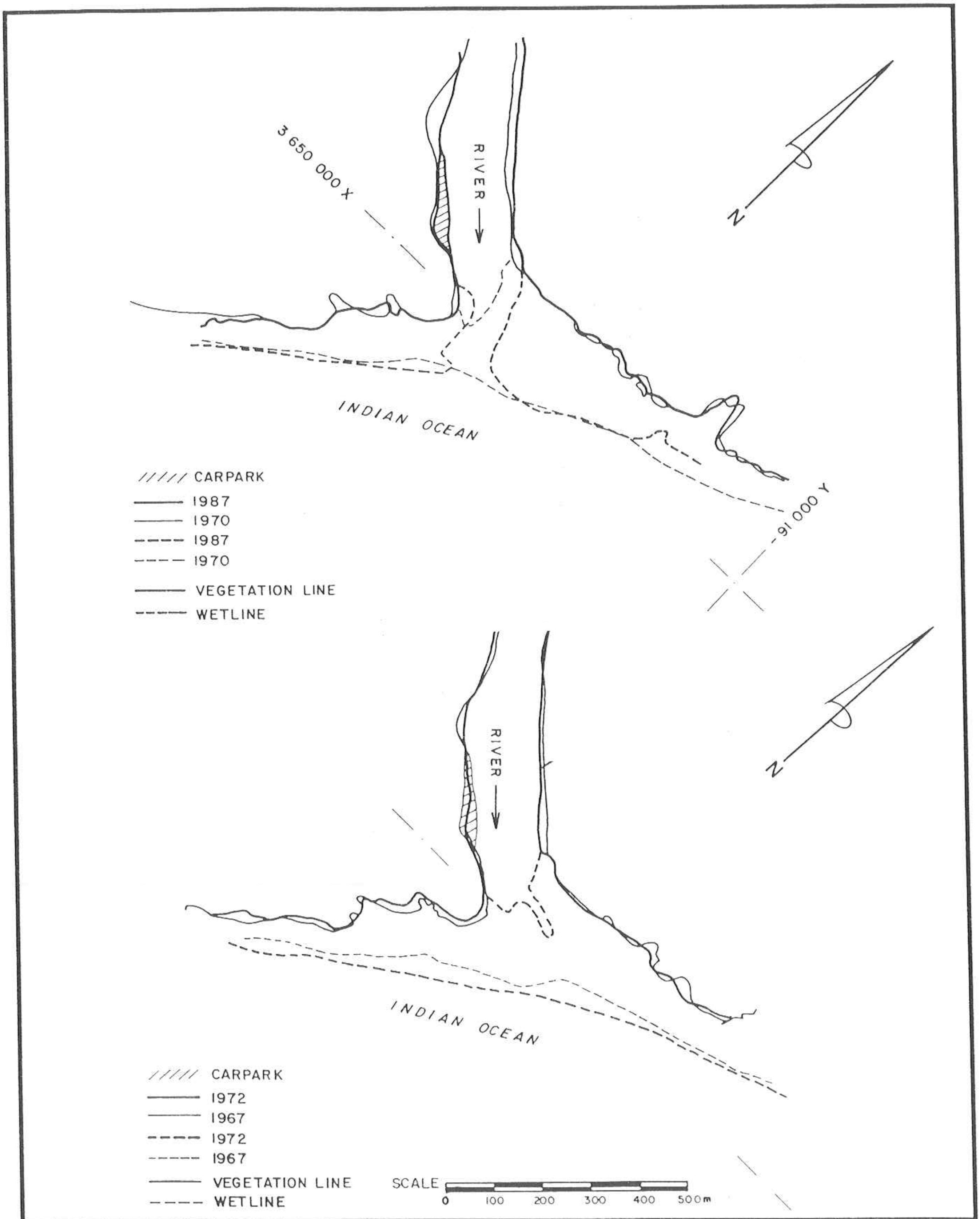
An offshore delta can be seen in the 1986 photograph. This may be the result of a flood that washed the sediment out to sea, forming an offshore delta whence sand is returned to the sandspit during calmer conditions. The 1985 flood resulted in less sediment being visible in the 1986 photograph than in the 1981 photograph (Section 3.1.7 and Figure 26).

Whereas only a few houses on the west bank can be seen in the 1938 photograph, the fully developed township of Gonubie is present today. Limited development has taken place on the east bank. Between 1981 and 1986 a holiday farm was developed on the hill on the east bank of the mouth.



	NAHOON ESTUARY HISTORICAL CHANGES IN NAHOON ESTUARY	FIGURE: 24

CSIR - EMATEK

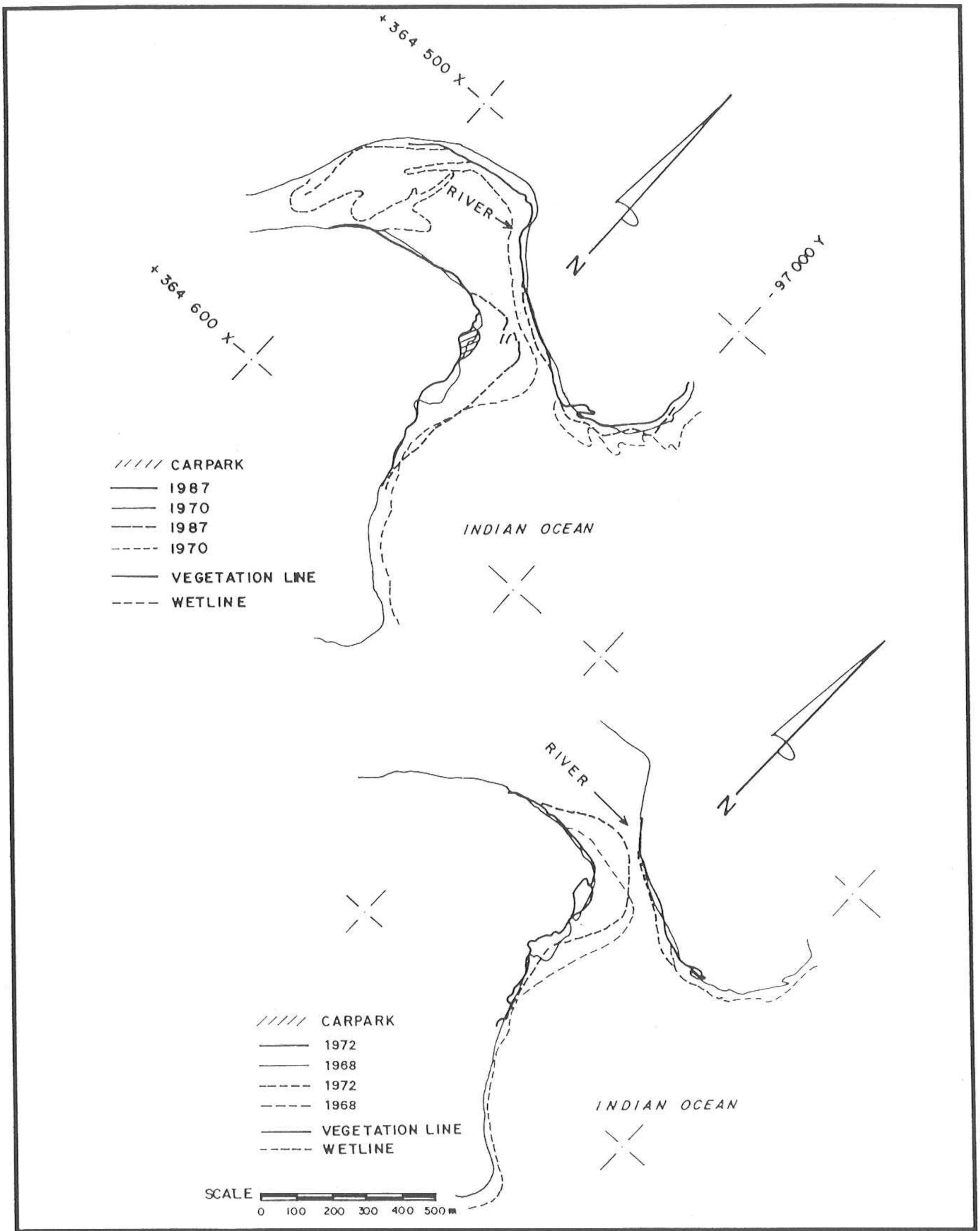


QINIRA ESTUARY

HISTORICAL CHANGES IN QINIRA ESTUARY

FIGURE: 25

CSIR - EMATEK



GQUNUBE ESTUARY

HISTORICAL CHANGES IN GQUNUBE ESTUARY

FIGURE: 26

CSIR - EMATEK

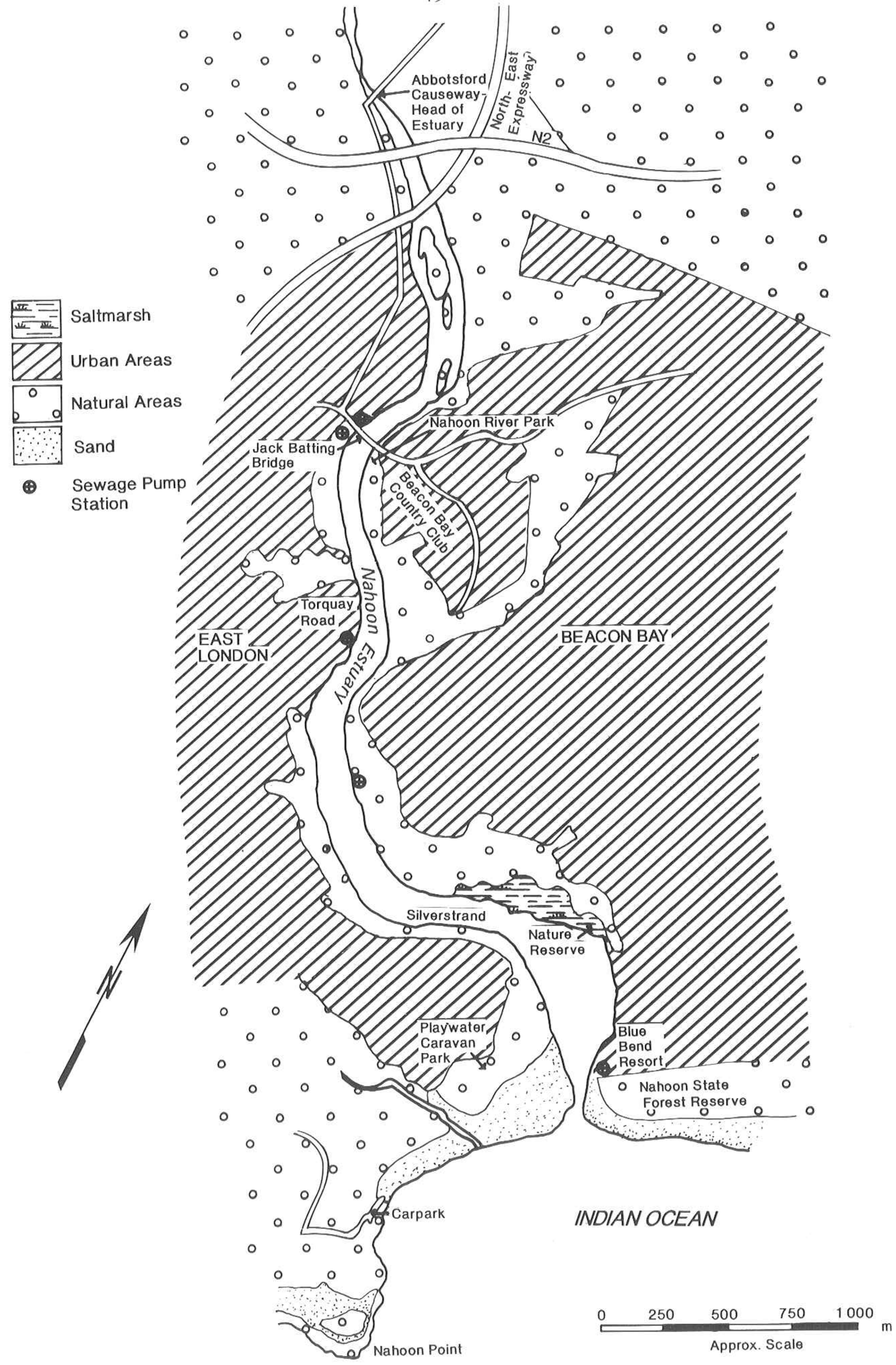


Figure 27: The Nahoon Estuary

3.2.6 Land ownership and uses

NAHOON: The Nahoon Estuary has been described as an important environmental asset and recreational area (Heydorn (ed.), 1986). The estuary is navigable by small craft from the river mouth as far as 4,5 km upstream (Esterhuysen and Reddering, 1985).

Existing land uses around the Nahoon Estuary (Figure 27) include residential areas, infrastructure (roads, sewers, stormwater drains etc), public and private open space, sporting facilities, holiday resorts and nature conservation areas. The estuary is intensively used for recreation, including water skiing, board sailing, canoeing, dinghy sailing, angling, bird watching, walking, picnicking, and sunbathing (Morris, 1986)

The south bank of the Nahoon Estuary is divided into three areas, called Campsites 1, 2 and 3. Campsite No. 1 is located at the mouth, and is presently utilised as public open space. Recreational facilities at the site include a children's play area. Campsite No. 2 contains the Nahoon Playwaters Caravan Park and the headquarters of the Border Canoe Club and of the East London Surf Life Saving Club. Campsite No. 3 contains the Nahoon Beach carpark access road. This site is no longer open to campers.

About 300 m upstream from the estuary mouth, the headquarters of the Duck 'n Dive Club for ir latable boat enthusiasts is located on the west bank at Playwaters. Canoeing

Figure 28: Congested and conflicting recreation activities in the Nahoon Estuary (Photo: ECRU 25.01.86)

and paddleskiing take place here in addition to water skiing and motor boating (ski boats and inflatable craft). There is no slipway at this site, although the relatively hard sand substrate allows boat launching to take place. Inflatable boats are light enough to be launched without using a trailer. The intensity of recreation in this area can be seen in Figure 28.

From Playwaters to the eastern end of Princess Alice Drive (about 1 km) the west bank is bounded by private open space and high density, low rise residential development. Club houses for Sea Scouts and Boy Scouts are located in Silverstrand, an area of land that is owned by Transnet. Between Annandale Road and Torquay Road, public open space borders the estuary.

At Torquay Road, upmarket housing is present on the floodplain eastwards of the public boat launching area. There is no public slipway at Torquay Road and boat launching is only possible at high tide. Nevertheless, several private jetties and slipways have been built by Torquay Road residents.

A recently upgraded sewage pipeline extends along the west bank from a pump station upstream of the Jack Batting Bridge to a connection located in private open space at Torquay Road. The river bank between Torquay Road and Jack Batting Bridge is steep, with dense vegetation and limited public access.

The east bank of the estuary is characterised by more extensive areas of public open space. The Beacon Bay Nature Reserve is located on the east bank opposite Playwaters and the Nahoon State Forest Reserve is located at the estuary mouth.

Adjacent to the forest reserve on the east bank are the Blue Lagoon Hotel and the Blue Lagoon Timeshare Resort. Canoes, paddle skis and inflatable boats are launched into the estuary from this site.

The remainder of the east bank is reserved as public open space. Bait collection and fishing take place in a number of areas, and a public footpath known as the Dassie Trail is being established along the east bank.

A picnic site and parking area have also been established by the Beacon Bay Municipality at Nahoon River Park, situated just downstream of the Jack Batting Bridge. The park is a popular fishing and bait collecting site. The nearby Beacon Bay Country Club is an area of private open space that is located in an area of infilled river wetlands and marshes.

QINIRA: The Qinira Estuary has been described as an important recreational and environmental facility (Heydorn (ed.), 1986). Land use around the Qinira Estuary is shown in Figure 29.

Recreation activities are focused on the lagoon and at Bonza Bay at the mouth of the estuary. Activities undertaken on the lagoon include swimming, boating, canoeing and boardsailing. The use of engines of greater power than 3,7 kW (5 hp) and of boats longer than five metres is prohibited by a municipal by-law (Cape of Good Hope, 1985). The lagoon at the estuary mouth is demarcated as a bathing area and no boating is allowed there.

The Beacon Bay municipal area comprises about 2 900 residential erven, of which about 200, or seven percent, were reported to be undeveloped in 1988 (Fabricius and Heath, 1988). Two privately owned caravan parks accommodating 12 and 60 caravan stands respectively are also located in the municipal area, as well as about 54 privately owned holiday cottages/chalets (*ibid*).

Residential development in Beacon Bay extends to the water's edge at Herons Way, on the west bank of the lagoon (see Figure 29). These upmarket properties have in the past been affected by rising water levels in the lagoon (Mr M Symon, Beacon Bay Municipality, pers. comm., 1991). A sewage pump station is also located near the water's edge at Herons Way. The pump station reportedly carries 1 800 m^3/day raw sewage (Mr W Selkirk, Pollution Control Technologies, pers. comm., 1991).

The west bank of the lagoon is bounded by a narrow strip of land designated Public Open Space. Nevertheless, in many areas, including Herons Way, so-called "gardening agreements" between property owners and the municipality have allowed the landowners to incorporate the public open space into their gardens. This includes land on which the pump station, referred to above, is located.

The Quenera Lagoon at the river mouth is characterised by recreational facilities. On the west bank a "Supertube" (water slide) is located in the dune forest, and there is a car park with "braaiing" (barbecue) facilities and a public slipway (Figure 30). A further picnic area is located at Pirates Creek on the east bank. To the north-east of the picnic area, private dwellings abut the estuary.

On the east bank of the estuary, is the Quenera Lagoon Holiday Resort which contains a low-density mixture of chalets and caravan sites. To the east of the estuary mouth lies the Public Services Association Resort. The resort occupies an area of subtropical thicket and dune forest in the frontal dune slacks. The resort does not abut the estuary, but

Figure 29: The Qinira Estuary

pedestrian access to the beach from the resort is possible through a small blow-out between the dune ridges.

