COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
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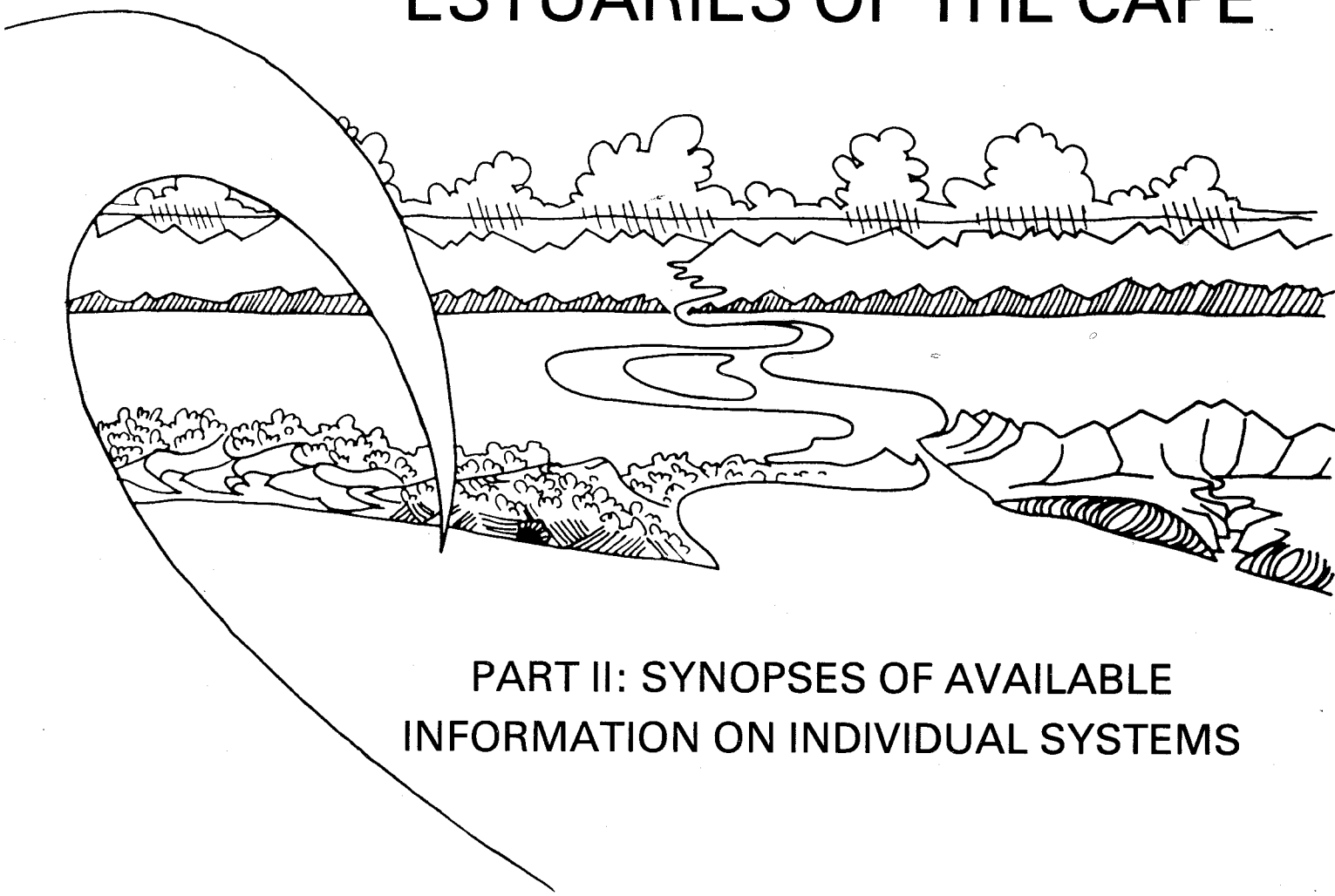
ESTUARIES OF THE CAPE



PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 39:

QUKO (CSE 56)

CSIR RESEARCH REPORT 438

Stellenbosch, South Africa
February 1988

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

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

FRONTISPIECE: THE QUKO ESTUARY FROM AN ALTITUDE OF 180 METRES (86-01-31)

REPORT NO. 39: QUKO (CSE 56)

(CSE 56 – CSIR Estuary Index Number)

BY: M E R BURNS*, M A DU PLESSIS** AND D J VERWOERD***

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UNIVERSITY OF STELLENBOSCH

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PREFACE

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

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

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

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

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

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

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

F P ANDERSON
CHIEF DIRECTOR

National Research Institute for Oceanology, CSIR

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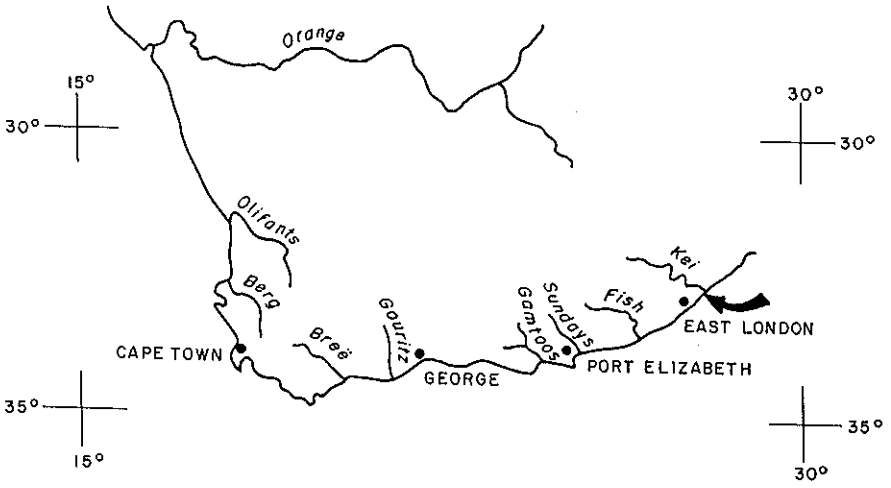
QUKO

1. LOCATION

The Quko River mouth is situated at 32°43'S; 28°19'E. It is approximately 55 km north-east of East London and 10 km south-west of the Kei River mouth (1:50 000 Sheet 3228 CB and CD Kei Mouth).