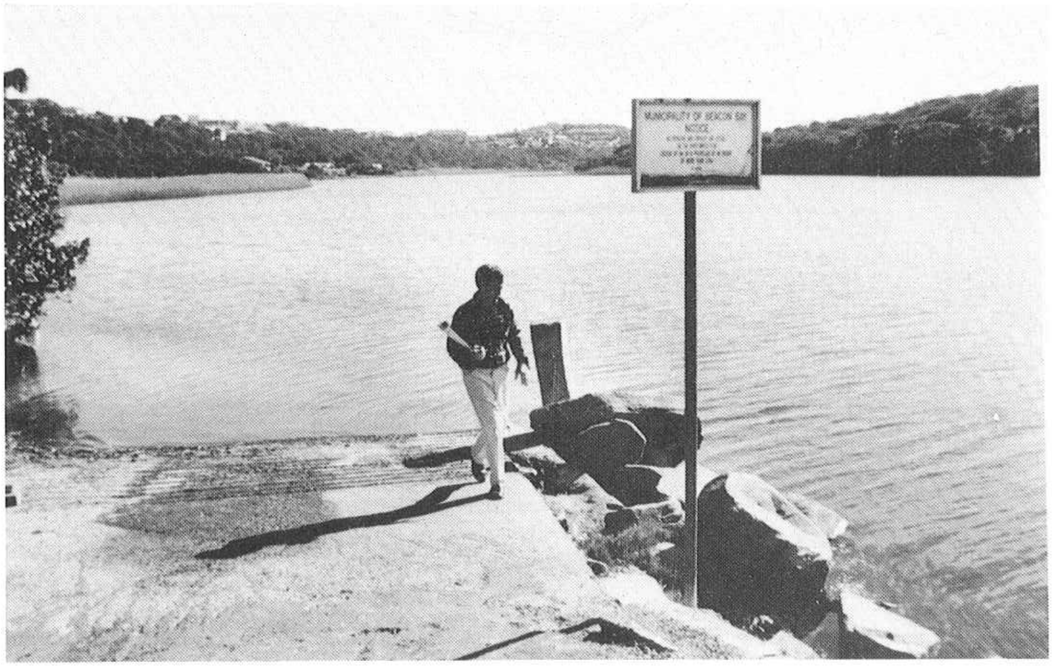


Figure 30: Slipway at the Qinira Estuary mouth. (Photo: ECRU 18.07.91).

The head of the Qinira Estuary and the limit of tidal penetration at ebb and flow is marked by a weir upstream of the Quenera Lagoon Holiday Resort. The weir restricts the movement of fish in the river and prevents fluvial inflow to the lagoon during periods of low river flow.

GQUNUBE: The Gonubie municipal area on the south bank of the Gqunube Estuary includes residential erven, holiday cottages, two caravan parks and a hotel. The coastline is, however, predominantly rocky and only a limited area of sandy beach is available at the estuary. Land use around the Gqunube Estuary is shown in Figure 31.

The Gonubie municipal caravan park is located at the estuary and incorporates 123 caravan stands. This caravan park is a focal point for tourists in Gonubie and is one of the most popular camping areas along the coastline between the Kei River mouth and Chalumna (Tyolomnqa) (Fabricius and Heath, 1988).

There are 2 645 residential erven in the Gonubie municipal area, of which 784 or 30% were reported to be undeveloped in 1988 (Fabricius and Heath, 1988). Located in close proximity to the Gqunube Estuary and adjacent coastline are 16 municipally owned and 40 privately owned holiday cottages/chalets (*ibid*).

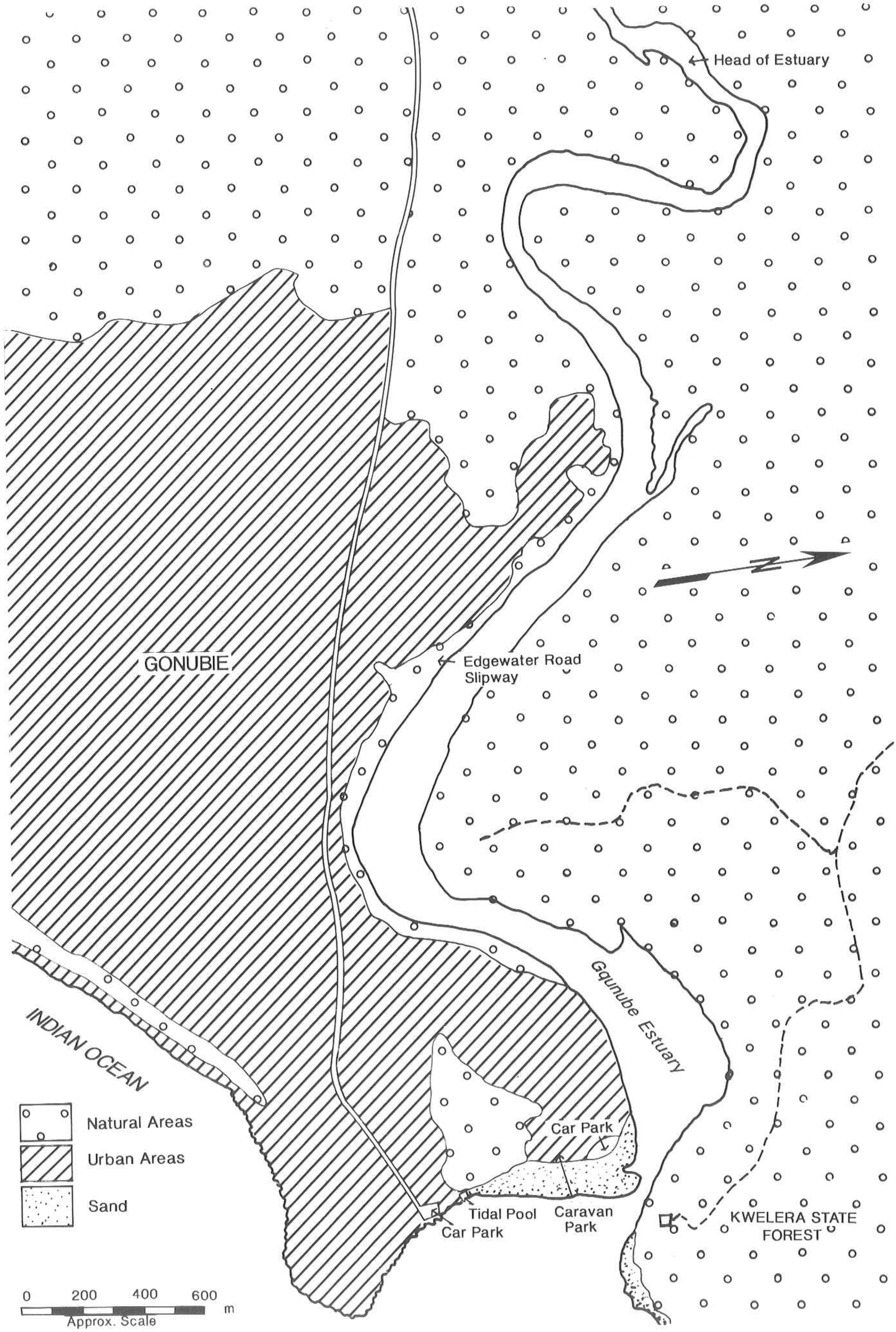


Figure 31: The Gqunube Estuary

The coast to the east of the Gqunube Estuary as far as the south bank of the Kwelera Estuary (CSE 47) forms the Kwelera State Forest Reserve. The Reserve extends a distance of about 4 km along the coast and inland for a distance of about 500 m from the shore. Recreational activities on the Gqunube Estuary are controlled by Regulations made under the Sea Shore Act 21 of 1935 (South Africa, 1972 and 1975). The regulations prohibit all forms of water skiing on the estuary and prescribe a speed limit for boats of three knots at the mouth, and ten knots elsewhere. Jet skis or wet bikes are also prohibited. The written permission of Gonubie Municipality is required to operate boats on the river. In practice, boat operators are required to be members of the Gonubie Marine Club in order to obtain permission to use the estuary (Mrs J Cooper, Gonubie Municipality, pers. comm., 1991).

The Gonubie Marine Club headquarters are located on the west bank of the estuary mouth, together with a car park, ablution facilities and cafe. The Gonubie Caravan Park also occupies a large part of the west bank, and extends into the face of the steep primary dune to the west of the river mouth. The carpark at the Gqunube mouth is shown in Figure 32. The northern end of the car park provides one of only two access points to the estuary for boat users. A tractor is employed to aid the transport of boats across the sand to the water's edge.

The second launching area is located in a strip of public open space that bounds the river at Edgewater Road on the west bank. A slipway has been constructed here, together with shaded picnic areas and braai sites. Signposts at both launching sites inform users of the speed restrictions, prohibition of water skiing and permit requirements for boats.

Figure 32: Carpark at the Gqunube River mouth. (Photo: ECRU 18.07.91).

The east bank of the Gqunube Estuary is mostly steep and undisturbed, although a single large dwelling is visible on the east bank of the estuary mouth. Elsewhere dense Xeric Transitional Thicket, including some rare cycads, can be seen on the east bank.

3.2.7 Physico-chemical characteristics

In common with many other estuaries on the Cape coast, little reliable physico-chemical data are available. No regular monitoring of water quality in the Nahoon Estuary has been undertaken, although the East London City Council conducts analyses of the quality of the water flowing into the Bridle Drift Dam and at the Dorchester Heights Bridge (upstream of the Abbotsford causeway). Some bacteriological monitoring of the Qinira Estuary is undertaken by the Beacon Bay Municipality. However, no water quality survey data for the Gqunube Estuary appear to be available.

Tidal propagation, mixing and salinity stratification

A study of the Nahoon, Gqunube and Kwelera estuaries by Reddering *et al.* (1986) included measurements of tidal propagation, mixing and salinity stratification. The major restriction to tidal propagation in each case existed at the narrow channels and flood-tide deltas of the inlets. The estuaries were shallow and well mixed, with salinity and temperature differences of only one part per thousand and one degree Celsius between top and bottom waters respectively. In addition, high salinity values (34 to 36 parts per thousand) were recorded in the upper estuaries during the dry season.

Water quality in the Nahoon Estuary

Watling (1988) presents a review of recent studies of the distribution of metals in the Eastern Cape coastal environment. The study area extended from the Kromme River to the Nahoon River, although only data from the Nahoon and Buffalo rivers are presented in Appendix I for comparison. High concentrations of lead have been found in the surface waters of the Nahoon River which could be as a result of the introduction of petroleum products into the water by outboard motors (Watling *et al.*, 1983). The concentration of metals in the surface waters of other nearby rivers, including the Qinira as well as the smaller Blind and Ihlanza (Hlaze) rivers, have also been found to be elevated (Talbot *et al.*, 1985; Watling *et al.*, 1983). The data also show that sediments from the East London area commonly have elevated concentrations of copper, lead, zinc, cobalt, nickel and chromium. Watling (1988) concluded that the highest degree of contamination in the Eastern Cape was found in the Buffalo River.

Watling (1988) also presents data on the heavy metal concentrations in molluscs along the Eastern Cape coast. The molluscs collected and analysed include *Perna perna, Patella oculus, P. barbara, P. longicosta, P. argenvillei* and *P. cochlear.* These data show elevated concentrations of Cu, Pb, Fe, Zn, Ni and Cr in molluscs collected off the East London coast.

A survey of water quality in the Nahoon River, with particular emphasis on the estuary, was undertaken as part of the recreational and development study prepared by Steffen, Robertson and Kirsten, Consulting Engineers (Pollution Control Technologies, 1991 in SRK, 1991). The survey included an analysis of water samples collected at seven locations in the estuary, from upstream of the Abbotsford Causeway to the Nahoon River mouth, during February and March 1991.

River inflow to the estuary at the Abbotsford Causeway was found to be of good quality, with low concentrations of nutrients and little mineralisation. Nevertheless, increasing urbanisation (particularly informal settlements) was found to result in bacterial pollution of the river. This results in an inflow of coliform-bearing water to the estuary. An oxygen gradient was reported to exist, with lowest concentrations at the headwaters of the estuary (5,7 mg/ℓ 0_2) rising to 7,8 mg/ℓ 0_2 at the estuary mouth. Poor mixing of organically rich water in the upper reaches of the estuary was suggested as a possible explanation for the variation in oxygen concentrations.

Chlorophyll *a* concentrations in the estuary were generally low (<10 mg/ℓ) although slightly higher levels were recorded in the freshwater inflow to the estuary. Algal blooms reportedly have occurred in the past at the head of the estuary and at the estuarine/marine water interface upstream of Playwaters (Pollution Control Technologies, 1991).

Microbiological analyses of water samples collected in the Nahoon Estuary showed that, during dry periods, the occurrence of faecal coliforms was limited to the headwaters of the estuary at Abbotsford Causeway. Following rain, however, bacterial contamination was found throughout the estuary. Contamination levels were generally below the criteria proposed by Lusher (ed.) (1984).

Water quality in the Qinira Estuary

No comprehensive surveys of water quality in the Qinira Estuary appear to have been undertaken. The contamination of the Quenera Lagoon by metals, particularly lead, was reported by Talbot *et al.* (1985).

Some investigations of the microbiological quality of water in the estuary have, however, been undertaken by the Beacon Bay Municipality. The results of sample analyses from August 1989 to February 1991 are shown in Appendix I. Interpretation of these results is, unfortunately, difficult since they do not represent a systematic or regular sampling programme. Instead, sampling appears to have been undertaken in response to pollution events, particularly sewage pump station spillages at Herons Way, and at peak recreational periods.

Nevertheless, the data clearly show that microbial pollution of the Qinira Estuary is such that it can result in a health risk to users of the estuary. Two sources of microbiological pollution in the estuary appear to be important - spills and overflows from sewage pumping stations, and stormwater run-off to the estuary. Further monitoring and analysis is, however, required in order to evaluate the relative significance of these to water quality in the estuary and the health risk to bathers.

Severe pollution of the estuary has in the past resulted in the closure of the lagoon and beach at Bonza Bay to bathers. This occurred at the end of November 1990, for example, following a "major sewer break" (Beacon Bay Municipality, *in litt.*). The municipality has also undertaken to open the estuary mouth artificially on such occasions. Other remedial measures have included the installation of buffer tanks at sewage pumping stations, although in the long term it is hoped to re-route the sewer away from the estuary (M Symon, Town Clerk, pers. comm.).

Water quality in the Gqunube Estuary

Little reliable data on the water quality in the Gqunube Estuary appears to be available. Tidal propagation, mixing and salinity stratification have been described above.

The determination of nitrate and ammonia concentrations in the Nahoon, Gqunube and Kwelera estuaries was undertaken by Talbot *et al.* (1985). Water samples taken during August 1983 showed the highest concentrations of inorganic nitrogen (probably resulting from agricultural activities) in the Gqunube and the lowest in the Kwelera estuaries. Surface and bottom ammonia concentrations and surface nitrate concentrations were also highest in the Gqunube Estuary.

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton

Little information is available on the phytoplankton of the three estuaries. The role which phytoplankton plays in primary production in the Nahoon and Gqunube estuaries has been studied by Campbell and Bate (1986a and 1986b) and Campbell *et al.* (1991). Primary production was determined by means of three-hour incubations at three sites in each estuary on two occasions, namely June 1984 and March 1985. The mean hourly rates of primary production by phytoplankton are shown in Table 7. Phytoplankton primary production rates are similar in the Nahoon and Gqunube estuaries. Differences between sampling occasions were not found to be large, although spatial and tidal variations within each system were found to be significant.

Phytoplankton production within the estuaries was considered to be correlated with temperature and salinity, both of which are affected by the tide. Sea water moving into the estuary at high tide, for example, has a lower chlorophyll content and lower temperature than the estuary water, while changes in salinity during tidal exchange induce corresponding production changes within the water column (Campbell and Bate, 1986a and 1986b, Campbell *et al.*, 1991). Turbidity within estuaries was not found to be correlated with phytoplankton distribution but was considered to influence primary production through the effect of light attenuation.

Table 7: Primary production by phytoplankton in the Nahoon and Gqunube estuaries (Campbell *et al.*, 1991).

Estuary	Mean hourly rate of primary production by phytoplankton (mg $C/m^2/h$)
Nahoon	89
Gqunube	113

4.1.2 Algae

Knoop *et al.* (1986) have studied the biomass and production of aquatic macrophytes in the Nahoon and Gqunube estuaries. The macrophytes investigated included the macroalgal species *Codium tenue* and *Hypnea viridis*. *Codium tenue* is relatively important in terms of the total biomass within the estuaries and occurs on subtidal rocky strata, while *H. viridis* occurs in similar environments but is restricted to the upper reaches of the estuaries.

The two macroalgae, *C. tenue* and *H. viridis,* and the seagrass *Zostera capensis* were found to make up 90 percent of the biomass of intertidal and shallow subtidal (<1 m) macrophytes in the estuaries (Knoop *et al.*, 1986). Both *C. tenue* and *H. viridis* recorded lower photosynthetic light responses than the dominant macrophyte *Z. capensis,* due to the effect of water turbidity at the lower elevation in which the macroalgal species were established. The carbon assimilation and production values recorded for the macroalgal species are shown in Table 8 below.

By comparing the total macroalgal carbon production to the daily primary production by macrophytes above, it can be seen that carbon production by algae is considerably less than that by phytoplankton in the Nahoon and Gqunube estuaries.

Table 8: Carbon assimilation and production by macroalgae in the Nahoon and Gqunube estuaries. (Knoop *et al.*, 1986).

		C. tenue	*H. viridis*
Daily carbon assimilation (mg C/g/day)	Nahoon Gqunube	22,1 21,4	42,8 42,2
Total estuarine Macroalgal carbon production (g C/day)	Nahoon Gqunube	1 746,0 1 284,0	876,0 246,0
Hourly carbon production rate (mg C/m^2/h)	Nahoon Gqunube	60,0 90,0	321,0 51,0

4.1.3 Aquatic vegetation

In addition to the macroalgal species described above, the dominant aquatic macrophytes occurring in the Nahoon and Gqunube estuaries are *Zostera capensis* and *Halophila ovalis*. Production estimates based on the standing biomass of *Z. capensis* have been made by Knoop *et al.* (1986) and are shown in Table 9. It can be seen that the total daily production of organic carbon by *Z. capensis* is insignificant when compared to that derived from phytoplankton (section 4.1.1 above).