1.1 Accessibility

The estuary is accessible from the township of Morgan's Bay, via the minor unsurfaced divisional road to the Double Mouth Caravan Park (Figure 1). The latter facility is situated to the north-east of the mouth, on State Forest land. Only pedestrian access to the estuary and mouth can be gained from the caravan park.

Black Rock, on the coast some 2 km south-east of the mouth, is the closest point for public vehicular access to the estuary from this direction. Access can then be gained on foot through the coastal Forest Reserve. A farm track also leads to the middle reaches of the estuary from the south, over the privately-owned property Black Rock and it is possible to make use of this route with the owner's permission.

1.2 Local Authorities

Both the estuary and the river catchments fall within the boundaries of jurisdiction of the Divisional Council of Kaffraria, in the Komga magisterial district. The forestry branch of the Cape Department of Nature and Environmental Conservation administers the State Forest Reserve which adjoins the mouth on both banks for a distance of approximately 300 m inland from the coast.

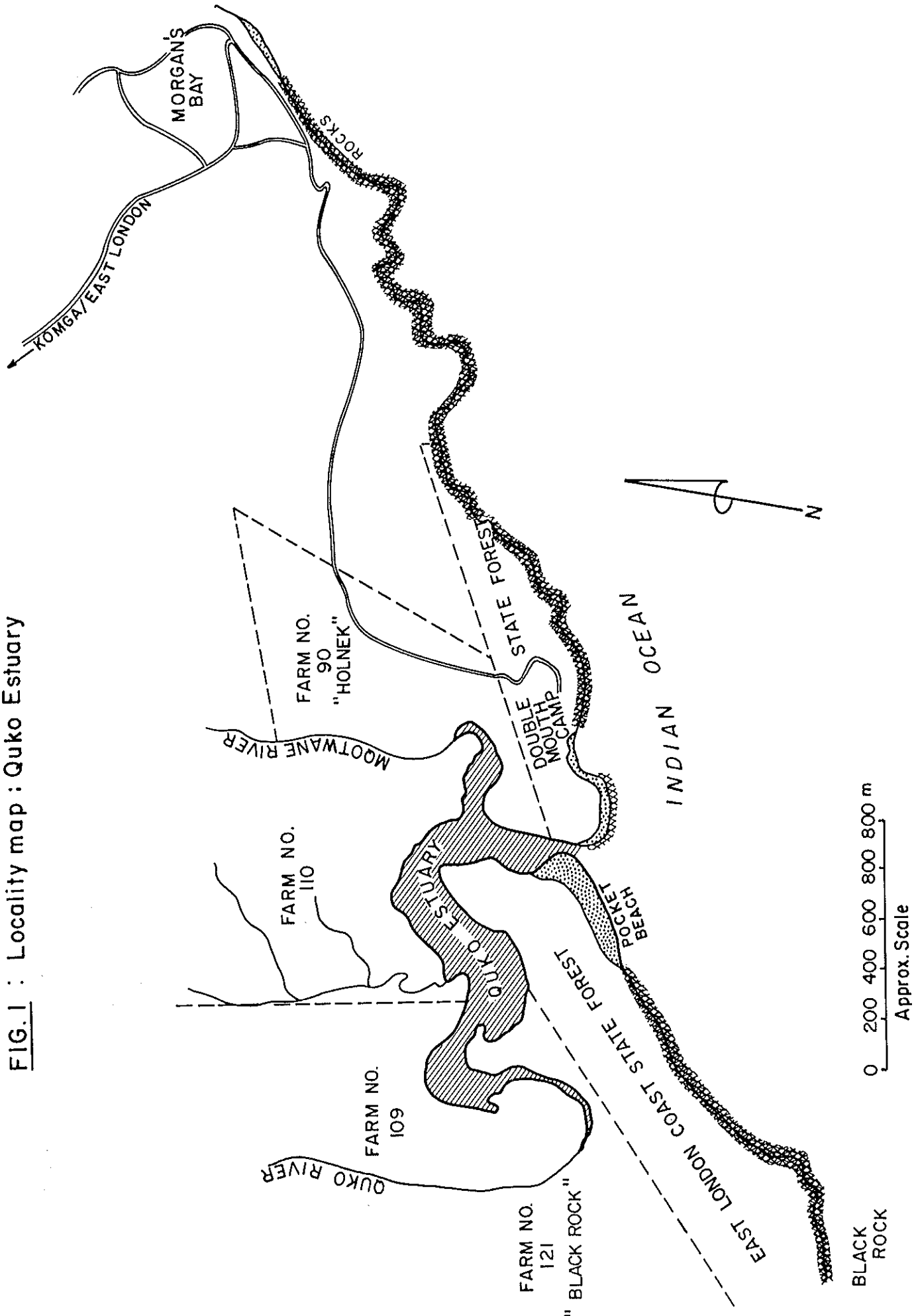


FIG. 1 : Locality map : Quko Estuary

Two privately-owned farms, "Holnek" (comprised, *inter alia*, of farm numbers 90, 109 and 110) and Black Rock (farm number 121) adjoin the middle and upper reaches of the estuary on the north and south banks respectively (Figure 1).

2. HISTORICAL BACKGROUND

2.1 Synonyms and Derivations

The Quko Estuary is referred to locally as Double Mouth, after the confluence of the two rivers which takes place close to the mouth. The name is somewhat misleading, as it could imply that the Quko River enters the sea at two places, which is not the case. According to Bulpin (1980), Quko or Khukho means "something which is spread out" in Xhosa.

The 1:50 000 Sheet 3228 CB and CD uses the name "Quko" for the estuary and also gives the name of the caravan park nearby as "Double Mouth Camp".

2.2 Historical Aspects

Earliest knowledge of the Quko was probably gained by sailors, shipwrecked at, or close to, the river mouth. Bell-Cross (1982, 1983) refers to at least eight wrecks which occurred in the vicinity of Double Mouth, the oldest of which is thought to be the *Santa Espiritu* (1608). The *Asphodel* was wrecked near the mouth on 15 October 1878 and the most recent ship to run aground on the beach to the south of the estuary was the *Margaret A* on 18 May 1972 (C J Vernon, East London Museum, *in litt.)*. Blue and white Oriental porcelain and carnelian and agate beads, included in the cargo of the *Santa Espiritu*, are still found on the beach at the mouth of the estuary and survivors of this wreck are known to have camped there before managing to sail away in makeshift vessels.

More recently, Double Mouth was used as a holiday campsite by the Dutch Reformed Church ministers of the Komga congregation from about 1856 until the early part of this century. The current owner of the farm "Holnek" and his family have the right to use a site on State Forest land at Double Mouth for holidaying and the cottages which were erected around 1930, in front of the caravan park, still stand today.

The Coastal Forest Reserve, which adjoins the estuary on both the north-eastern and south-western banks at its mouth, was demarcated in 1904 in the Government Gazette of the Cape of Good Hope, Proclamation No. 1108, dated 14 October 1904.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Area

The catchment area of the Quko is given by Noble and Hemens (1978) as 254 km^2 and by Heydorn and Tinley (1980) as 312 km^2. An estimate of the catchment area, derived from the effective quaternary catchment size, given by Middleton *et al.* (1981) is 157,1 km^2 (unpublished NRIO records).

3.1.2 River Length

The Quko rises within the coastal lowland region at about the 470 m contour, along the Late Tertiary shoreline and follows a meandering route to the coast for a distance of approximately 40 km. It has one named tributary, the Gwevana, which is 4,5 km long.

The second river of any significance, entering the estuary from the north-east, is the Mqotwane, which is approximately 11 km long. A much smaller, unnamed stream of about 3 km in length enters the middle reaches from the north (see Figure 1).

3.1.3 Geology, Topography and Soils

The majority of the geological formations encountered within the catchment area of the Quko River belong to the Karoo system (Figure 2). The mud- and sandstones of the Beaufort Series predominate and are mainly of fluvial origin, having been laid down after the Permo-Carboniferous glaciation during the warmer Permian and Triassic periods (Truswell, 1977). Post Karoo intrusions of igneous material during the Jurassic period are evident in the relatively abundant presence of dolerite sheets and dykes, which consist mainly of plagioclase and augite. Metamorphism of the 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)). A relatively wide vein of granitized sediment can be seen in the dolerite at Keightleys Krantz, which is situated between the Quko River and Morgan's Bay.

Incision of the river course 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 between the Sundays and Tugela rivers (including the Quko), 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 *et al.*, 1986).

The Quko Estuary lies between relatively steep convex interfluve foreland spurs, which rise to a little over 70 m in altitude, to the remnant former coastal plain (Heydorn and Tinley, 1980). The catchment topography is hilly and undulating and is typical of the area, with the numerous small unnamed tributaries of the Quko having contributed towards this feature.

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 of Beaufort (sedimentary) affinity. A description of the regional soils is provided by Bader in Board (1962). The 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 also 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 only discontinuously along the coastal strip (1-2,5 km wide) where they have not been overlain by aeolian or calcareous Tertiary deposits.