Table 9: Primary production by *Zostera capensis* in the Nahoon and Gqunube estuaries (Knoop *et al.,* 1986).

		Z. capensis (short-leaved)	*Z. capensis* (long-leaved)
Daily carbon assimilation (mg C/g/day)	Nahoon Gqunube	49,1 46,5	46,3 41,8
Total estuarine carbon production (g C/day)	Nahoon Gqunube	98,0 442,0	2 964,0 1 065,0
Hourly carbon production rate (mg C/m^2/h)	Nahoon Gqunube	14,0 12,0	57,0 30,0

Other species that occur on intertidal mud flats in the estuaries include *Sarcocornia perennis, S. decumbens, Chenolea diffusa* and *Sporobolus virginicus*. These plants play an important role in binding and stabilising sediments, as well as providing habitats for estuarine macrofauna. The reed *Phragmites australis* is found along some parts of the banks in the middle and upper reaches of the estuaries.

Mangrove trees *Rhizophora mucronata* have been introduced into the salt marsh in the Beacon Bay Nature Reserve on the east bank of the Nahoon Estuary. Although the plants appear to be thriving, and provide habitat for a variety of macrofauna, they are not endemic to the area and occur naturally only north of the Kei River.

4.1.4 Terrestrial Vegetation

A revised classification of the vegetation of the Eastern Cape is provided by Everard (1987) and Lubke *et al.*, (1988). This represents a refinement to the veld type classification of Acocks (1975) and is based on a biome, rather than an agricultural potential approach.

The thicket communities are predominantly of Tongaland - Pondoland sub-tropical affinity (White, 1983) and are an expanding vegetation type which has migrated south-westward along the coast and penetrated some distance into the hinterland up the river valleys as so-called Valley Bushveld. The same river courses have served as migration routes for several Afrotemperate species which occur within the dune forests and in this respect they differ from similar forests in Natal, where the upland areas are considerably further from the coast than in the Eastern Cape (Tinley, 1985).

The two other floristic units which converge within the Eastern Cape are not well represented within the immediate proximity of the coastline and estuaries. Species of Cape and Karoo affinity do not contribute significantly towards the plant communities. Scattered patches of Dune Fynbos do, nevertheless, occur along the well drained and leached dune crests between the Nahoon and Qinira rivers and between the Gqunube and Kwelera rivers.

The different terrestrial plant communities occurring within coastal habitats in the Eastern Cape are described by Lubke and Van Wijk (1988) and Raal and Burns (1989) and a detailed review of the dune forests is provided by Burns (1986). The community types represented in the immediate vicinity of the Nahoon, Qinira and Gqunube estuaries are shown in Figures 33, 34 and 35. The communities comprise:

Xeric Transitional Thicket

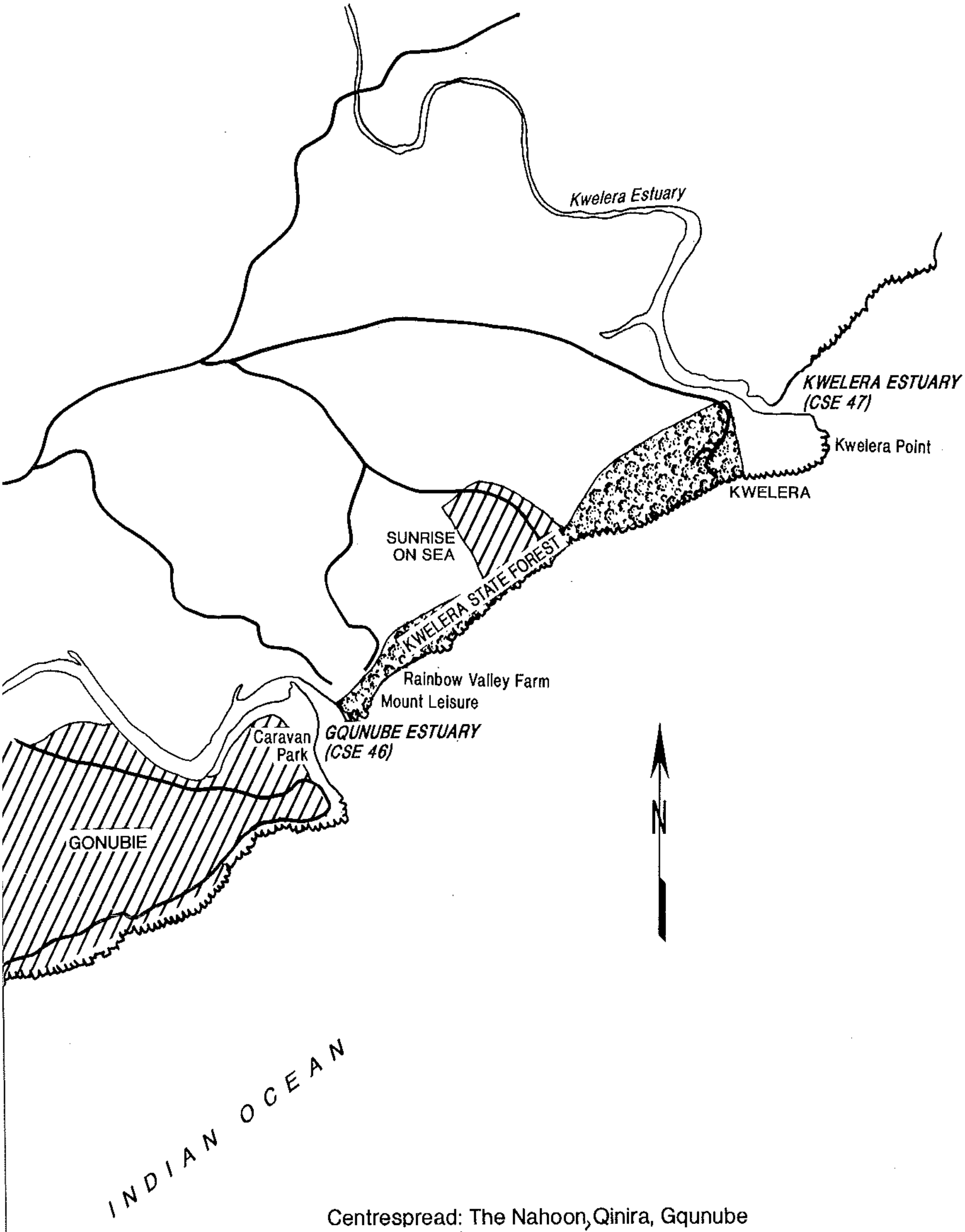
Xeric Transitional Thicket is a variety of the Xeric Kaffrarian Thicket described by Everard (1987) and is confined to relatively arid valley slopes with moderately deep, well-drained soils.

The communities form a dense, closed thicket rarely exceeding five metres and can be stratified into tree/shrub and herbaceous layers. The woody stratum tends to form a dense, impenetrable tangle of spinescent shrubs, low trees and lianes and is dominated by vegetation of Tongaland-Pondoland affinity. There is a relatively large component of succulent Karoo-Namib species including, for example, euphorbias and aloes. The herb layer comprises grass and forb elements that are tolerant of shade.

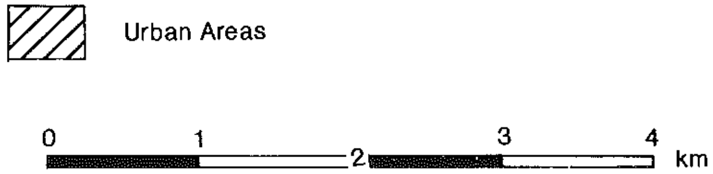
Xeric Transitional Thicket has the highest species diversity and endemism of all the xeric thicket types described by Everard (1987), with most of the endemics being of succulent Karoo-Namib or Tongaland-Pondoland association. Indicator species include: *Euphorbia triangularis, E. tetragona, E. grandidens, Cussonia spicata* (cabbage tree), *Diospyros scabrida* (hard-leaved monkey plum), *Scutia myrtina* (cat-thorn), *Azima tetracantha* (needle bush), *Olea europaea* (wild olive) and *Canthium spinosum*.

The thicket formations are fairly limited in extent within the Eastern Cape and are becoming heavily impacted throughout their distribution. Bush clearing has considerably reduced their extent and they are now largely restricted to valley slopes that are too steep for agricultural activities. Within the coastal zone the sites where Xeric


N2
Gqunube River
N2
Nahoon River
Abbotsford
De Waalbrug
BEACON BAY
Beacon Bay Bridge
BONZA BAY
Quenera
Lagoon
Caravan
Park
NAHOON STATE FOREST
Eastwar
Danger Point
QINIRA ESTUARY
(CSE45)
EAST LONDON
NAHOON ESTUARY (CSE 44)
Nahoon Beach
HLAZE RIVER (CSE 43)
Nahoon Point



Centrespread: The Nahoon, Qinira, Gqunube and Kwelera Coast.



Transitional Thicket occurs are perceived as having high development potential because of the often close proximity to the sea and the spectacular views from such sites.

Many of the remaining communities are in a relatively well preserved state and are not extensively infested by aliens. The communities have the highest number of threatened plants of all vegetation types represented within the region and also have a high species diversity. The remaining areas of thicket within the study area should be conserved wherever possible.

Dune Forest and Thicket and Stunted Dune Thicket

The woody dune communities occur on mesic sites along the coastal dune cordon on poorly developed calcareous littoral sands of Late Pleistocene to Recent origin. The vegetation is essentially a non-succulent subtropical thicket type, having fewer succulent species than the Xeric Transitional Thicket, and is dominated by trees and shrubs that are mostly of Tongaland-Pondoland origin. Some component species also have strong Afromontane affinities, particularly within the study area (Cowling, 1983).

Dune thicket is included in the classification by Everard (1987) as Xeric Kaffrarian Thicket. It has a relatively low species diversity and very few endemics, which tend to be mainly Tongaland-Pondoland elements.

The communities tend to form a unistratal canopy of often multiple-stemmed trees and shrubs. The variation in canopy height is dependent on the dune relief and exposure to wind and salt spray, particularly on the sea-facing slopes. Here, the frequent deposition of wind-blown sand is largely responsible for stimulating the branching of the trees and shrubs and for suppressing the development of a ground layer, which is often absent due to shading. Two communities, which are mapped as a single vegetation unit in Figures 33 and 34, can be differentiated within the area of Dune Forest at the Nahoon and Qinira estuaries. The forest occurring on the dune slopes with a landward aspect tends to be relatively stunted and is seldom higher than five metres tall. It comprises a great number of canopy and sub-canopy trees, with the dominant species being *Mimusops caffra* (red milkwood), *Schotia afra* (boer-bean) and *Cassine aethiopica* (koeboebessie) in the canopy stratum and *Cassine aethiopica, Euclea natalensis* and *Olea exasperata* in the sub-canopy. The climax forest which occurs in the more sheltered dune valleys comprises fewer trees which create a relatively high canopy of approximately 10 m. *Diospyros natalensis* (jackal-berry), *Sideroxylon inerme* (white milkwood) and *Harpephyllum caffrum* (wild plum) are dominant canopy species and *Cassine aethiopica, Acokanthera oblongifolia* (dune poison-bush) and *Deinbollia oblongifolia* (dune soap-berry) are conspicuous in the sub-canopy.

Two forest communities can also be differentiated at the Gqunube Estuary. The forest on the seaward dune slopes is approximately six metres tall and is dominated by *Mimusops caffra* and *Maytenus heterophylla* (spike thorn) in the canopy and *Cassine aethiopica, Dovyalis rotundifolia* (dune dovyalis) and *Acokanthera oblongifolia* as sub-canopy species. The forest on the hotter landward dune aspects is also relatively stunted and is generally less than five metres tall. The dominant species in both the canopy and sub-canopy is *Cassine aethiopica*, while *Mimusops caffra, Brachylaena discolor* (wild silver oak), *Sideroxylon inerme* and *Dovyalis rotundifolia* are also relatively common.

Dune Slack and Strand Communities

The physical characteristics of the beach and littoral dunes have restricted the extensive development of a pioneer dune community within the study area. Between the Nahoon and Qinira estuaries, for example, the mobile nature of the transverse dune system has prevented the establishment of pioneer species and only isolated patches of *Scaevola plumieri* (seeplakkie) and *Arctotheca populifolia* (sea pumpkin) occur. An ephemeral pioneer community tends to become established on the dunes along the south bank of the Nahoon and Gonubie estuaries following floods and includes species such as *Scaevola plumieri, Ipomoea brasiliensis* (seepatat) and *Arctotheca populifolia.* Typical pioneer shrubland species which occur as a narrow fringe along the seaward margin of the dune thicket include *Chrysanthemoides monilifera* (bietou) and *Passerina rigida* (gonna).

A fringe of low, dense thicket, which represents a later development stage of the pioneer communities referred to above, occurs along the seaward margin of the forest vegetation, where it is exposed to the effects of high velocity winds, sand abrasion and salt spray. This plant community has not been differentiated from the Dune Forest and Thicket community since it grades into the latter along an environmental gradient rather than across a clearly defined boundary.

Typical species of this community include *Maytenus procumbens*, (dune kokoboom), *Chrysanthemoides monilifera, Rhus crenata, Passerina rigida* and the creepers *Rhoicissus digitata* (baboon grape) and *Cynanchum natalitium.*