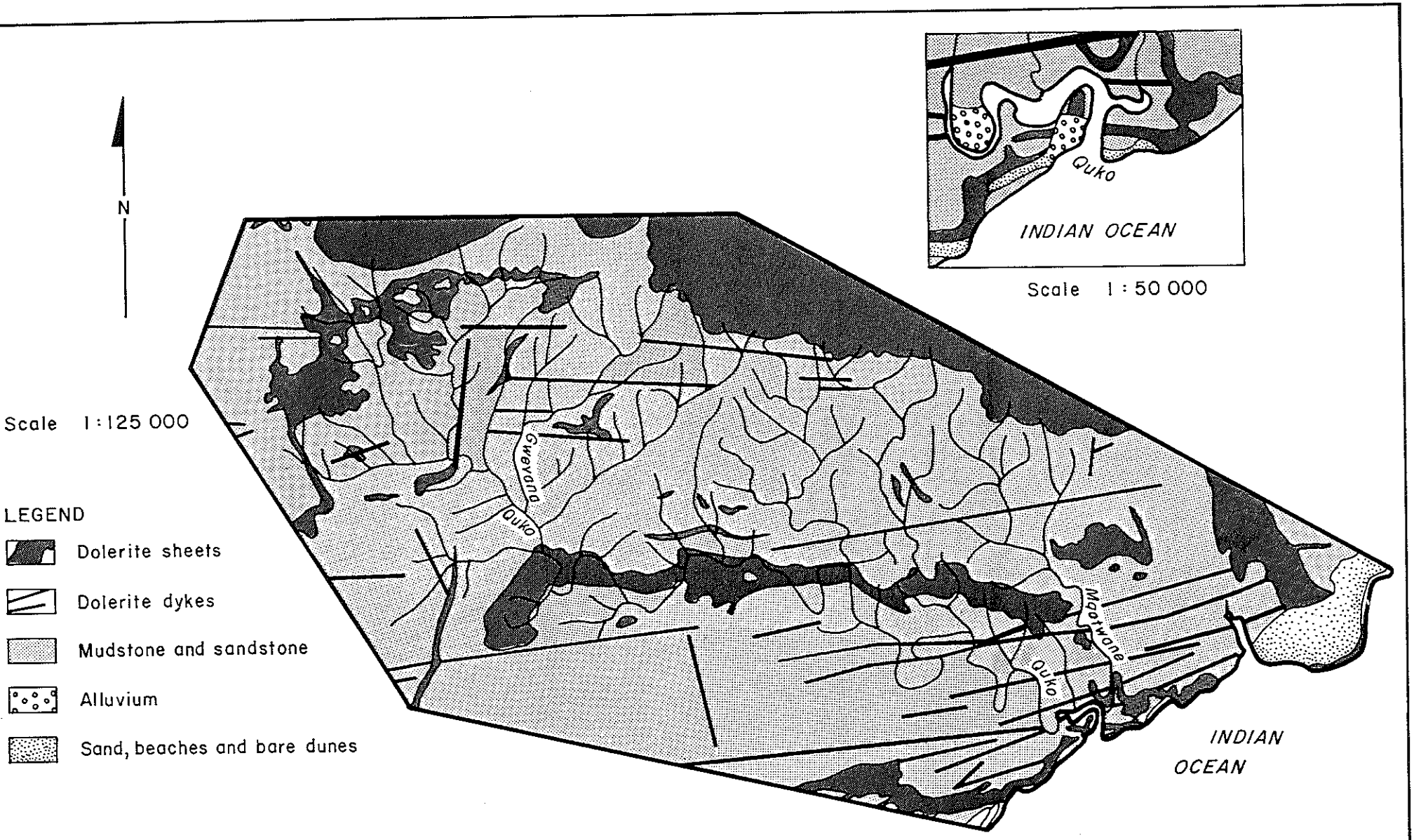


FIG. 2 : Geology and drainage of the Quko River catchment (from Geological sheets 3227D East London and 3228C Kei Mouth)

In general, only the red doleritic clays are adequately drained, where an impervious B-horizon is not encountered. The latter frequently occurs in the black clays, particularly on gentle slopes and valley bottoms, where it impedes drainage, although the A-horizon can be highly porous if sufficiently deep, thereby permitting lateral drainage to take place. The grey sandy loams invariably show impeded drainage due to ther morphological make up, in that they are generally not developed to any great depth, with the B-horizon typically being hard and impervious.

3.1.4 Climate and Run-off

Climate

The climate of the south-eastern Cape coast has been described by a number of authors (Poynton, 1971; Heydorn and Tinley, 1980; Walter and Leith, 1960). Schulze (1947), using the system devised by Köppen, describes the climate experienced at Double Mouth as being humid and temperate, with sufficient rainfall in all seasons and classifies it as the 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 below 22°C; l = lukewarm, mean temperature of all months between 10°C and 22°C).

In general, however, the climate can be described as temperate to warm and humid, tending towards sub-tropical, with a bimodal summer rainfall pattern (see Figure 3).

The major climatic controls which have the greatest influence on the local weather regime are the warm offshore southwards-flowing Agulhas Current, the coastline topography and, as with the sub-continent as a whole, the interaction between the east-moving cyclones of the circumpolar westerlies and the subtropical belt of anticyclonic cells of high pressure (Heydorn and Tinley, 1980; Schulze, 1965; Tinley, 1985).

Precipitation

Rainfall contributes the major input of moisture along the coast and its bimodal (spring and autumn) pattern of distribution is evident from the published rainfall records for East London (Table 1). Rainfall data from unpublished Weather Bureau records for Haga Haga and Kei Mouth are also included in Table 1 and provide a more accurate indication of the local rainfall, since both stations are closer to Double Mouth than East London.

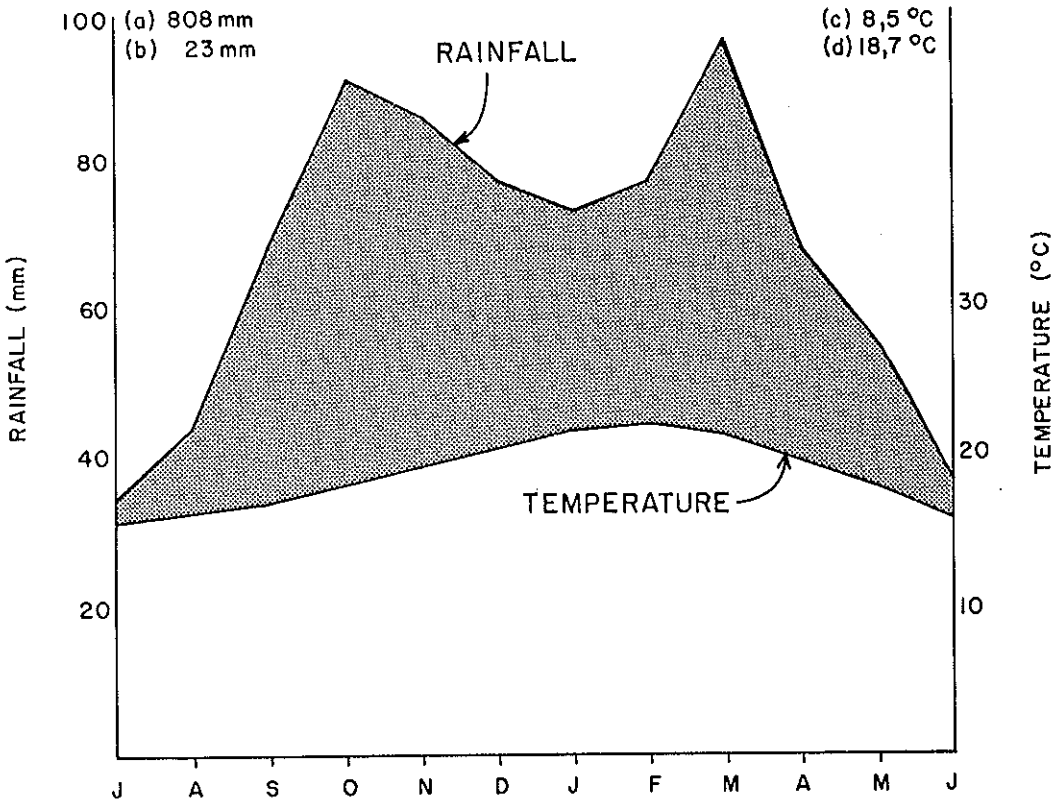
The Quko Estuary is likely to receive a mean annual rainfall of between 954 and 1 005 mm, while the estimated figure for the catchment is 1 051 mm (Middleton *et al.*, 1981).

No information is available on the moisture input from fog but its occurrence is associated with the development and longshore movement of coastal low pressure systems which create favourable conditions for the advection and subsequent condensation of warm moist air from above the Agulhas Current over the colder inshore waters.

TABLE 1: Rainfall recorded in mm at stations close to the Quko Estuary. (Data from published and unpublished Weather Bureau records).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Yr
East London (67)	73	77	97	68	55	36	35	44	69	91	86	77	808
Haga Haga (27)	89	97	133	91	56	38	38	72	94	93	97	86	984
Kei Mouth (84)	63	133	115	84	79	13	32	62	119	83	139	83	1005

(Figures in brackets indicate period in years, for which records were kept).



(a) Mean total annual rainfall
(b) Total number of days with 10mm or more rainfall.
(c) Annual temperature range
(d) Mean annual temperature

Humid period (after Walter + Leith, 1960)

FIG. 3 : The climate diagram for East London.
(data from published Weather Bureau statistics recorded over 67 years)

Temperature

Along the south-eastern Cape coast, sub-normal temperatures are associated with increased cyclonic activity, cloudy weather and minimum insolation, while hotter weather occurs throughout anticyclonic conditions with clear skies and optimum insolation.

Minimum temperatures tend to be relatively stable due to the ameliorating influence of the sea and Agulhas Current but the maxima can show large fluctuations due to berg wind incidence, cold front effects and high cloud cover variability (Schulze, 1965). Mean daily temperature ranges differ from month to month and are greatest in July when both hot berg winds and cold spells can occur. The smallest temperature range occurs in March (see Table 2).

TABLE 2: Mean daily temperature maxima, minima and ranges recorded for East London. (Data from published Weather Bureau records).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean daily maximum (^{o}C)	22,2	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 (^{o}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 (^{o}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

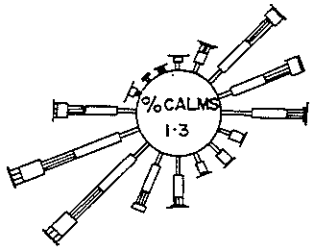
Wind

The predominance of winds with an easterly component (anticyclonic) and a westerly component (cyclonic) change according to the seasonal movement of the major pressure systems. In summer, the stronger winds blow from the east-north-east and in winter, the pattern is reversed, with the winds prevailing from the west and west-south-west (Figure 4). Spring is generally the windiest season of the year, while the months with most calm periods are January to March. The months which are least windy in terms of velocity are April to June. Berg winds (hot offshore) occur in all months of the year but are most common during winter, when synoptic conditions necessary for their formation develop more frequently.

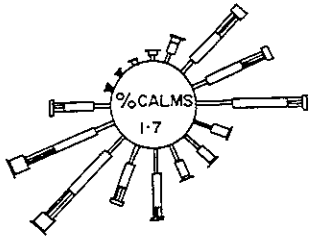
Run-off and Flow Patterns

Noble and Hemens (1978) estimate the mean annual run-off for the Quko to be 41×10^{6} m^{3}. This figure should be regarded as an over-estimate due to the exaggerated catchment size (254 km^{2}) used in its calculation. No actual river flow data are available.

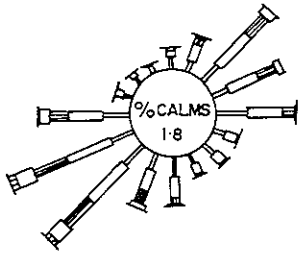
The data given in Table 3 and Figures 5 and 6 are derived from simulated run-off data compiled by Middleton *et al.* (1981) for tertiary catchments and have been adjusted for an estimated catchment area of 157,1 km^{2}. The mean annual run-off figure of $33,94 \times 10^{6}$ m^{3} is considered to be a reasonably accurate estimate.



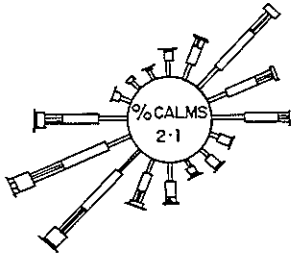
SPRING



SUMMER



ALL YEAR



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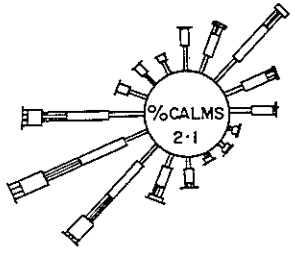


WINTER

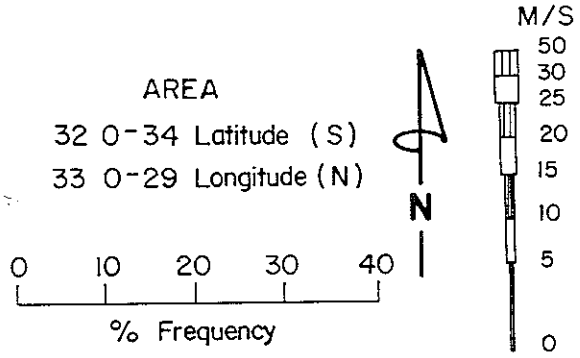


FIG: 4: VOS wind roses for the south-eastern Cape

FIG.5 : Simulated annual run-off for the Quko catchment for the period 1921-1976 (after Middleton et al.,1981) The histograms relate to mean annual rainfall (Figure from CSIR, 1987)