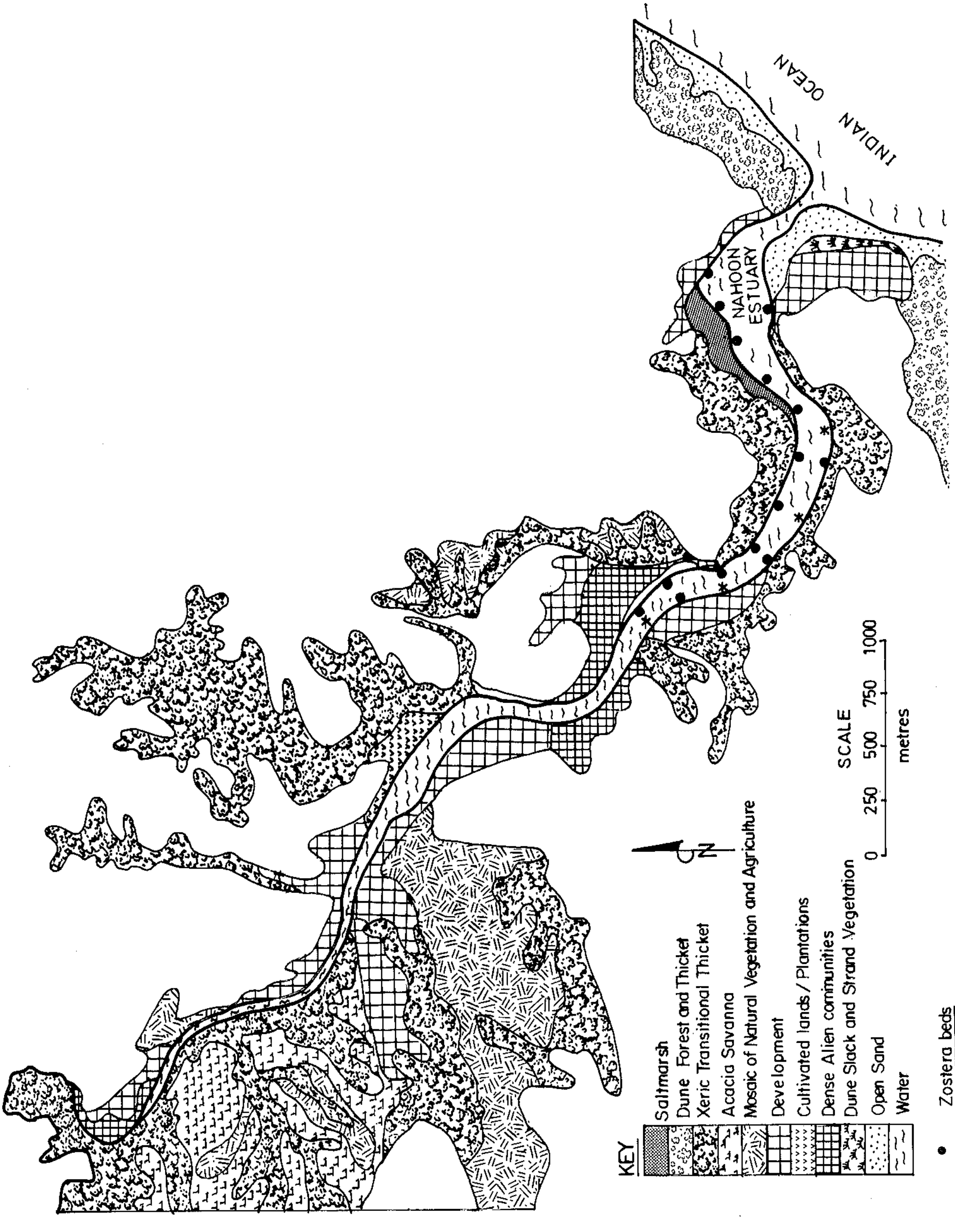


Figure 33: Vegetation of the Nahoon Estuary

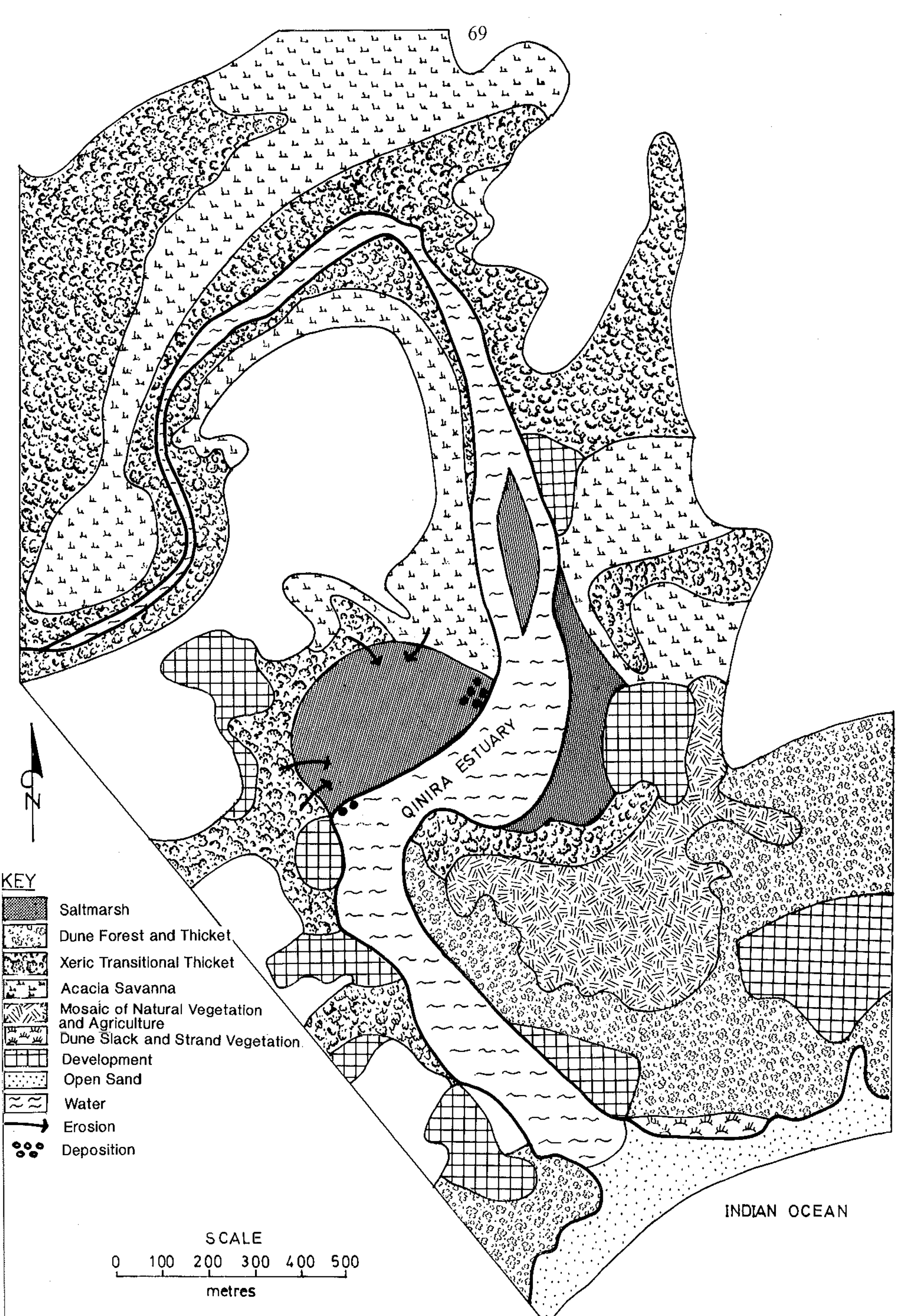


Figure 34: Vegetation of the Qinira Estuary

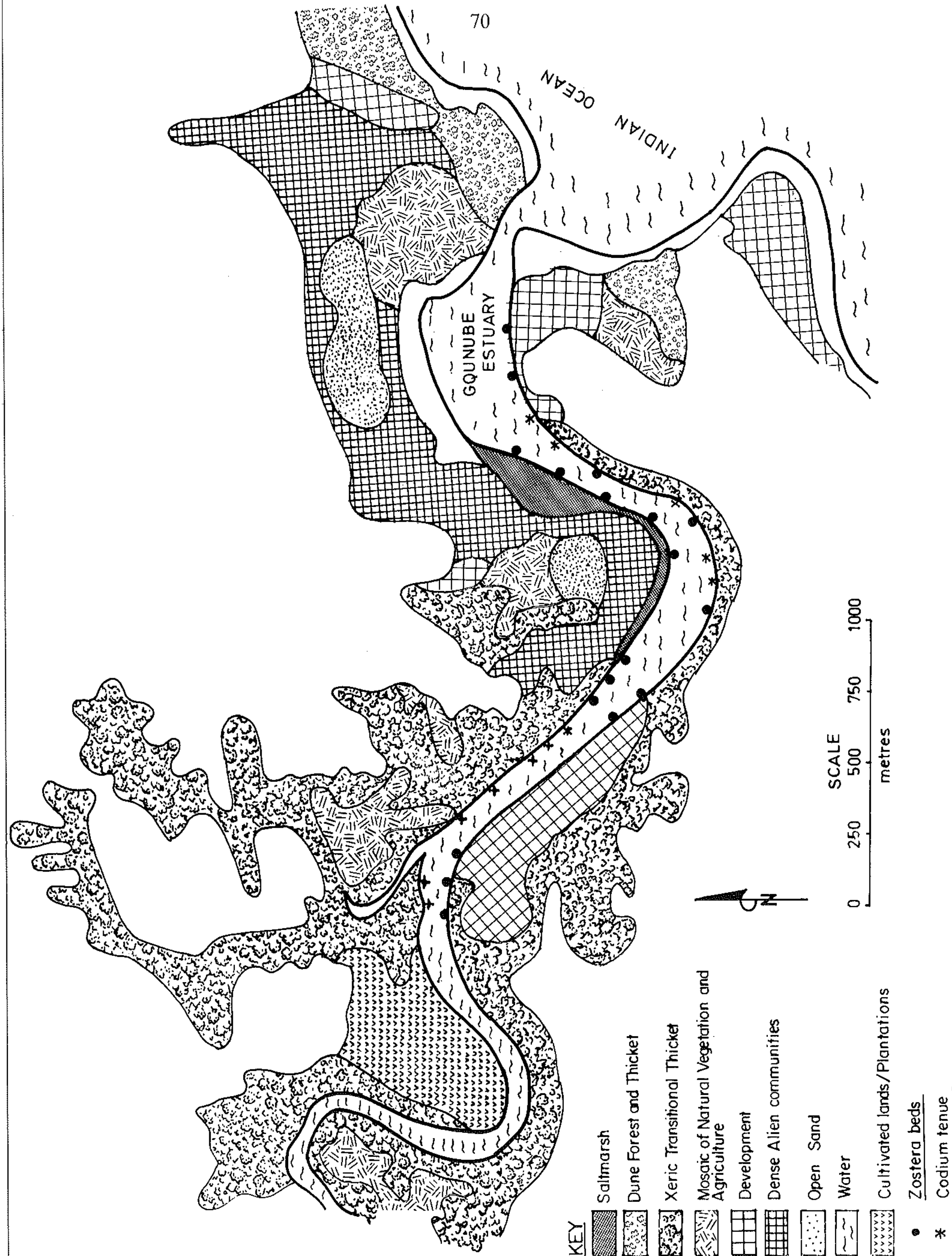


Figure 35: Vegetation of the Gqunube Estuary

Acacia Savanna

In the eastern Cape, Acacia Savanna is a transitional vegetation type between secondary grassland communities and a former woody community, such as Subtropical Thicket. It develops when secondary grassland is left free from disturbance for a length of time and is common around the margins of existing woodlands where the adjacent vegetation has been cleared for agricultural purposes. It seldom develops beyond the pioneer seral stages due to agricultural impacts but it does, however, often form an important buffer between secondary grassland or agriculture and natural thicket communities.

Acacia Savanna has a short to tall, sparse to open structure with *Acacia karroo* as the dominant pioneer tree species. During the initial recovery process from secondary grassland to woodland, *A. karroo* is usually the only tree species occurring in the grassland communities but in time other tree elements and mixed bush clumps become established. The communities are simple in structure and have a low species diversity.

Dune Fynbos

Small patches of dune fynbos occur within the forest areas at the Gqunube and Qinira estuaries. Structurally, the vegetation is established either as shrubland, dominated by *Metalasia muricata* (blombos), or stunted scrub-thicket, where *Olea exasperata* (coast olive) is dominant. Other herbaceous elements include *Restio eliocharis* (cat's tail) and *Phylica littoralis.*

Mosaic of Natural Vegetation and Agriculture

This mapping unit includes areas where the thicket communities are in the process of being cleared for agriculture and there is a transition between the former natural vegetation type and secondary grassland or cultivated land. The disturbance to the natural vegetation is generally irreversible and from a conservation aspect such areas are of reduced significance.

Alien and Invasive Vegetation

Stands of alien plant species are well established within the study area. *Lantana camara, Sesbanea punicea, Acacia mearnsii* (black wattle), *Acacia saligna* (Port Jackson), *Acacia cyclops* (rooikrans), *Cestrum laevigatum* (ink berry), *Pereskia aculeata, Circium vulgare* (Scotch thistle), *Psidium guajava* (guava) and *Ricinus communis* (castor oil plant) are the major problem species encountered along the coast.

4.2 Fauna

4.2.1 Zooplankton

The only available information on the zooplankton of the estuaries of the East London area appears to be that contained in a report by Wooldridge (1986). The Nahoon and Kwelera estuaries were surveyed by Wooldridge (1986) as part of a multidisciplinary study on the impact of discharged sewage and industrial waste materials into the East London coastal environment. The zooplankton of the estuaries was sampled five times over a period of a year, using 200 μm mesh nets at night.

The surveys found that the effect of reduced freshwater inflow was reflected in zooplankton composition and abundance. The population of the pioneer species *Pseudodiaptomus hessei*, for example, was found to be depressed in the upper reaches of both estuaries, indicating little freshwater inflow (Wooldridge, 1986).

The location of the estuaries in a transition zone from sub-tropical to warm temperate was also reflected in the composition of zooplankton. The spatial and temporal variations in the abundance of the copepods *Acartia longipatella* (usually found in temperate areas) and *A. natalensis* (found further northwards) were attributed to salinity and temperature changes.

The effects of reduced freshwater inflow to the Nahoon Estuary include changes in the temperature and salinity profiles in the estuary, which affect the populations of the copepods *A. longipatella* and *A. natalensis*. The depressed population of *P. hessei* is more significant, however, since this copepod is a key organism in many estuarine food webs. Reduced freshwater inflow to the Nahoon Estuary could therefore suppress zooplankton production, and ultimately affect higher trophic levels in the estuary (Wooldridge, 1986).

4.2.2. Invertebrate macrofauna

This section was contributed by Ms Sandy Muller, Environmental Consultant, East London.

NAHOON: The majority of the invertebrate macrofauna found within the Nahoon Estuary are characteristic of quiet water fauna similar to that of sheltered parts of the sea (See Appendix II). The species found, however, include the invasive Australian oyster drill (*Bedeva paivae*).

The state of the invertebrate macrofauna of the Nahoon Estuary appears to resemble a post-flood recovery phase, the last significant flood having occurred in 1985. During pre-flood conditions, population densities reflected a decline in reproductive activities due to decreasing freshwater inflow (Wooldridge, 1986), population decimation due to high concentrations of contaminants in the water column, and reduced abundance due to habitat constriction as a consequence of drought and human activities. For example, very low numbers or an occasional total absence of *Cleistosoma* spp. have been recorded in the Nahoon Estuary due to high concentrations of phenolic leachates. The razor shell (pencil bait) *Solen capensis* has been severely affected by human disturbance and its distribution is now limited to a few localised areas.

The post flood recovery of invertebrate macrofauna in the Nahoon Estuary has been hindered by human interference, particularly in sensitive areas. This is clearly demonstrated by the recent removal of sand at the river mouth. In this area there were viable populations of *Solen capensis, Psammotelina capensis* and *Eumarcia paupercula.* These bivalves live in clean sand within a few centimetres of the sand surface, and are thus susceptible to compaction by heavy vehicular traffic and physical removal for bait or for food, which reduces the viability of the breeding population. These activities destroy not only the habitat of these species, but also effectively eliminate any possibility of rehabilitating the habitat or of future recruitment.

A number of the small streams entering the upper estuary are often contaminated by effluent from nearby industrial areas, causing localised mass mortalities of invertebrate fauna. The insensitive siting of road construction camps in close proximity to the water course has also been responsible for mass mortalities.

Although laboratory tests indicate that water in the estuary is of an acceptable quality, available empirical data on biotic factors suggest the converse. Quantitative biotic data are sparse, yet areas previously densely populated by a single species are now either sparsely populated or show no visible signs of life.

This degradation of the Nahoon Estuary is progressing subtly, and cannot be quantified unless monitored over an extended period. Such a monitoring period should be in excess of ten years, and should include a pre-flood/flood/recovery cycle.

QINIRA: No data are available on the invertebrate fauna of the Qinira Estuary itself. McLachlan (1986) sampled the seaward face of the beach berm which closed the estuary mouth at the time of his survey. Six species *Eurydice longicornis*, *Pontogeloides latipes, Ocypode* spp., *Donax sordidus, D. serra* and *Bullia rhodostoma* were present. Of these *D. sordidus* was the most numerous (610 m^{-1} of transect) and *B. rhodostoma* had the highest biomass (27,45g m^{-1} of transect).

GQUNUBE: McLachlan (1986) visited the Gqunube Estuary in June 1984 and found the invertebrate fauna of the mouth area to be so impoverished as not to be worthy of further investigation. No species list has been published.

4.2.3 Fish

The data and synthesis presented in this section were contributed by Mr G Brett, East London Museum.

A list of the fishes found in the Nahoon, Qinira and Gqunube estuaries is provided in Appendix III. There are no fish endemic to these estuaries. One species, *Myxus capensis* (freshwater mullet), that occurs in the estuaries is a vulnerable species which has a distribution from the Breë River to Kosi Bay (Skelton, 1987). The ebb and flow of the Nahoon Estuary is constrained by the Abbotsford Causeway (Section 3.1.5). The existing causeway design, however, includes a fish ladder which permits access to the river and estuary for *Myxus capensis* during various stages of its lifecycle. The ladder is also utilised by *Anguilla* sp. (eels) to complete their lifecycles.

The East London estuaries support a relatively poor component of large fish caught by gill nets. The Nahoon and Qinira estuaries, however, are important for resident small fish and as nursery areas for marine fish (Marais, 1986). The biomass of "larger" fish may be low in these estuaries as a result of the smaller turbidity and salinity ranges from estuary mouth to ebb and flow relative to more productive estuaries such as the Kei and the Great Fish estuaries (*ibid.*).

Nevertheless, the fish diversity in the Nahoon and Gqunube estuaries can be expected to be high since they:

i) have a rocky berm at the river mouth,
ii) are permanently open and have relatively stable conditions, and
iii) support *Zostera* beds which provide essential refuge habitat for fish (Branch and Grindlèy, 1979; Beckley, 1983; Hanekom and Baird, 1984).

In comparison, the fish diversity in the Qinira Estuary is relatively low since:

i) the river mouth is often closed, causing extreme salinity conditions to occur,
ii) there are no *Zostera* beds as a result of the closed mouth,
iii) there is no rocky habitat at the mouth to shelter coral reef visitors or intertidal species such as *Caffrogobius caffer* and *Chirodactylus brachydactylus*, and
iv) the estuary is colder than the sea in summer and warmer than the sea in winter.

There are five categories of marine fish which utilise estuaries (Wallace, 1975). They are:

I: Those fish which have their entire lifecycles within estuaries.

II, III & IV: Those fish which spawn in the sea and use estuaries in various stages of their lifecycles.

V: Stenohaline fish which enter estuaries, although estuaries have no significant role in their lifecycles.

Fish belonging to all these categories occur in the Nahoon and Gqunube estuaries (Appendix III). The estuaries are in the transitional zone between the warm, tropical waters to the north and colder waters to the south. As a result, tropical fish reach East London estuaries at the southern limit and cold water fish species at the northern limit of their respective ranges.

4.2.4 Amphibians and reptiles

A list of the amphibians and reptiles which have been recorded, or are likely to occur, in the environs of the Nahoon, Qinira and Gqunube estuaries is provided in Appendix IV. The list is based on published information and existing museum specimens.

4.2.5 Birds

A list of the birds recorded at the Nahoon and Qinira estuaries is presented in Appendix V.

The waterbirds on the Nahoon and Qinira estuaries have been counted since 1986 in order to detect the responses of the birds to the different regimes of the two estuaries. Details of these counts are housed at the East London Museum. Four patterns have been detected:

1) The Qinira Estuary is used as a winter feeding ground by grebes, cormorants, ducks, herons, reed warblers and swallows. The intensity of the winter drought determines the number of birds utilising the estuary. In years when there is abundant water elsewhere, few birds visit the Qinira Estuary in winter. Similarly, when the lagoon level is low and there is a relatively small area of surface water there are fewer birds than when the lagoon is full. The birds which use the inundated reed beds to feed and roost, such as herons, swallows, reed warblers and weavers, move elsewhere when the reedbeds are not in standing water.

2) Both the Nahoon and Qinira estuaries are feeding grounds for relatively small numbers of summer visiting, Palaearctic waders. Waders are consistently present at the Nahoon, with up to ten species present. However, the number of birds and diversity of species appears to have declined since the 1985 flood, possibly as a result of deposition of material on the mud flats. Unfortunately, this point cannot be verified as bird counts prior to 1985 were stolen when a vehicle was broken into. The number of waders on the Qinira is almost always lower than that on the Nahoon. This is because the Qinira has a smaller area of tidal mudflats. When the Qinira mouth is closed the lagoon is not attractive to waders even if mud flats are available, as the waders depend on tidal inundation of the mud flats to replenish food supplies. The dominant waders on the Qinira tend to be species which prefer inundated grasslands, such as the Wood Sandpiper which is not found at the Nahoon.

3) The Qinira Estuary is used opportunistically by herons and cormorants whenever the lagoon water level changes abruptly, for example when the river mouth is opened, when river floods enter the lagoon, or when sea water washes over the bar. The birds either feed on the fish that are stranded when the water level drops, or feed at the place where new water is entering the estuary.

4) The Nahoon Estuary avifauna is more stable than that of the Qinira, in terms of both the number of species and the number of individuals present seasonally and annually.

5) The avifauna of the Gqunube Estuary has not been studied but is likely to be very similar to that of the Nahoon (C J Vernon, East London Museum, pers. comm.).

The long term trends of siltation and development in the estuaries will have the effect of decreasing both the density and diversity of waterbirds occurring on the estuaries.

4.2.6 Mammals

In general mammals, other than humans, are scarce in the area because they have been either killed or displaced. The mammals that remain do so as residual populations. A complete list of mammals occurring naturally in the study area is presented in Appendix VI.

In the dune bush and forest, Blue Duiker and Vervet Monkeys can still be seen, while Bushpig, Bushbuck and Grysbok are now scarce. The Tree Dassie may still occur in the riparian forest along the Gqunube Estuary, but no recent sightings have been reported.