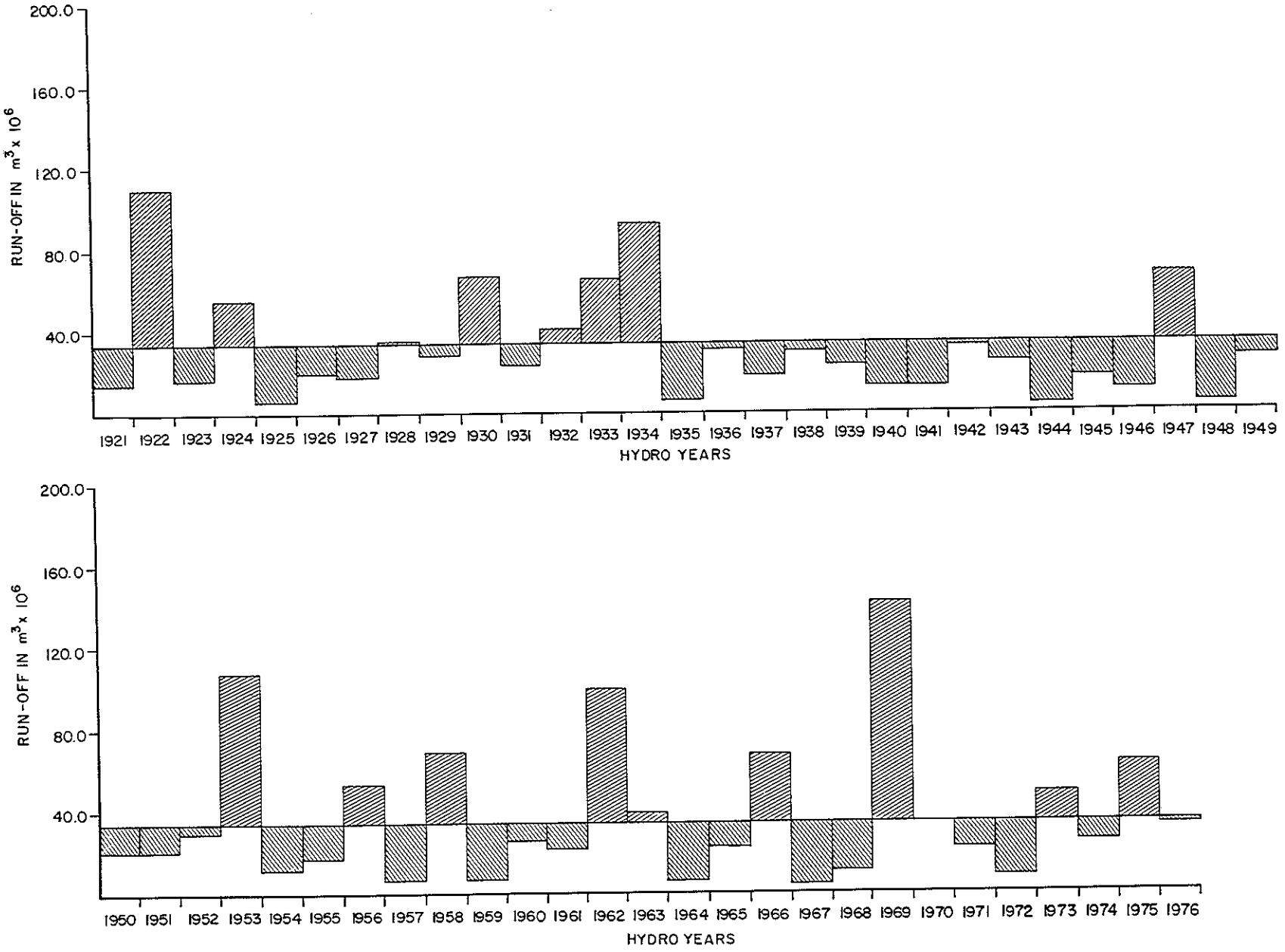
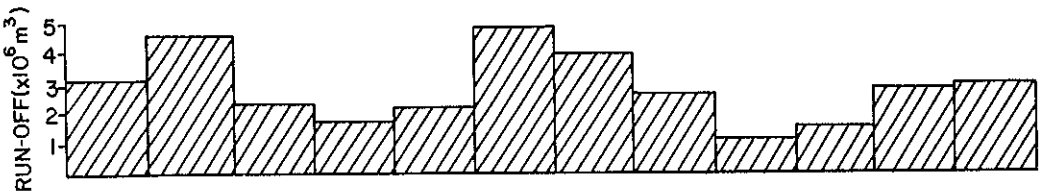


TABLE 3: Simulated mean run-off of the Quko River for the period 1921 to 1976, based on a catchment area of 157,1 km^2 (CSIR, 1987a, after Middleton *et al.*, 1981).

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Total (x 10^6 m^3)
3,21	4,64	2,32	1,70	2,16	4,98	4,02	2,65	1,12	1,51	2,77	2,86	33,94



The bimodal pattern in the simulated monthly run-off data is evident in Table 3, with peaks occurring in spring and autumn and reduced run-off during winter, which correlates with the rainfall pattern. The annual variability between the simulated run-off figures can be seen in Figure 5, where years with below average run-off prevail over those with significantly higher than average run-off, indicating that periodic floods are a feature of the Quko system.

3.1.5 Land Ownership/Uses

Most of the catchment area is utilized for various agricultural practices, of which cattle ranching is the most intensive. Small stock farming, with sheep in particular, is also carried out but is of less significance than the cultivation of pineapples which is showing an increasing trend in response to the recent revival in this market. Other crops raised on a small scale include maize and sunflowers.

The catchment is all under private ownership apart from the "Sotho location" which comprises part of the Kwenxura Scheduled Area. The Sotho residents also carry out a mixture of large and small-stock farming and crop cultivation.

3.1.6 Obstructions

There are no major water impoundments on either the Quko or its tributaries. The largest farm dam in the catchment area is situated on the Gwevana River on the property Batchelor's Rest and has a capacity of 4500 megalitres.

The design of the few small road bridges crossing the various streams and rivers in the catchment is such that it is unlikely that they have any impact on the estuary.