The small Hottentot Golden Mole is regularly found, but is often killed on the roads and by domestic animals. McLachlan (1986) reported the presence of the gerbil *Gerbillurus paeba* in the hummock dunes on the southern side of the Qinira Estuary mouth.

Valley Bushveld vegetation in the study area still contains residual populations of Antbear and Porcupine, even in the suburban areas. Grey Duiker are now scarce, as are Genets, Water Mongoose and Cape Grey Mongoose. The most commonly occurring mammal is now the Rock Dassie which is found on krantzes, in storm water drains and occasionally on the roofs of houses.

In grassland areas there are few mammals other than those already mentioned, with the exception of the Cane Rat. These are still found in the rank wet areas but their habitat is rapidly disappearing.

The main rodent seen is the Vlei Rat. Evidence from owl pellets is that the diversity of rodents and shrews in the area is low. Bats are frequently seen, but little is known about them. There is a large roost of Egyptian Fruit Bats at Bats Cave (to the west of Nahoon Estuary) in summer. Other small bats (*Miniopterus* sp.) emerge from crevices at dusk.

5. SYNTHESIS

5.1 Present state of the systems

NAHOON: The state of the Nahoon Estuary has been described as "poor" by Heydorn (ed.) (1986), who recommended that any further development should take place according to environmentally acceptable guidelines.

The 76,5 km long Nahoon River has been subjected to substantial changes (O'Keeffe, 1986), many of which have contributed to the poor status of the estuary. Although the catchment is located in an area of all year rainfall with bimodal peaks, the high variability of seasonal rainfall causes periodic floods which are an important hydrological feature of the system. The frequency with which smaller floods reach the estuary, however, has been severely reduced by the raising of the Nahoon Dam wall in 1979. The dam will nevertheless have little effect on the frequency or passage of larger floods.

A characteristic feature of sedimentation processes in the Nahoon Estuary is that marine sediment accumulates in the mouth between floods. The reduced frequency of floods has exacerbated this sedimentation process, resulting in the accumulation of greater amounts of sand between floods (CSIR, 1985).

Water quality in the Nahoon Estuary has deteriorated, as illustrated by the elevated concentrations of lead and of other heavy metals (Watling, 1988). Bacteriological pollution has also been noted, particularly after rain (Pollution Control Technologies, 1991).

Terrestrial vegetation around the estuary is relatively well preserved, particularly in the State Forest Reserve. Dune vegetation has, however, been degraded mainly by increased human pressure and trampling (Avis, 1986a and 1986b). Both the Dune Forest and Dune Fynbos communities are biogeographically important since they are close to their southern and eastern distribution limits respectively.

Primary production in the Nahoon Estuary is mainly by phytoplankton (Campbell and Bate, 1986a and 1986b; Campbell *et al.*, 1991). The macroalgae *Codium tenue* and *Hypnea viridis* are relatively important in terms of total biomass, whereas *Zostera capensis* is not well established but provides an important habitat for fish. The productivity of key zooplankton species such as *Pseudodiaptomus hessei* is susceptible to the effects of reduced freshwater inflow (Wooldridge, 1986).

Few large fish species occur in the Nahoon Estuary, although the diversity of habitats in the estuary and the permanently open mouth result in a high diversity of fish species present. The location of the estuary in a transition zone between sub-tropical and warm temperate climates further increases the diversity of fish in the estuary.

The Nahoon Estuary is an important aesthetic and recreational resource for East London. The increasing intensity of recreation on the estuary, however, has contributed to its degradation and resulted in conflicts between different user groups (Morris, 1986; SRK, 1991). Large numbers of power-driven craft on the estuary, for example, have contributed to erosion of the river banks, overcrowding of the available water space, increased noise pollution and the disturbance of wildlife (*ibid.*). Fishermen have also noted reduced catches from the estuary (SRK, 1991) and at the time of the CSIR survey it was noted that bait species, particularly the mud prawn *Upogebia africana*, are heavily over-exploited in some areas.

QINIRA: The state of the Qinira Estuary has been described as "fair" by Heydorn (ed.) (1986), who recommended that development in and around the estuary should take place according to environmentally sensitive guidelines.

The 20,5 km Qinira River flows to an estuary that is semi-permanently closed (>80 percent of the time) (C Gaigher, Cape Nature Conservation, *in litt.*, 1990). The mouth closes as a result of the north-easterly moving current which transports marine sand into the inlet. The accumulated sand is periodically removed by river floods.

River inflow to the estuary has been noticeably reduced by activities in the catchment. In particular, water is impounded by farm dams and is utilised for irrigation of pineapples and, to a lesser extent, tomatoes. River inflow is also constrained by a weir which creates an artificial limit to tidal ebb and flow in the estuary.

Pineapple cultivation on moderate to highly erodible soils in the Qinira River catchment has also contributed to increased sedimentation in the river (Rooseboom, 1975 in Middleton *et al.*, 1981). Some of the sediment from the catchment is retained by riparian vegetation on the river margins. Nevertheless, sediment shoals are visible in the upper reaches of the estuary, and sedimentation has resulted in colonisation by *Phragmites* reedbeds in marshy areas.

The western shore of the Qinira Estuary is completely altered by residential development, whilst the eastern banks have been partially modified by resort developments. Stormwater run-off to the estuary and spillages from sewage pipelines and pump stations have caused microbial pollution of the estuary. The health risk from sewage contamination and unsightly conditions have in the past caused Beacon Bay Municipality to close the estuary for recreational activities.

Low-lying properties on the banks of the Quenera Lagoon have in the past been affected by rising water levels following rainfall (Mr M Symon, Beacon Bay Municipality, pers. comm., 1991). The risk of flooding particularly affects residential properties in Herons Way on the west bank.

The occurrence of faecal pollution in the lagoon and the risk of flooding residential properties have both resulted in efforts to open the estuary mouth artificially. The presence of a sand bank extending 150 m to 300 m up the estuary, however, causes the mouth to close again before the water level has dropped significantly. Detailed records of this process for the last eight years are available from East London Museum.

The Qinira Estuary supports only a limited diversity and abundance of fish since the mouth is often closed and there are no *Zostera* beds. The estuary is, however, an important winter feeding ground for a number of bird species.

Riparian vegetation in the estuary is relatively well preserved, particularly on the east bank. The middle reaches of the estuary contain a notable area of saltmarsh. Vegetation in the saltmarsh has, however, been modified by sedimentation from the catchment and by sediment resulting from the urbanisation of the surrounding areas.

The Qinira Estuary is an "important environmental asset and recreational amenity" for East London (Heydorn (ed.), 1986). Visitor and recreational facilities have been developed at the mouth, as well as on the banks of the lagoon. Activities undertaken on the lagoon include swimming, boating, canoeing and boardsailing.

GQUNUBE: The condition of the Gqunube Estuary has been described as "fair" by Heydorn (ed.) (1986), who recommended that the estuary be conserved and only strictly controlled development be permitted.

The 108 km long Gqunube River flows to a permanently open, tidal estuary. The mouth is characterised by a rocky point on the east bank and a flood tide delta of marine sand on the west bank. As in the case of the Nahoon and Qinira estuaries, marine sand accumulates to the west of the inlet, constricting tidal exchange until a river flood scours the estuary mouth. There are no dams or other obstructions which significantly alter the flow of the Gqunube River, or which unnaturally constrict tidal penetration in the estuary.

Alluvial sediment also enters the estuary from the moderate to highly erodible soils in the catchment and due to intense grazing and pineapple cultivation. This has resulted in the deposition of mudbanks in the middle and upper reaches of the estuary. The presence of dense *Phragmites australis* reedbeds in the estuary is evidence of this process.

Agricultural activities in the Gqunube River catchment appear to have affected water quality in the estuary. In particular, Talbot *et al.* (1985) found elevated concentrations of inorganic nitrogen in the estuary, as well as high levels of ammonia and nitrate compared with those in the Nahoon and Kwelera estuaries.

The western shore of the Gqunube Estuary has been substantially altered by residential development, although the fringe vegetation on steep slopes is relatively undisturbed. The dune forest in the Kwelera Nature Reserve on the east bank is well preserved. The Xeric Transitional Thicket on steep slopes on the west bank has been affected by pathways and the illegal tipping of refuse from nearby properties.

Primary productivity in the Gqunube Estuary is dominated by phytoplankton. Macroalgal species such as *Ulva capensis* (sea lettuce), *Codium tenue* and *Hypnea viridis*, as well as the macrophyte *Zostera capensis*, are relatively insignificant in terms of carbon assimilation. They do, however, provide key habitats and food, for fish and aquatic invertebrates.

The Gqunube Estuary contains a high diversity of fish species, including tropical species originating from the north and temperate species from the south. The permanently open tidal inlet, rocky berm at the mouth and *Zostera* beds are important to the diverse fish life in the estuary.

A number of recreational activities are pursued on the estuary, including fishing, boating, boardsailing, swimming and birdwatching. The recreational value of the estuary has been enhanced by the provision of a strip of public open space along the banks. Furthermore, intrusive activities such as waterskiing and the use of jet skis have been prohibited. As a result of these controls and the relative remoteness of the estuary from East London, recreational use of the estuary has not yet caused any notable degradation to the system.

5.2 Present state of knowledge

NAHOON: The present state of knowledge with respect to the Nahoon Estuary is good. Considerable baseline data are available on the physical characteristics of the system, although less is known of the estuarine ecology. Socio-economic issues relevant to the management of the estuary have been addressed recently (Steffen, Robertson and Kirsten (SRK), 1991) although long term solutions to some of those issues are still needed.

Much of the available biological and physical information on the Nahoon Estuary has been researched and reported under the auspices of the Institute for Coastal Research at the University of Port Elizabeth (Wooldridge (ed.), 1986). Their studies included estuarine morphology, sediment distribution and tidal characteristics, as well as investigations into the role of phytoplankton and macroalgae as primary producers. Descriptions of the status of the zooplankton, macrobenthos, fish populations and birds were also included.

Sedimentation processes in the Nahoon Estuary have been investigated by Esterhuysen and Reddering (1985) and Reddering and Esterhuysen (1987). The potential for the removal of marine sediment from the estuary mouth in order to enhance recreational conditions and tidal exchange, has been studied by the CSIR (1985).

Three areas in which further knowledge is needed, however, can be identified. Firstly, it is not clear to what extent sedimentation in the estuary, from both marine and terrestrial origins, is affected by the presence of the Nahoon Dam. Of particular importance is the likelihood that the mouth could close as a result of the reduced frequency of river floods.

Secondly, further information is needed on water quality in the estuary. This is important since the limited water quality data presently available indicate that contamination by heavy metals has occurred and that microbial pollution affects the estuary after rain (Talbot *et al.*, 1985; Pollution Control Technologies, 1991).

Thirdly, further studies are needed to determine the effect of recreational activities on the ecological status of the estuary. The over-exploitation of bait organisms has already been noted (Morris, 1986; SRK, 1991) and local fishermen have reported reduced catches from the estuary (Morris, 1986). Other activities, such as boating in the estuary mouth may affect the migration of fish during the summer months (Mr G Brett, East London Museum, pers. comm., 1991).

QINIRA: Information on the Qinira Estuary is very limited. Some baseline data are available on the physical characteristics of the system. No measured run-off data are available. Reliable information on the biotic characteristics of the system is scarce. Socio-economic issues relevant to the management of the estuary appear to have received little attention.

The Qinira Estuary was not included in the biological and physical studies undertaken by the University of Port Elizabeth (Wooldridge (ed.) 1986). Available biotic information appears to be limited to that provided by the East London Museum on the fish and birds in the estuary (Appendix III and V). The vegetation of the estuary and surrounding coastal areas has been described by Raal and Burns (1989).

Some water quality data are available from Beacon Bay Municipality. The data indicate that a health risk to users of the estuary has occurred due to microbial contamination of the water. A regular sampling and monitoring programme is needed in order to identify and quantify water quality trends in the estuary. In the absence of such data, the water quality criteria provided by Lusher (1984) cannot be applied.

An improved understanding of socio-economic issues relevant to the status and management of the Qinira Estuary is also needed. These issues include the treatment of properties at risk from flooding due to rising water levels, and the costs and benefits associated with the control of the various pollution sources in the estuary.

GQUNUBE: The present state of knowledge with respect to the Gqunube Estuary is fair. Some baseline data on the physical characteristics of the system are available, but measured run-off data are limited to one seven-year period.

The Gqunube Estuary was included in the surveys of East London estuaries by the Institute for Coastal Research (Wooldridge (ed.) 1986). Data are thus available on the estuarine morphology, sediment distribution and tidal characteristics of the system, as well as on the roles of phytoplankton, algae and aquatic vegetation as producers of organic carbon. The zooplankton, macrobenthos, fish and birds were also investigated (Wooldridge (ed.) 1986).

Little water quality data on the Gqunube River appear to be available. Agricultural activities in the catchment have been found to affect nitrate concentrations in the estuary (Talbot *et al.*, 1985). Further water quality studies and a sampling and monitoring programme are needed to determine long term trends and influences on water quality in the estuary.

5.3 Problems present and foreseeable

NAHOON: Five key problems exist in the Nahoon Estuary. They are increased sedimentation, poor water quality, the reduced abundance and diversity of estuarine organisms, inappropriate development on the floodplain, and the increasing demand for recreational resources.

Increased sedimentation

Sedimentation in the Nahoon Estuary occurs as a result of marine sediment transported into the river mouth by tides, and to fine, clayey silt derived from natural weathering in the catchment and accelerated soil erosion due to intensive agricultural practices. Under natural conditions, accumulated sediment is periodically removed from the estuary by river floods.

The presence of the Nahoon Dam, however, will have the effect of reducing the frequency with which river floods scour the estuary. There will be longer periods between floods, during which sediment will continue to accumulate. The increased amount of marine sand in the estuary mouth reduces the water area available for recreation and restricts tidal exchange. These problems have already resulted in a study of the potential for dredging marine sand from the estuary mouth area (CSIR, 1985). A natural river flood in 1985, however, removed the need for any dredging.

Dredging would, however, be intrusive and is only a temporary solution since marine sand accumulates in the river mouth at an estimated rate of about 58 m^3/day (Reddering and Esterhuysen, 1987). If a river flood fails to occur, and dredging is unsuccessful, it is possible that the estuary mouth could close for an extended period, disrupting the estuarine ecology and producing recreationally and aesthetically undesirable conditions.

Poor water quality in the estuary

Four water quality problems exist in the Nahoon Estuary (Pollution Control Technologies, 1991). These are:

i) River inflow at the Abbotsford Causeway is contaminated with faecal bacteria as a result of growing informal or unserviced settlements in the catchment.

ii) The stream draining the area north-west of Jack Batting Bridge is visibly polluted by organic matter. This may be either as a result of spills from a nearby sewage pumping station, or due to the careless discharge of the contents of conservancy tanks.

iii) Overflows from the sewage pumping station at the intersection of Beaconhurst Drive and Blue Bend Road cause pollution of the estuary. Overflows result from stormwater infiltration of the sewers and occasional pump failures. Sewage overflows can also occur at the pumping stations downstream of Jack Batting Bridge and at the Blue Lagoon timeshare resort.

iv) Bacterial pollution of the estuary also occurs after rain due to poor quality stormwater run-off.

Reduced abundance and diversity of estuarine organisms

Although little quantitative data are available, qualitative data from local experts, residents and users of the estuary, as well as recorded observations in some cases, indicate that fewer fish, bait organisms, birds and other organisms are present than in the past. Morris (1986), for example, reported that residents near the Nahoon Estuary had perceived a decline in the number and diversity of fish caught between 1976 and 1986. A recent questionnaire survey recorded a similar perception (SRK, 1991). The numbers of the sand prawn *Callianassa kraussi* have declined due to intense exploitation throughout the estuary (Raal, 1993). The diversity and abundance of birds in the estuary has decreased, probably as a result of human disturbance and loss of habitat.

The ecological degradation of the estuary will result in reduced aesthetic and amenity values for the system, as well as a reduced biological carrying capacity.

Development on the floodplain

The Nahoon River has caused extensive damage to structures in the estuary during floods. The flood of 1970 and, to a lesser extent, those of 1985 for example, burst the banks and caused extensive damage to bridges and private properties. Nevertheless, development on the floodplain has continued and a number of properties are situated in areas at risk from flooding. These include developments below the level of the 1970 flood at the Abbotsford Causeway, the Beacon Bay Country Club, and parts of Torquay Road.

The East London City Council have adopted a policy for the control of development on the 1-in-50 year floodplain (Mr C Theart, East London City Council, pers. comm., 1991). At present the Council policy provides guidelines for the control of development below the 1-in-50 year floodline, although these guidelines may be promulgated in the form of a by-law, subject to the approval of the Administrator of the Cape. Existing development rights are not, however, affected by the policy. As a result, the Council is able to influence plans for subdivision or rezoning, and attach conditions to the approval of such plans, but cannot prohibit development where it is allowed in terms of the existing Town Planning Scheme.

Increasing demand for recreational resources

The demand for recreational resources in the East London Metropolitan Area is increasing as a result of population growth, in-migration, rising living standards, and the increasing economic importance of tourism and the demand for coastal holiday accommodation. The Nahoon Estuary is a key recreational resource in East London due to its scenic qualities and suitability for both passive and active recreation. Due to the limited water area in the estuary and the diversity of recreational activities and their varying space requirements, some control is needed in the form of activity zoning, time zoning, speed restrictions and the enforcement of regulations and by-laws. Thus far, conflicting recreational activities have been allowed throughout the estuary, with little control of, for example, the number and speed of power-driven craft on the water.

The East London City Council have acknowledged this problem and have commissioned an interdisciplinary team to prepare guidelines for the development and recreational use of the Nahoon Estuary (SRK, 1991). Although the results of that study have not yet been finalised, a number of problems concerning the control of recreation can be seen to exist.

These include divided jurisdiction and the lack of a single management authority for the estuary.

QINIRA: Four key problems can be identified that affect the Qinira Estuary. They are increased siltation, poor water quality, the risk of flooding low-lying properties, and the loss of species and habitats. Although the demand for recreational resources in the Qinira Estuary is increasing, no evidence of intense demands or conflicting activities, such as those on the Nahoon Estuary, has yet been reported.