3.1.7 Siltation

Both the regional climate and soil types encountered in the catchment are agents which could aggravate siltation in the estuary. Periodic droughts and floods cause erosion of the clayey soils, derived from the Beaufort series, under the combined influences of reduced soil cover through overgrazing and the inherently low potential of the soils to permit moisture percolation. High rainfall invariably gives rise, therefore, to surface run-off, erosion and river flooding.

The fact that pineapples are grown on a relatively large scale in the catchment, makes the risk of increased erosion potentially high. As this crop does not thrive under conditions of impeded drainage, it is necessary to cultivate sites

on sloping terrain, where excess surface water can drain off rapidly. Hartman *et al.* (1981) estimate that a significant proportion of the coastal belt in the Komga district consists of highly erodible soils. It is also estimated that 18 percent of the land under cultivation in the East London and Komga districts is comprised of soils of high to very high erosion hazard ratings on slopes exceeding six percent, and that 34 percent is comprised of soils with moderate erosion hazard ratings on slopes exceeding 12 percent. Guidelines, which supplement the general provisions contained in the Conservation of Agricultural Resources Act No. 43 of 1983, (which supercedes the Soil Conservation Act of 1969) have been drawn up in order to improve situations which are currently unacceptable and which lead to erosion (Hartman *et al.*, 1981).

Although the pineapple farms in the Quko River catchment were not investigated in detail, they appear from aerial photograph interpretation to have been reasonably well planned, in that much of the riparian vegetation within and adjacent to the natural water courses has been retained. This measure would tend to ameliorate the siltation process, although it is very likely that the rate of soil loss to the river and estuary has increased due to the drastic type of cultivation which is implemented.

Regular visitors to the estuary have reported an increase in the extent of the mudbanks in the estuary over time due to siltation and although it cannot be quantified, this might be so. During the ECRU inspection in February 1987, the water, although somewhat turbid, was not carrying a particularly high silt load and the turbidity appeared to be largely as a result of tidal reworking of flood-deposited silt. During periods of strong river flow however (Table 3), the Quko River is known to carry high silt loads.

Middleton *et al.* (1981) estimate the sediment yield of the catchment to be approximately 150 t/km^2/annum, while Noble and Hemens (1978) estimate it to be between 101 and 150 t/km^2/annum.

3.1.8 Floods

The occurrence of floods can be identified from the simulated monthly run-off data presented in Figure 6. Severe floods during the past 50 years are shown to have occurred during May 1934, April 1947, October 1952 (1953 Hydro year), March 1962 and August 1969 (when 102,87 x 10^6 m^3 of run-off was estimated for this single month).

If a minimum monthly run-off figure of 20 x 10^6 m^3 of water is defined as constituting a significant flood, such floods can be expected to occur approximately every 2,5 years (Figure 6). Flood seasons appear to be limited to spring and autumn.