Increased siltation

Marine sand naturally enters the Qinira Estuary mouth when it is open. The sand causes shoaling as far as 300 m upstream, which eventually closes the mouth. Silt enters the upper estuary from the naturally erodible rocks and soils in the catchment. The silt load of the river has been increased by intense agricultural practices in the catchment and by disturbances associated with development activities on the river banks. River floods open the mouth and remove marine sand, but also cause silt deposition in the upper estuary. The increased deposition of silt has resulted in shoaling of the middle and upper estuary. Dense *Phragmites* reeds have colonised areas of saltmarsh on which silt has been deposited.

Poor water quality

Bacterial contamination of the Qinira Estuary results from stormwater inputs from the catchment and from sewage pumping station overflows. Insufficient data are at present available to determine the relative importance of these pollution sources. Nutrient input to the lagoon has caused unsightly algal blooms to occur and large numbers of coliform bacteria in the water have led to the closure of the lagoon for recreational activities. Attempts to open the mouth artificially in order to flush contaminated water from the estuary have been only partially successful. This is because the extensive sand shoal upstream of the mouth limits the amount of water that can be flushed out to sea.

Risk of flooding low-lying properties

Rising water behind the closed river mouth has in the past threatened to flood low-lying properties on the lagoon banks. In particular, residential properties in Herons Way on the west bank have been affected. Complaints from these property owners have prompted the Beacon Bay Municipality to attempt to open the estuary mouth artificially. Such efforts have been only partially successful, however, due to the extensive sand shoal in the estuary mouth.

Loss of natural species and habitats

The encroachment of urban development on the banks of the estuary has resulted in the loss of habitats for birds and other animals. In particular, the west bank of the estuary has been completely altered by development, although the east bank is thus far relatively undisturbed. Deteriorating water quality in the estuary could also affect the number and diversity of fish and other aquatic organisms. This is likely since the high organic load of sewage and stormwater pollutants will cause dissolved oxygen levels in the water to drop.

GQUNUBE: The Gqunube Estuary has thus far been less affected by development, major dams or pollution inputs to the system than either the Nahoon or Qinira estuaries. Similarly, no major conflicts or degradation of the system resulting from recreational activities have yet been reported. Nevertheless, three key problems with respect to the present and future state of the estuary can be identified. They are the pressure for residential development, nutrient enrichment of the estuary, and inappropriately located facilities.

The pressure for residential development

Two distinct types of residential development are occurring near the Gqunube Estuary or on its banks. Firstly, a peninsula on the west bank in the upper reaches of the estuary has been earmarked for low density residential development. Although it is not yet clear what form this development will take, it was observed on a site visit on 19.07.91 that a large area had been cleared of natural vegetation and pegged prior to construction. The area was, however, bounded by a narrow strip of remaining natural vegetation on the estuary banks, which has been demarcated as Public Open Space.

Secondly, a number of high density, low income unserviced areas exist near the estuary and in the catchment. In some cases the living conditions of these communities have been extremely poor, as a result of inadequate or non-existent water supply and sewerage. Negotiations and consultations with the communities and other interest groups in order to identify acceptable sites to which the communities can relocate have, however, been undertaken (Council for the Environment, *in litt*, 1991). As a result a "suitable" site between Eastward Ho and Bonza Bay was identified (*ibid*). The site lies in the dune slacks of the primary coastal dunes, although it is already disturbed as a result of sand mining activities. Objections to the choice of this site have, however, been voiced. The objections include the incompatibility of a "squatter settlement" with proposed resort developments for the area, its effect on nearby land and property values, poor access and transportation routes, a lack of employment in the area, the inadequate size of the site with respect to future housing needs, and the effect of the squatters on sensitive dune ecology and vegetation (Gonubie Ratepayers Association, *in litt.*, 1991).

Nutrient enrichment of the estuary

Elevated concentrations of nitrates, nitrites and ammonia occur in the Gqunube Estuary, probably as a result of agricultural activities in the catchment (Talbot *et al.*, 1985). The increasing nutrient load of the river could cause algal blooms to occur in the estuary.

Inappropriately located facilities

Two developments are inappropriately located in dynamic areas of the estuary. Firstly, the car park at the estuary mouth on the west bank is located in an area subject to river floods and storm seas. The car park has already been damaged on a number of occasions by floods (Figure 32).

Secondly, the caravan park on the west bank of the estuary mouth has a number of sites that extend into the face of the frontal dune. The vegetation on the dune face has been damaged by trampling, and the placing of brushcut bushes near the base of the dune face in an attempt to restrict access has not been successful. As a result the sand is unstable and subject to erosion and slumping.

5.4 Recommendations

NAHOON: The Nahoon Estuary is an important recreation amenity for the residents of East London and Beacon Bay. There is an urgent need to implement an overall management plan for the estuary to ensure that it can continue to serve as an amenity while retaining its ecological viability. The management plan must provide guidelines, for the utilization and development of the system, which are supported and implemented by the municipalities of East London and Beacon Bay which share responsibility for the estuary.

Increased sedimentation

It is recommended that no further raising of the Nahoon Dam should be considered unless a management plan to ensure the continued natural functioning of the estuary has been implemented.

Poor water quality in the estuary

Unless remedial measures are implemented, the health risk due to microbial pollution and the incidence of algal blooms in the estuary will increase. It is therefore recommended that:

i) Upgrading of the sewerage system should continue, and appropriate devices such as buffer dams should be installed to prevent sewage overflows from pumping stations.

ii) A water allocation for the benefit of water quality in the estuary should be reserved in the Nahoon Dam.

iii) A joint water quality monitoring programme and management plan for water releases from the Nahoon Dam should be implemented by the East London City Council and the dam operators. Regular monitoring will allow unacceptably high pollution levels and pollution trends to be detected. Water releases from the dam can be used to flush contaminated water from the estuary when necessary.

Reduced abundance and diversity of estuarine organisms

The abundance and diversity of flora and fauna in the estuary are key contributors to the recreational, scenic and socio-economic values of the system. It is therefore recommended that:

i) Further research should be supported to determine the impact of various recreational activities on the components of the estuarine ecosystem, and the sustainable levels of utilisation of estuarine organisms.

ii) Important macrophyte and macroalgal species in the estuary should be protected from disturbance by limiting access to the Beacon Bay Nature Reserve and by prohibiting the beaching of craft except in demarcated areas.

iii) Bag limits for bait species and fish should be strictly enforced. Bait collection should be prohibited in key areas, such as the Beacon Bay Nature Reserve.

iv) Stricter controls should be prescribed for construction camps and development sites in order to minimise the disturbance to and loss of natural vegetation. Developers should be required to rehabilitate all areas disturbed by construction activities.

Development on the floodplain

The control of new developments on the floodplain is currently the focus of a new policy and by-laws proposed by the East London City Council. It is further recommended that a flood warning system and evacuation plan be established for the Nahoon River and estuary. The increasing number of users, visitors and residents near the estuary requires that a practical warning and evacuation plan is implemented.

Increasing demand for recreation resources

The effective management and control of the recreational use of the Nahoon Estuary is a key ingredient for the sustainable management of its biological, physical and socio-economic resources. Effective management requires that the type of development on the estuary banks be carefully chosen, and that by-laws pertaining to the type, time, area and nature of recreation activities be enforced effectively. It is therefore recommended that:

i) Proposed development plans be scrutinised with respect to their effect on the demand for recreational resources. Developments that require passive resources (e.g. scenery and desirability of location) should be favoured over those that require active resources (e.g. marinas, jetties).

ii) The preliminary recommendations of the SRK (1991) report with respect to activity zoning and limiting numbers of power-driven craft should be implemented.

iii) A management committee for the estuary, having a constitution and jurisdiction that are acceptable to both the East London and Beacon Bay municipalities, should be appointed.

iv) River Control Officers should be appointed by the management committee, and should have jurisdiction over activities on the water and on the estuary banks. The costs associated with this recommendation could be off-set by charging launching fees for boats and parking fees for popular sites during the holiday season.

QINIRA: The increasing intensity of recreation in the Qinira Estuary does not yet appear to be a major problem. Nevertheless, it is recommended that a multidisciplinary recreational development and management plan be prepared in order to identify specific problems that could occur and provide guidelines for utilisation, development and the provision of facilities into the next century.

Increased siltation

Increased siltation due to disturbance of the catchment could result in the loss of water area, habitats and estuarine and saltmarsh flora and fauna. It is therefore recommended that:

i) More stringent soil conservation measures be prescribed for agricultural activities in the Qinira River catchment.

ii) Similarly, strict soil conservation and run-off control measures should be prescribed for all development and construction activities in the catchment and on the river banks.

Poor water quality

Both point and diffuse sources of pollution affect the Qinira Estuary, although their relative importance is not known. Opening the estuary mouth to flush contaminated water from the estuary is only partially successful. It is therefore critical that a pro-active solution to water quality problems be implemented for the estuary. The following steps are recommended:

i) A regular water quality monitoring and analysis programme for the estuary should be instituted. This will allow water quality trends to be detected and the relative significance of various pollution sources to be determined.

ii) Sewage pipelines and pumping stations near the estuary should be upgraded to reduce stormwater infiltration, and buffer dams or other appropriate devices should be installed in order to prevent sewage spills from reaching the estuary.

iii) Instream flow devices to prevent contaminated stormwater run-off from reaching the estuary should be installed. Suitable devices to reduce the "first flush" pollution effect include detention basins, microstrainers, dissolved air flotation, diversion boxes and improved street cleaning and waste collection services.

Risk of flooding low-lying properties

Existing properties that are at risk of flooding by rising water levels in the Quenera Lagoon cannot be relocated and hence only flood protection measures are likely to be a suitable solution in such cases. Nevertheless it is recommended that:

i) The Beacon Bay Municipality encourage the owners of properties in Herons Way to install appropriate flood protection measures, and to indemnify the Council from prosecution should flooding occur. This is desirable since allowing water levels to rise as far as possible before the sand bar is breached will maximise the scouring of marine sand from the estuary mouth.

ii) The 1-in-50 year flood line should be determined.

iii) No subdivisions, rezonings or extensions below the 1-in-50 year flood level should be approved.

iv) Where property rights entrenched by the existing Town Planning Scheme fall below the 1-in-50 year floodline, land swops or the rezoning to private or public open space should be encouraged. Where property owners insist on exercising an existing right to develop, they should indemnify the Council against damages by floods or by rising water levels in the lagoon for the reasons already described.

Loss of natural species and habitats

In order to conserve and enhance the scenic, recreational and socio-economic values of the Qinira Estuary, it is necessary that improved measures to protect the remaining natural vegetation and habitats be implemented. It is recommended that:

i) The dune forest and frontal dune cordon on the east bank be proclaimed a Nature Reserve or, alternatively, a Protected Natural Environment in terms of the Environmental Conservation Act 73 of 1989.

ii) Similarly, remaining areas of dune forest and Xeric Transitional Thicket on the first bend of the east bank upstream from the river mouth should be protected.

iii) Recreation facilities in the form of well-demarcated picnic sites, braai areas and pathways should be provided in order to channel visitors into suitable areas and prevent *ad hoc* encroachment and trampling in undisturbed areas.

GQUNUBE: Although no major impacts resulting from recreational activities in the Gqunube Estuary are evident, it is recommended that a recreation and development management plan for the estuary be prepared. The plan should include a multidisciplinary assessment of the recreational carrying capacity of the system, as well as the effect of future development and population growth on the demand for recreational resources.

The pressure for residential development

Two distinct types of residential development could affect the Gqunube Estuary: low density development for middle and upper income groups, and high density development for low-income families. In the case of low-density development it is recommended that:

i) The Public Open Space bounding the peninsula development and the river banks should be protected from disturbance. This can be achieved by providing stepped pathways and clearly demarcated access points for residents and visitors. Disturbance of the riparian vegetation on the river banks will result in erosion, the loss of habitats and increased siltation in the estuary, as well as increasing the risk of flooding of properties on the peninsula.

ii) Private jetties and slipways should be prohibited.

iii) Soil erosion and run-off control measures should be prescribed for all developments on or near the river and estuary banks.

iv) No new township developments should be approved unless at least 80 percent of adjacent or nearby proclaimed development areas have been developed.

v) No subdivisions or rezonings of land for development on the east bank of the estuary should be permitted. Protection of the steep slopes is needed to prevent erosion and sedimentation, and the maintenance of the riparian vegetation will retain the diverse habitats and abundance of wildlife in the estuary.

vi) The status and effective management of the Kwelera State Forest Reserve should be upgraded to improve the protection of the sensitive dune ecosystems contained within the reserve. This is particularly important since the coastal dunes between the Qinira and Gqunube estuaries are already disturbed by sand mining and are subject to increasing pressure for residential and tourist development.

With respect to the identification of suitable sites for low-income, high density residential development, it is recommended that:

i) Settlements should be located near to existing access routes and sources of employment.

ii) Sites near areas of undisturbed natural vegetation or sensitive dune systems should not be considered.

iii) Control measures to minimise the effects of bacterial pollution, soil erosion and litter should be incorporated into the design of stormwater drainage, sewerage and waste collection systems for low-income housing areas.

Nutrient enrichment of the estuary

Agricultural activities in the river catchment may be responsible for elevated concentrations of nitrites, nitrates and ammonia in the Gqunube Estuary (Talbot *et al.*, 1985). In order to determine the water quality status of the system more clearly it is recommended that:

i) A regular water quality monitoring programme be instituted by the Gonubie Municipality. The programme should monitor the concentrations of the plant nutrients, nitrogen and phosphorus, as well as the degree of bacterial contamination in the estuary.

ii) The monitoring programme should be utilised to determine water quality trends and to identify the sources of nutrient enrichment or pollution in the estuary.

Inappropriately located facilities

With respect to the location of parking and recreational facilities in dynamic and sensitive areas of the Gqunube Estuary, it is recommended that:

i) The car park on the west bank of the river mouth should be relocated or, if an alternative site cannot be found, the extent to which the car park intrudes into a dynamic zone should be accurately determined and that part of the car park should be removed.

ii) The car park edges abutting the beach should be sloped, landscaped and revegetated in order to enhance their appearance and stabilise the boundary area.

iii) The caravan sites which intrude into the dune face (sites 90, 91, 92, 122 and 123) should be relocated.

iv) Access to the dune face from the caravan park should be restricted by blocking pathways and erecting visitor information boards that explain the sensitivity of the dune system.

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7.2 Maps

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7.3 Aerial Photographs

Date	**Job No.**	**Photo No.**	**Scale 1:**	**Type**	**Source**
Nahoon					
Jan 39	134/38	14545	25 000	B&W	Trig. Survey
1954	-	-	36 000	B&W	Trig. Survey
Sept. 1959	-	-	50 000	B&W	Trig. Survey
3/10/67	152	4366	8 000	B&W	Dept Transport
24/10/67	558	015	20 000	B&W	Trig. Survey
19/12/68	295/8	9 703	8 000	B&W	Dept Transport
28/04/70	295/8	5765-5767	8 000	B&W	Dept Transport
14/08/70	498/8	2190	36 000	B&W	Trig. Survey
21/07/72	704	654	50 000	B&W	Trig. Survey
02/08/72	-	1 078	40 000	B&W	Trig. Survey
26/09/72	295/8	7417-7419	8 000	B&W	Dept Transport
09/04/77	284	188	8 000	Colour	Univ. of Natal
26/06/78	498/112	760	30 000	B&W	Trig. Survey
19/04/79	326	138	8 000	Colour	Univ. of Natal
/12/80	374	33	20 000	B&W	Univ. of Natal
07/12/81	391	132/4 133/4	30 000	Colour	Univ. of Natal
10/06/86	896	-	30 000	B&W	Trig. Survey

7.3 Aerial photographs (continued)

Date	Job No.	Photo No.	Scale 1:	Type	Source
26/02/87	-	108/1	10 000	Colour	EMATEK
04/05/90	-	93/4	10 000	Colour	EMATEK
Qinira					
1966	-	-	20 000	B&W	Trig. Survey
03/10/67	-	4363-4364	8 000	B&W	Dept Transport
19/12/68	295/8	9705	8 000	B&W	Dept Transport
28/04/70	295/8	5765/5767	8 000	B&W	Dept Transport
21/07/72	704	0655	30 000	B&W	Trig. Survey
29/06/72	295/8	7420-7422	8 000	B&W	Dept Transport
19/04/79	326	136	8 000	Colour	Univ. of Natal
12/80	374	32	20 000	B&W	Univ. of Natal
12/81	391	131/4	20 000	Colour	Univ. of Natal
10/06/86	896	107	30 000	B&W	Trig. Survey
26/02/87	-	109/9	10 000	Colour	EMATEK
04/05/90	-	93/3	10 000	Colour	EMATEK
Gqunube					
Jan. 1939	-	4470	25 000	B&W	Trig. Survey
1954	336	2663	36 000	B&W	Trig. Survey
1959	436	1266	50 000	B&W	Trig. Survey
1973	721	3544	50 000	B&W	Trig. Survey
09/04/77	284	740	4 000	Colour	Univ. of Natal
19/04/79	326	134 & 135	8 000	Colour	Univ. of Natal
12/80	-	-	11 500	B&W	Trig. Survey
12/81	391	129/4 & 130/4	20 000	Colour	Univ. of Natal
10/06/86	896	105	30 000	B&W	Trig. Survey
26/02/87	-	111/17	10 000	Colour	EMATEK
04/05/90	-	94/6	10 000	Colour	EMATEK

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-wéstern 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°, 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: Physico-chemical data and bacteriology

The metal concentrations in surface waters and surface sediments of the Nahoon and Buffalo rivers are shown below (Watling, 1988):

($\bar{x}$ = mean; s = standard deviation)

Metal concentrations in surface waters ($\mu g/\ell$)

	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	Hg
Buffalo R.$\bar{x}$	12,0	0,2	5,0	41,6	166	179	32,6	1,3	1,93	1,61
s	10,1	0,3	4,2	57,4	103	244	43,9	1,8	2,48	0,16
Nahoon R.$\bar{x}$	4,6	0,06	0,3	97,6	91	18	17,7	0,3	0,33	2,36
s	4,5	0,06	0,6	79,2	79	19	24,9	0,2	0,26	0,67

Metal concentrations in surface sediments ($\mu g/\ell$)

	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	Hg
Buffalo R.$\bar{x}$	196,2	0,10	186	19,5	36 000	353	27,3	12,5	40,2	0,289
s	227,2	0,05	331	18,0	29 000	216	38,9	13,2	24,4	0,162
Nahoon R.$\bar{x}$	51,8	0,08	17,0	3,3	14 210	184	18,9	7,1	32,0	0,081
s	39,9	0,05	12,3	2,2	7 650	131	15,1	7,3	21,8	0,055

APPENDIX I (Continued)

Bacteriological analyses of Quenera Lagoon, Bonza Bay
Source: Beacon Bay Municipality

Date	Probable number of coliforms MPN/100 mℓ in	
	river at Bonza Bay	sea at Bonza Bay
29.08.89	1 600	-
08.11.89	>1 800	-
12.12.89	0	0
21.12.89	0	0
27.12.89	70	13
27.03.90	>1 800	-
28.03.90	>1 800	1 600
30.03.90	920	240
02.04.90	16 000	5 400
04.04.90	0	0
09.04.90	95	40
23.04.90	700	17
07.05.90	70	13
21.05.90	1 700	5 400
11.07.90	>1 800	-
25.07.90	16 000	-
31.07.90	0	-
17.10.90	17 (east), 35 (west)	
21.10.90	11	2
26.10.90	350 (Herons Way - 1 800)	2
07.11.90	>1 800	>1 800
13.11.90	920	4
02.01.91	9	2
13.02.91	80 (east), 45 (west)	-
19.02.91	2	-

APPENDIX II: Aquatic flora and invertebrate macrofauna recorded at the Nahoon Estuary

Source: Ms Sandy Muller, Environmental Consultant, East London

FLORA	
CHLOROPHYTA	RHODOPHYTA
Enteromorpha sp. *Chaetomorpha* sp. *Codium* sp.	*Laurentia* sp. *Bostrychia* sp. *Hypnea* sp.
FAUNA	
MOLLUSCA	
Gastropoda	Bivalvia
Assiminea bifasciata *Hydrobia dubia* *Nassarius kraussianus* *Siphonaria* sp. *Cerithidea decollata* *Littorina scabra* *Bedeva paivae*	*Solen capensis* *Dosinia hepatica* *Psammotellina capensis* *Tellina trilaterata* *Branchiodontes virgiliae (Musculus virgiliae)*
NEMERTEA	
Ficopomatus enigmatica (Mercierella enigmatica)	
ARTHROPODA	ECHINODERMATA
Upogebia africana *Callianassa kraussi* *Palaemon pacificus* *Scylla serrata* *Uca chloropthalmus* *Uca lactea f. annulipes* *Potamon* sp. *Sesarma meinerti* *Sesarma catenata* *Hymenosoma obiculare* *Balanus elizabethae* *Chthalamus dentatus*	*Echinocardium cordatum*

<u>APPENDIX III</u>: Fish species in the Nahoon, Qinira and Gqunube estuaries

Data contributed by Mr G Brett, East London Museum.

The name and systematic order follows Smith and Heemstra (1986). For each species of fish, the following information is given:

1. The zoogeographic distribution as either N arriving from the north, or S from the south. Fish species endemic to the South African coast are listed as E; those which are cosmopolitan are listed as K. Freshwater species are indicated as F. Fish having unknown characteristics are marked ?

2. The status in estuaries, where A indicates entire life-cycle in estuaries (Wallace, 1975 category I), B indicates use of estuaries at some part of life-cycle (Wallace, 1975 categories II, III and IV), and C indicates fish incidental to estuaries (Wallace, 1975 category V).

3. Whether the fish species has been recorded in the Nahoon, Qinira or Gqunube estuaries and the source of the record where:

   a = angling records published by the *Daily Dispatch,*
   b = data collected by Dr A H Bok of CNC, Amalinda Fish Research Station,
   g = gill netting data published by Marais (1986),
   k = species observed by East London Museum staff in the Kwelera Estuary and likely to occur in other nearby estuaries,
   l = species recorded in existing museum records for other estuaries and likely to occur here,
   m = East London Museum accession records of wet collection and mounted specimens,
   o = live specimens collected by Mr Willie Maritz, East London Aquarium, and
   s = seine netting records published by Marais (1986).

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Carcharhinidae					
Carcharhinus ? obscurus	N	C	-	-	a
Odontaspididae					
Eugomophodus taurus	?	C	-	-	a
Torpedinidae					
Torpedo sinuspersici	N	B	mb	-	ab
Rhinobatoidei					
Rhinobatos annulatus	SE	C	-	-	a
Myliobatidae					
Myliobatus aquila	K	B	b	-	ba
Dasyatidae					
Gymnura natalensis	N	C	ma	a	a
Dasyatis pastinaca	S	C	-	-	ab
Elopidae					
Elops machnata	N	B	gb	g	amb
Anguillidae					
Anguilla sp.	N	FB	m	-	a
Congridae					
Conger wilsoni	?	C	-	-	a
Muraenidae					
Gymnothorax undulatus	N	C	o	-	-
Ophichthidae					
Ophisurus serpens	K	B	k	-	k
Clupeidae					
Gilchristella aestuaria	E	A	s	s	k

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Engraulidae					
Engraulis capensis	S	C	s	-	-
Stolephorus holodon	N	B	k	-	k
Chanidae					
Chanos chanos	N	B	a	-	b
Gonorhynchidae					
Gonorhynchus gonorhynchus	K	C	m	-	-
Arridae					
Galeichthys feliceps	SE	B	g	g	b
Synodontidae					
Trachinocephalus myops	N	C	m	-	-
Synodus indicus	N	C	k	-	k
Saurida gracilis	N	C	k	-	k
Antennariidae					
Antennarius striatus	N	B	-	o	-
Atherinidae					
Atherina breviceps	E	B	k	s	k
Hemiramphidae					
Hemiramphus far	N	B	m	-	-
Hyporamphus h. capensis	SE	B	l	l	l
Holocentrinae					
Sargocentron diadema	N	C	o	-	-
Fistulariidae					
Fistularia sp.	N	C	m	-	m
Syngnathidae					
Syngnathus acus	S	B	k	-	k

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Scorpaenidae					
Pterois miles	N	C	k	-	k
Platycephalidae					
Platycephalus indicus	N	B	l	-	l
Kuhliidae					
Kuhlia mugil	N	C	k	-	k
Serranidae					
Anthias squamipinnis	N	C	o	-	-
Epinephalus guaza	N	C	k	-	k
Epinephalus sp. *malabaricus*	N	C	m	-	-
Teraponidae					
Terapon jarbua	N	B	k	-	k
Pomatomidae					
Pomatomus saltatrix	KS	C	ag	g	ab
Haemulidae					
Pomadasys commersonnii	N	B	bg	g	ab
Pomadasys olivaceum	?	C	s	s	b
Lutjanidae					
Lutjanus argentimaculatus	N	B	l	-	a
Sparidae					
Acanthopagrus berda	N	B	m	g	k
Diplodus cervinus	S	c	s	-	k
Diplodus sargus	S	B	k	s	k
Lithognathus lithognathus	SE	B	a	ga	a
Rhabdosargus holubi	E	B	bs	gs	ab
Rhabdosargus sarba	N	B	-	-	m
Sarba salpa	SE	B	bk	g	k

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Monodactylidae					
Monodactylus falciformis	N	B	b	g	b
Mullidae					
Parupeneus rubescens	N	C	k	-	k
Sciaenidae					
Argyrosomus hololepidotus	S	B	bg	g	ab
Atractocion aequidens	S	C	-	-	a
Leiognathidae					
Uniden sp.	N	B	k	-	k
Pomacanthidae					
Pomacanthus striatus	N	C	o	-	-
Chaetodontidae					
Chaetodon auriga	N	C	o	-	k
Chaetodon blackburnii	N	C	o	-	k
Chaetodon lunula	N	C	o	-	k
Chaetodon marleyi	E	C	o	-	k
Chaetodon vagabundus	N	C	o	-	-
Heniochus acuminatus	N	C	o	-	-
Oplegnathidae					
Oplegnathus conwayi	E	C	k	-	k
Oplegnathus robinsoni	N	C	o	-	-
Carangidae					
Caranx ignoblis	N	B	g	-	m
Caranx sexfasciatus	N	B	g	-	b
Caranx sp.	N	B	bg	-	-
Lichia amia	S	B	bg	l	ab

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Cheilodactylidae					
Chirodactylus brachydactylus	SE	C	k	-	k
Cichlidae					
Oreochromis mossambicus	N	F	-	g	l
Pomacentridae					
Abudefduf sp.	N	C	k	-	k
Labridae					
Halichoeres nebulosus	N	C	o	-	-
Labroides dimidiatus	N	C	o	-	k
Stethojulis sp.	N	C	k	-	k
Thalassoma lunare	N	C	o	-	-
Thalassoma amblycephalum	N	C	o	-	-
Thalassoma purpureum	N	C	o	-	-
Scaridae					
Leptoscaris vaigiensis	N	B	o	-	k
Scarus sp.	N	C	k	-	k
Mugilidae					
Liza alata	N	B	l	-	sb
Liza dumerilii	E	B	s	gs	mb
Liza macrolepis	E	B	-	g	-
Liza richardsonii	SE	B	mgs	gs	mb
Liza tricuspidens	E	B	bg	gs	b
Mugil cephalus	K	B	bg	g	mb
Myxus capensis	E	B	bg	g	b
Valamugil buchanani	N	B	b	-	b

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Polynemidae					
Polydactylus sp.	N	B	m	-	-
Sphyraenida					
Sphyraena sp. *jello*	N	B	-	a	-
Sphyraena qeni	N	-	m	-	-
Blennidae					
Parablennius sp.	N	C	k	-	k
Omobranchus sp.	E	B	k	-	k
Clinidae					
Clinus superciliosus	SE	C	k	-	k
Gobiidae					
Caffrogobius caffer	SE	C	k	-	k
Caffrogobius multifasciatus	SE	A	k	m	k
Caffrogobius natalensis	E	A	k	-	k
Caffrogobius nudiceps	SE	A	k	-	k
Caffrogobius saldanha	E	C	k	-	k
Glossogobius callidus	N	F	k	m	k
Oligolepis keiensis	N	A	k	-	k
Psammogobius knysnaensis	SE	A	k	k	k
Eleotridae					
Eleotris fusca	N	B	m	-	k
Acanthuridae					
Acanthurus dussumieri	N	C	o	-	k
Acanthurus nigrofuscus	N	C	o	-	k
Siganidae					
Siganus sutor	N	B	k	-	k

Family and Scientific Name	Zoogeo-graphic status	Estuary depen-dence category	Estuary		
			Nahoon	Qinira	Gqunube
Trichiuridae					
Trichiurus lepturus	K	C	-	-	m
Bothidae					
Bothus pantherinus	Nc	K	-	K	k
Soleidae					
Heteromycteris capensis	E	B	k	k	k
Solea bleekeri	E	B	k	k	k
Synaptura marginata	N	C	k	-	k
Balistidae					
Pseudobalistes fuscus	N	C	o	-	k
Rhinecanthus aculeatus	N	C	o	-	-
Sufflamen chrysopterus	N	C	o	-	-
Monacanthidae					
Pervagor melanocephalus	N	C	k	-	k
Laputa sp.	N	C	k	-	k
Ostraciidae					
Ostracyon cubiceps	N	C	o	-	-
Ostracyon meleagris	N	C	o	-	-
Tetraodontidae					
Amblyrhynchotes honckenii	E	C	k	-	k
Arothron hispidus	N	B	k	-	k
Arothron immaculatus	N	B	k	-	k
Arothron inconditus	E	C	k	-	k
Arothron stellatus	N	C	k	-	k
Chelonodon laticeps	N	C	k	-	k

APPENDIX IV: Amphibians and reptiles

This section was compiled by Mr C Vernon of the East London Museum.

Amphibians

The order and nomenclature follows that of Passmore and Carruthers (1979). The species were recorded by Poynton (1964) in any of the quarter degree squares 3227 DA, 3227 DC, 3227 DD or 3228 CC.

Scientific Name	Common Name:
Xenopus laevis	Common platanna
Bufo rangeri	Raucous toad
Bufo pardalis	Leopard toad
Breviceps verrucosus	Plaintive rain frog
Breviceps adspersus	Bushveld rain frog
Tomopterna cryptotis	Tremolo sand frog
Tomopterna delalandii	Cape sand frog
Tomopterna natalensis	Natal sand frog
Rana angolensis	Common river frog
Rana grayii	Clicking stream frog
Rana fasciata	Striped stream frog
Ptychadena porosissima	Striped grass frog
Phrynobatrachus natalensis	Snoring puddle frog
Cacosternum boettgeri	Common caco
Cacosternum nanum	Bronze frog
Kassina senegalensis	Bubbling cassina
Kassina wealii	Rattling cassina
Afrixalus brachycnemis	Golden leaf-folding frog
Hyperolius semidiscus	Yellow-striped reed frog
Hyperolius marmoratus	Painted reed frog

Reptiles

The order and nomenclature follows that of Branch (1988).

B = Specimen recorded by Broadley (1988) in one or more of the grid squares 3227 DA, 3227 DC, 3227 DD, 3228 CC or 3327 BB.

M = Museum specimen exists for the area.

L = Likely to occur in the environs of the Nahoon, Qinira and Gqunube estuaries.

Order / Family / Scientific Name	Common Name	Evidence
Chelonii		
Testudinidae		
Geochelone pardalis	Leopard Tortoise	L
Pelomedusidae		
Pelomedusa subrufa	Marsh terrapin	M
Squamata		
Typholopidae		
Typhlops bibronii	Bibron's Blind Snake	B
Typhlops lalandei	Delalande's Blind Snake	B
Leptotyphlopidae		
Leptotyphlops nigricans	Black Thread Snake	B
Leptotyphlops conjectus	Cape Thread Snake	B M
Colubridae		
Lycodontomorphus laevissimus	Dusky-bellied Water Snake	B M
Lamprophis fuliginosus	Brown House Snake	B M
Lamprophis inornatus	Olive House Snake	B M
Lycophidion capense	Cape Wolf Snake	B M
Duberria lutrix	Common Slug Eater	B M
Pseudaspis cana	Mole Snake	B
Psammophylax rhombeatus	Spotted Skaapsteker	B M
Psammophis crucifer	Cross-marked Snake	B
Aparallactus capensis	Cape Centipede Eater	B
Macrelaps nicrolepidotus	Natal Black Snake	B M
Homoroselaps lacteus	Spotted Harlequin Snake	B
Philothamnus semivariegatus	Spotted Bush Snake	B
Philothamnus hoplogaster	Green Water Snake	B M
Philothamnus natalensis	Natal Green Snake	B M
Dasypeltis scabra	Common Egg Eater	B M
Dasypeltis inornata	Southern Brown Egg Eater	B
Crotaphopeltis hotamboeia	Herald Snake	B M
Dispholidus typhus	Boomslang	B M

Order **Family** **Scientific Name**	**Common Name**	**Evidence**
Elapidae		
Naja nivea	Cape Cobra	L
Haemachatus haemachatus	Rinkhals	B M
Viperidae		
Causus rhombeatus	Common Night Adder	B M
Bitis arietans	Puff Adder	B M
Bitis atropos	Cape Mountain Adder	B
Scincidae		
Acontias meleagris	Cape Legless Skink	L
Acontias plumbeus	Giant Legless Skink	M
Mabuya capensis	Cape Skink	L
Mabuya homalocephala	Red-sided Skink	L
Mabuya varia	Variable Skink	L
Lacertidae		
Pedioplanis lineoocellata	Spotted Sand Lizard	L
Cordylidae		
Gerrhosaurus flavigularis	Yellow-throated Plated Lizard	M
Chaemaesauria anguina	Cape Grass Lizard	M
Cordylus cordylus	Cape Girdled Lizard	L
Varanidae		
Varanus exanthelmaticus	Rock Monitor	L
Varanus niloticus	Water Monitor	M
Agamidae		
Agama atra	Southern Rock Agama	L
Chamaeleonidae		
Brachypodion sp.	Dwarf Chameleon	L
Gekkonidae		
Hemidactylus mabouia	Moreau's Tropical House Gecko	L
Pachydactylus maculatus	Spotted Gecko	L

APPENDIX V: Birds recorded at the Nahoon and Qinira estuaries.
The table below is based on observations and records collected by Mr C Vernon of the East London Museum.

F = frequently seen
O = occasionally seen
R = rarely seen
\- = no recorded sightings.

Scientific Name	Common Name	Roberts No.	Nahoon	Qinira
Tachybaptus ruficollis	Dabchick	8	-	F
Phalacrocorax carbo	Whitebreasted Cormorant	55	O	F
Phalacrocorax africanus	Reed Cormorant	58	O	F
Anhinga melanogaster	Darter	60	O	O
Ardea cinerea	Grey Heron	62	O	F
Ardea melanocephala	Blackheaded Heron	63	-	O
Ardea goliath	Goliath Heron	64	-	O
Ardea purpurea	Purple Heron	65	-	F
Egretta alba	Great White Heron	66	R	R
Egretta garzetta	Little Egret	67	O	F
Egretta intermedia	Yellowbilled Egret	68	R	-
Bubulcus ibis	Cattle Egret	71	-	F
Nycticorax nycticorax	Blackcrowned Night Heron	76	-	O
Gorsachius leuconotus	Whitebacked Night Heron	77	R	R
Ixobrychus minutus	Little Bittern	78	-	R
Scopus umbretta	Hamerkop	81	R	R
Ciconia nigra	Black Stork	84	R	R
Threskiornis aethiopicus	Sacred Ibis	91	-	F
Bostrychia hagedash	Hadeda	94	-	F
Platalea alba	Spoonbill	95	-	O
Alopochen aegyptiacus	Egyptian Goose	102	O	F

Scientific Name	Common Name	Roberts No.	Nahoon	Qinira
Tadorna cana	Shelduck	103	-	O
Anas undulata	Yellowbilled Duck	104	O	F
Anas sparsa	Black Duck	105	-	R
Anas capensis	Cape Teal	106	-	R
Anas erythrorhyncha	Redbilled Teal	108	-	O
Anas smithii	Cave Shoveller	112	R	O
Plectropterus gambensis	Spurwinged Goose	116	-	R
Haliaeetus vocifer	Fish Eagle	148	R	O
Circus ranivorus	Marsh Harrier	165	-	R
Pandion haliaetus	Osprey	170	R	R
Balearica regulorum	Crowned Crane	209	-	R
Porphyrio porphyrio	Purple Gallinule	223	-	R
Fulica cristata	Redknobbed Coot	228	-	O
Podica senegalensis	Finfoot	229	-	R
Haematopus moquini	Black Oystercatcher	244	F	-
Charadrius hiaticula	Ringed Plover	245	F	F
Charadrius marginatus	Whitefronted Plover	246	F	F
Charadrius tricollaris	Threebanded Plover	249	-	F
Charadrius leschenaultii	Sand Plover	251	R	O
Pluvialis squatarola	Grey Plover	254	O	O
Vanellus armatus	Blacksmith Plover	258	-	O
Arenaria interpres	Turnstone	262	F	R
Xenus cinereus	Terek Sandpiper	263	F	R
Tringa hypoleucos	Common Sandpiper	264	F	F
Tringa glareola	Wood Sandpiper	266	-	O
Tringa stagnatalis	Marsh Sandpiper	269	-	O
Tringa nebularia	Greenshank	270	F	O
Calidris canutus	Knot	271	-	R

APPENDIX V: (Continued)

Scientific Name	Common Name	Roberts No.	Nahoon	Qinira
Calidris ferruginea	Curlew Sandpiper	272	O	O
Calidris minuta	Little Stint	274	R	R
Calidris alba	Sanderling	281	O	-
Philomachus pugnax	Ruff	284	R	-
Gallinago nigripennis	Ethiopian Snipe	286	-	R
Limosa lapponica	Bartailed Godwit	288	R	R
Numenius phaeopus	Whimbrel	290	O	R
Recurvirostra avosetta	Avocet	294	R	-
Burhinus vermiculatus	Water Dikkop	298	F	O

APPENDIX VI: Mammals occurring in the vicinity of the Nahoon, Qinira and Gqunube estuaries. (Source: C.J. Vernon, East London Museum).

The order and nomenclature follow that of Smithers (1983). Species listed in brackets may occur, or once did occur in the area but are now extirpated. The evidence supporting inclusion in this list is based on the following:

A - Museum specimen for the study area.
B - Known through observation to live in the study area.
C - Known from museum specimens to occur in the catchment of the three rivers and so could be found in the study area.
D - Known from observation to occur in the catchment and so could be found in the study area.
E - Evidence based on skeletal material in owl pellets.
F - Study area falls within the distribution of the species as reported by Smithers (1983).
G - Reported by McLachlan (1986).

Order **Family** **Scientific Name**	**Common Name**	**Evidence**
Insectivora		
Soriciidae		
Myosorex cafer	Dark-footed forest shrew	E
Myosorex varius	Forest shrew	F
Suncus infinitesimus	Least dwarf shrew	F
Crocidura cyanea	Reddish-grey musk shrew	F
Crocidura flavescens	Greater musk shrew	E
Chrysochloridae		
Chrysospalax villosus	Rough-haired golden mole	C
Amblysomus iris	Zulu golden mole	F
Amblysomus hottentotus	Hottentot golden mole	A
Chiroptera		
Pteropodidae		
Epomophorus wahlbergi	Wahlberg's epauletted fruit bat	A
Eidolon helvum	Straw-coloured fruit bat	F
Rousettus aegyptiacus	Egyptian fruit bat	A
Emballonuridae		
Taphozous mauritianus	Tomb bat	D
Molossidae		
Tadarida condylura	Angola free-tailed bat	F
Tadarida aegyptiaca	Egyptian free-tailed bat	F

Order Family Scientific Name	Common Name	Evidence
Vespertilionidae		
Miniopterus schreibersii	Schreiber's long-fingered bat	F
Myotus tricolor	Temminck's hairy bat	F
Pipistrellus kuhlii	Kuhl's bat	F
Pipistrellus nanus	Banana bat	BF
Eptesicus hottentotus	Long-tailed serotine bat	F
Eptesicus capensis	Cape serotine bat	F
Scotophilus dinganii	Yellow house bat	F
Nycteridae		
Nycteris thebaica	Common slit-faced bat	F
Rhinolophidae		
Rhinolophus clivosus	Geoffroy's horseshoe bat	F
Rhinolophus capensis	Cape horseshoe bat	F
Rhinolophus swinnyi	Swinny's horseshoe bat	F
Hipposideridae		
Hipposideros caffer	Sundeval's leaf-nosed bat	F
Primates		
Cercopithecidae		
(Papio ursinus)	(Chacma baboon)	F
Cercopithecus aethiops	Vervet monkey	A
(Cercopithecus mitis)	(Samango monkey)	D
Lagomorpha		
Leporidae		
Lepus saxatilis	Scrub hare	B
Pronolagus rupestris	Smith's red rock rabbit	D
Pronolagus crassicaudatus	Natal red rock rabbit	F
Rodentia		
Bathyergidae		
Cryptomys hottentotus	Common molerat	A
Hystericidae		
Hystrix africaeaustralis	Porcupine	B
Pedetidae		
Pedetes capensis	Springhaas	D
Gliridae		
Graphiurus ocularis	Spectacled dormouse	B
Graphiurus murinus	Woodland dormouse	F
Thryonimyidae		
Thryonomys swinderianus	Greater cane rat	A
Cricetidae		
Dendromus melanotis	Grey climing mouse	D
Dendromus mesomelas	Brant's climbing mouse	F
Mystromys albicaudatus	White-tailed mouse	E
Otomys irroratus	Vlei rat	B
Saccostomus campestris	Pouched mouse	E

Order **Family** **Scientific Name**	**Common Name**	**Evidence**
Muridae		
Rhabdomys pumilio	Striped mouse	E
Grammomys dolichurus	Woodland mouse	D
Mus musculus	House mouse	F
Mus minutoides	Pygmy mouse	F
Mastomys natalensis	Natal multimammate mouse	E
Aethomys namaquensis	Namaqua rock mouse	F
Rattus rattus	House rat	B
Rattus norvegicus	Brown rat	F
Gerbillurus paeba	Hairy-footed gerbil	G
Carnivora		
Hyaenidae		
(Proteles cristatus)	(Aardwolf)	F
(Hyaena brunnea)	(Brown hyaena)	D
(Crocuta crocuta)	(Spotted hyaena)	D
Felidae		
(Panthera pardus)	(Leopard)	F
(Panthera leo)	(Lion)	F
(Felis caracal)	(Caracal)	F
(Felis lybica)	(African wild cat)	C
(Felis serval)	(Serval)	C
(Felis catus)	(Domestic cat)	F
Canidae		
(Lycaon pictus)	(Wild dog)	F
(Canis mesomelas)	(Black-backed jackal)	C
Mustelidae		
Aonyx capensis	Cape clawless otter	B
(Lutra maculicollis)	(Spotted-necked otter)	F
(Mellivora capensis)	(Honey badger)	F
Poecilogale albinucha	Striped weasel	B
(Ictonyx striatus)	(Striped polecat)	C
Viverridae		
Genetta genetta	Small-spotted genet	C
Genetta tigrina	Large-spotted genet	A
Herpestes ichneumon	Large grey mongoose	C
Galerella pulverulenta	Small grey mongoose	C
Ichneumia albicauda	White-tailed mongoose	D
Atilax paludinosus	Water mongoose	B
Tubulidentata		
Orycteropodidae		
Orycteropus afer	Antbear (Aardvark)	B
Proboscidae		
Elephantidae		
(Loxodonta africana)	(Elephant)	A

Order Family Scientific Name	Common Name	Evidence
Hyracoidae		
Procaviidae		
Procavia capensis	Rock dassie	B
(Dendrohyrax arboreus)	(Tree dassie)	D
Perissodactyla		
Rhinocerotidae		
(Diceros bicornis)	(Black rhinoceros)	C
Artiodactyla		
Suidae		
Potamochoerus porcus	Bushpig	B
Hippopotamidae		
(Hippopotamus amphibius)	(Hippopotamus)	B
Bovidae		
Philantomba monticola	Blue duiker	B
Sylvicapra grimmia	Common duiker	B
(Raphicerus campestris)	(Steenbok)	F
Raphicerus melanotis	Grysbok	B
(Syncerus caffer)	(Buffalo)	F
Tragelaphus scriptus	Bushbuck	B
(Taurotragus oryx)	(Eland)	C
(Redunca arundinum)	(Reedbuck)	F

APPENDIX VII: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: Nahoon, Qinira, Gqunube	YEAR (DATE OF INFORMATION)	Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing	Salinity	General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Food webs/Ecosystems	Water	Legislation	Management/Planning	Conservation/Utilization	Historical
		ABIOTIC														BIOTIC																MANAGEMENT					
		Physiography			Geology			Physics				Salinity	Chemistry			Microbiology	Flora					Fauna										Food webs/Ecosystems					
Sources of information		Guide to available information																																			
Acocks	1975																				*																
Antrobus	1986																																			*	
Avis	1986a																				*															*	
Avis	1986b																				*																
Beckley	1983																										*										
Bell-Cross	1983																																				*
Board	1962				*																																
Bok	1979																										*										
Bok	1988																										*										
Branch	1988																												*								
Branch and Grindley	1979																										*										
Broadley	1988																												*								
Bulpin	1980																																				*
Burns	1986																				*																
Burns and Lubke	1986																				*																
Burns et al	1988																											*									
Campbell and Bate	1986a																*																				
Campbell and Bate	1986b																*																				

APPENDIX VII: (Continued)

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																	MANAGE-MENT				
		Physio-graphy			Geology			Physics					Chemistry				Flora					Fauna															
Nahoon, Qinira, Gqunube		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing	Salinity	General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Food webs/Ecosystems	Water	Legislation	Management/Planning	Conservation/Utilization	Historical
Sources of information		Guide to available information																																			
Cape of Good Hope	1975																																			*	
Cape of Good Hope	1985																																	*	*	*	
Courtenay-Latimer	1964																													*							
Cowling	1983																				*																
CSIR	1985		*				*				*																									*	
CSIR	1987	*					*			*																											
Du Toit	1926				*																																
Esterhuysen and Reddering	1985						*		*																											*	
Everard	1987																				*																
Fabricius and Heath	1988																																		*	*	
Giffen	1963																*																				
Hall	1988					*																															
Hanekom and Baird	1984																										*										
Hartmann	1988					*																															
Hartmann et al.	1981						*																														
Heydorn	1986																																			*	
Heydorn and Tinley	1980	*		*				*	*																												
Jezewski and Roberts	1986	*	*																																	*	

APPENDIX VII: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: Nahoon, Qinira, Gqunube

Sources of information	YEAR (DATE OF INFORMATION)	ABIOTIC: Physiography: Catchment characteristics	ABIOTIC: Physiography: Dams/Obstructions	ABIOTIC: Physiography: Morphology	ABIOTIC: Geology: Geology	ABIOTIC: Geology: Palaeoenvironment	ABIOTIC: Geology: Sedimentology	ABIOTIC: Physics: Climate	ABIOTIC: Physics: Oceanography	ABIOTIC: Physics: Hydrology / Flood regime	ABIOTIC: Physics: Circulation and mixing	ABIOTIC: Salinity	ABIOTIC: Chemistry: General Chemistry	ABIOTIC: Chemistry: Eutrophication	ABIOTIC: Chemistry: Pollution	BIOTIC: Microbiology	BIOTIC: Flora: Phytoplankton	BIOTIC: Flora: Algae	BIOTIC: Flora: Aquatic vegetation	BIOTIC: Flora: Semi-aquatic vegetation	BIOTIC: Flora: Terrestrial vegetation	BIOTIC: Fauna: Zooplankton	BIOTIC: Fauna: Terrestrial invertebrates	BIOTIC: Fauna: Other aquatic invertebrates	BIOTIC: Fauna: Crustaceans	BIOTIC: Fauna: Molluscs	BIOTIC: Fauna: Fish	BIOTIC: Fauna: Amphibians	BIOTIC: Fauna: Reptiles	BIOTIC: Fauna: Birds	BIOTIC: Fauna: Mammals	BIOTIC: Food webs/Ecosystems	MANAGEMENT: Water	MANAGEMENT: Legislation	MANAGEMENT: Management/Planning	MANAGEMENT: Conservation/Utilization	MANAGEMENT: Historical
		Guide to available information																																			
Kassier et al.	1988																																			*	
Knoop et al.	1986																	*	*																		
Lubke and Van Wijk	1988																				*																
Lubke et al.	1988																				*																
Lusher	1984														*	*																					
Marais	1986																										*										
Middleton et al.	1981	*					*	*		*																										*	
Morris	1986							*											*		*			*	*	*	*								*	*	*
Mountain	1945				*																																
Mountain	1966				*																																
Mountain	1968				*																																
Mountain	1974				*																																
Nicol	1988				*																																
Noble and Hemens	1978									*																											
O'Keeffe	1986																																		*	*	
Passmore and Carruthers	1979																											*									
Pollution Control Technologies	1981									*			*	*	*	*																					
Poynton	1964																											*									

APPENDIX VII: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: Nahoon, Qinira, Gqunube

		ABIOTIC														BIOTIC																	MANAGEMENT				
		Physiography			Geology			Physics					Chemistry				Flora					Fauna															
Sources of information	YEAR (DATE OF INFORMATION)	Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing	Salinity	General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Food webs/Ecosystems	Water	Legislation	Management/Planning	Conservation/Utilization	Historical
Poynton	1971							*																													
Raal	1992		*						*																*											*	
Raal and Burns	1989																				*															*	
Randall and Martin	1986																													*		*					
Raper	1989																																				*
Reddering and Esterhuysen	1986	*			*		*			*																										*	
Reddering and Esterhuysen	1987						*			*																											
Reddering et al.	1986										*	*																									
Revel Fox et al.	1986																																		*		
Richards	1982			*			*																														
Rossouw	1969			*																																	
Rust	1988				*																																
Rust et al.	1985		*	*	*		*			*																											
Schulze	1947							*																													
Schulze	1965							*																													
Shore Protection Manual	1973								*																												
Skelton	1987																										*										
Smith and Heemstra	1975																										*										

APPENDIX VII: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: Nahoon, Qinira, Gqunube

Guide to available information

Sources of information	YEAR (DATE OF INFORMATION)	ABIOTIC: Physiography			ABIOTIC: Geology			ABIOTIC: Physics				ABIOTIC	ABIOTIC: Chemistry			BIOTIC	BIOTIC: Flora					BIOTIC: Fauna										BIOTIC	MANAGEMENT				
		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing	Salinity	General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Food webs/Ecosystems	Water	Legislation	Management/Planning	Conservation/Utilization	Historical
Smithers	1983																														*						
South Africa Sea Shore Act	1935																																	*	*	*	
South Africa	1972																																	*	*	*	
South Africa	1975																																	*	*	*	
South Africa Envir. Cons. Act	1989																																	*		*	
South Africa Dept Water Affairs	1963		*																																		
South Africa Dept Water Affairs	1975		*																																		
South Africa Dept Water Affairs	1976		*																																		
South Africa Dept Water Affairs	1978									*																											
Stephan Robertson & Kirsten	1991																								*	*	*								*	*	
Stone	1988							*																													
Stuart	1981																														*						
Swart	1986						*	*																													
Swart and Serdyn	1981								*																												
Talbot et al.	1985												*	*	*	*																					
Tinley	1985							*													*																
Tow	1981																																*				
Truswell	1977				*																																

APPENDIX VII: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: Nahoon, Qinira, Gqunube

Category	Subcategory	Guide to available information	Van Eeden	Vernon	Wallace	Walter and Leith	Watling et al.	Watling	White	Wooldridge	Zeller
MANAGEMENT		Historical	*								
		Conservation/ Utilization									
		Management / Planning									
		Legislation									
		Water									
BIOTIC		Food webs / Ecosystems									
	Fauna	Mammals									
		Birds		*						*	
		Reptiles									
		Amphibians									
		Fish			*					*	
		Molluscs									
		Crustaceans									
		Other aquatic invertebrates								*	
		Terrestrial invertebrates									
		Zooplankton								*	
	Flora	Terrestrial vegetation							*		
		Semi - aquatic vegetation									
		Aquatic vegetation								*	
		Algae									
		Phytoplankton								*	
		Microbiology									
ABIOTIC	Chemistry	Pollution					*	*			
		Eutrophication									
		General Chemistry						*			
		Salinity									
	Physics	Circulation and mixing								*	
		Hydrology / Flood regime								*	
		Oceanography								*	
		Climate				*					
	Geology	Sedimentology								*	*
		Palaeoenvironment									
		Geology									
	Physiography	Morphology								*	*
		Dams/Obstructions									
		Catchment characteristics									
YEAR (DATE OF INFORMATION)			1985	1991	1975	1960	1983	1988	1983	1986	1987

PLATE III:
Slipways and jetties at Torquay Road on the Nahoon Estuary (Photo: ECRU 18.07.91)

PLATE IV:
The Quenera Lagoon (Photo: ECRU 18.07.91).

PLATE V: Public open space near the slipway at Edgewater Road on the Gqunube Estuary. (Photo: ECRU 18.07.91)

LIST OF REPORTS PUBLISHED BY ECRU TO DATE

Estuaries of the Cape Part I. Synopsis of the Cape Coast. Natural features, dynamics and utilization. A E F Heydorn and K L Tinley. *CSIR Research Report* 380.

Estuaries of the Cape Part II. Synopses of available information on individual systems.

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3	Groen	402
4	Swartlintjies	403
5	Holgat	404
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10	Kowie	409
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12	(Buffels Wes, Elsies, Sir Lowry's Pass, Steenbras, Buffels Oos)	411
13	Silvermine	412
14	Sand	413
15	Zeekoe	414
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18	Bot	417
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35	Boknes, Boesmans, Kariega, Kasuka (in prep.)	434
36	Rufane, Riet, Kleinemondes (in prep.)	435
37	Palmiet	436
38	Gourits	437
39	Quko	438
40	Klein	439
41	Groot Berg (in prep.)	440
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