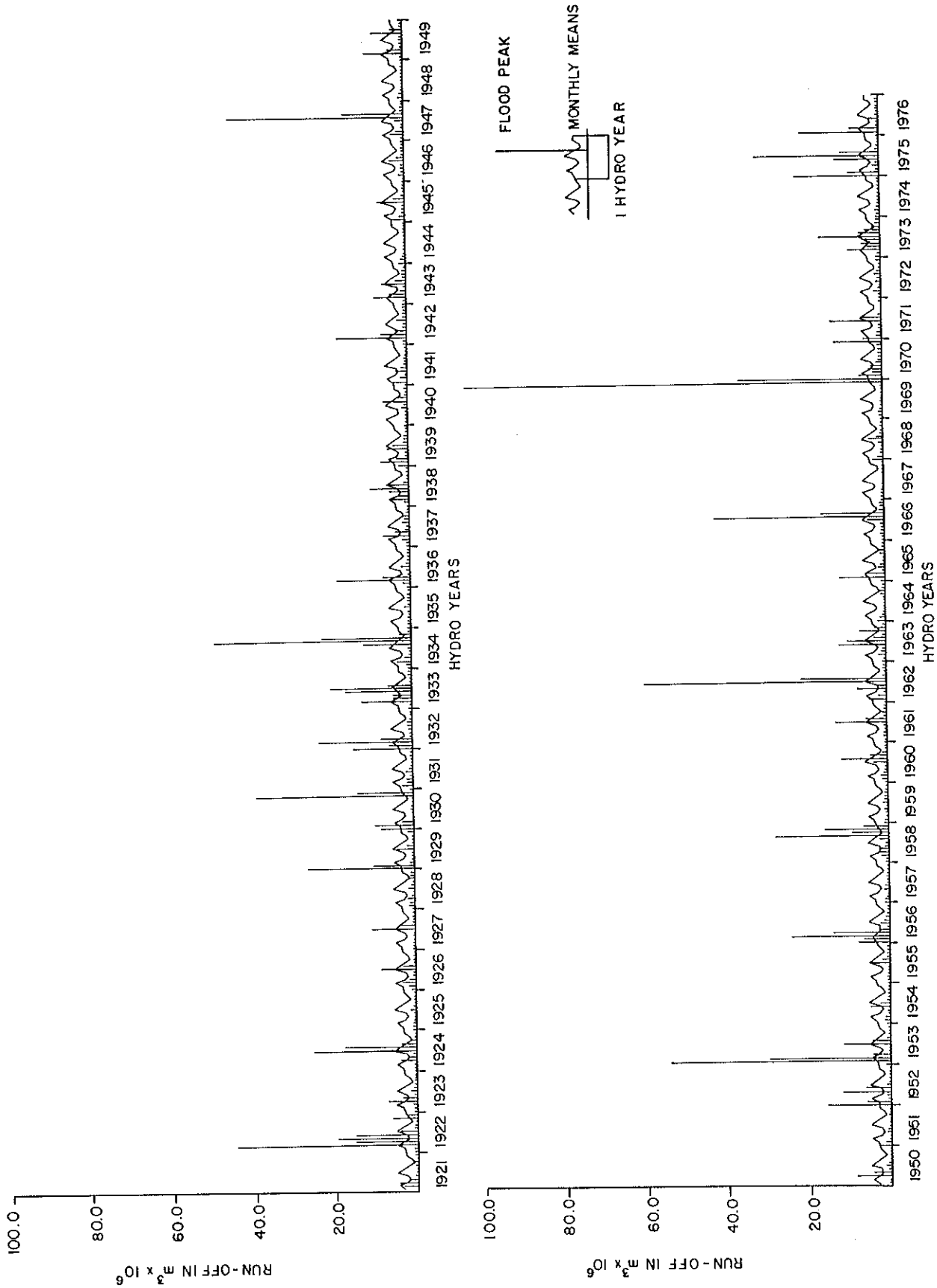
3.2 Estuary

3.2.1 Estuary Characteristics

The mouth of the estuary is located between a single sandspit on the south-western bank with a rocky platform and low cliffs opposite. The channel width, through which normal tidal exchange occurs, varies according to sediment movement, tidal conditions and river flow but it is generally relatively narrow (less than 30 m) and can become reduced seasonally until, on rare occasions, the estuary can close completely. The width of the mouth during floods is approximately 160 m.

Some 500 m upstream from the mouth, the estuary divides into two arms, with the major, western arm representing the drowned and filled course of the Quko River and the eastern arm, that of the Mqotwane. The middle and upper reaches of the

FIG.6 Simulated monthly run-off for the period 1921-1976 (after Middleton et al., 1981) The mean monthly run-off is indicated for comparison with flood peaks (Figure from CSIR, 1987)



Quko meander through two incised hairpin bends up to the limit of tidal exchange, which is approximately 3 km from the mouth. The eastern arm extends for some 360 m to the limit of marine influence (Figure 8).

The total tidal and subtidal areas of the estuary have been determined by Duvenage (1983) as 43 and 31 ha respectively.

3.2.2 Geology and Soils

Geology

The geological formations within the environs of the estuary are exposed only along the north-eastern bank of the estuary in its lower reaches and in the tidally exposed upper reaches. The predominant formations are Beaufort series sand- and mudstones, with dolerite intrusions in the lower and upper reaches (see Figure 2).

Soils

An extensive deposit of alluvium occurs within the uppermost bend at the head of the estuary and sediment of marine origin has formed a dune cordon along the south-western bank at the mouth. The fixed portion of this dune cordon supporting mature dune forest probably dates to the late Pleistocene while the younger dunes, which remain in a dynamic state of erosion and accretion are a product of Recent times (Meissner, 1977; Tinley, 1985). The dune soils are classified by Van der Merwe (1962) as belonging to the arenosol order of soils and are included in the eastern group of higher rainfall, fersiallitic[1] dunes. McLachlan *et al.* (1981) distinguish between beach sands with high and low $CaCO_3$ content and place those in the vicinity of the Quko within the transition zone of intermediate calcareous concentration. The dune sands of the East London coast consist of between 60 and 95 percent of the lighter quartz minerals, with most of the balance being made up of calcite, derived from shell material (Meissner, 1977). Heavy minerals such as ilmenite, rutile and zircon can account for between 0,2 and 3 percent of the sand volume (Tinley, 1985).

Edaphic succession within the dunes has resulted in the development of two soil types which can be classified according to the South African binomial system of Macvicar *et al.* (1977). Most of the younger dune soils fall within the description given to the Motopi or Langebaan series of the Fernwood form, while some of the older duplex dune soils correspond to the Oakleaf form.

3.2.3 Obstructions

There are no artificial obstructions which influence the normal functioning of the estuary and, apart from very infrequent closure during extended periods of drought, unhindered tidal exchange takes place at the mouth between the rocky eastern bank and the sandspit of the western bank. When river flow does cease, a sandbank develops temporarily at the mouth, closing off the estuary from the sea for short periods of time. The position of the channels within the estuary are determined by the natural configurations of the Quko and Mqotwane river courses, their relative flow rates and the presence of sand- and mudbanks which are of marine and terrestrial origin respectively.

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[1] fersiallitic: *less weathered red and yellow lateritic soils with higher clay fraction and appreciable reserves of weatherable minerals. Formed in areas where mean annual rainfall is between 400 and 800 mm.* (Tinley, 1985).

3.2.4 Estuary Mouth Dynamics

(Section contributed by P Badenhorst, Sediment Dynamics Division, NRIO)

Coastal hydraulics

The functioning of an estuary mouth and therefore the estuary as a whole is largely influenced by approaching deep sea swells. Waves approaching the coast at an oblique angle are responsible for the generation of a longshore current carrying a sediment load which, together with the river flow, control the position and state of the estuary mouth.

Based on Voluntary Observing Ship (VOS) recordings, the predominant swell direction for the region originates from the south-west (Swart and Serdyn, 1981) (see Figure 7). This implies that the predominant direction of the longshore current is from south-west to north-east. Since the nearshore wave climate does not vary significantly along the eastern Cape coast, it is reasonable to expect that the potential sediment transport rate at the Quko would be of the same order as that at East London, which is about 600 000 m^3/year (CSIR, 1979). However, because of the rocky coast to the south-west of the Quko, no large source of sediment is available and the actual transport rate will, therefore, be much less than the potential of 600 000 m^3/year.

Estuary hydraulics

A study of available aerial photographs from 1939 to 1987 (ten sets) shows that the mouth is usually open in the form of a shallow channel about 20 m in width, trapped against the rocks on the northern side. A sandy pocket beach of about 400 m in length adjoins the estuary to the south. The first 500 m of the lower reaches, up to the confluence of the two arms is usually in various phases of being sanded-up, that is, the system is flood-tide dominated. It can, therefore, be assumed that a slow build-up of sand normally takes place in the mouth section of the estuary and that this is removed periodically during floods.

The mean annual run-off is estimated at 33,94 x 10^6 m^3 (Middleton *et al.*, 1981). Graphs of simulated annual run-off indicate a very erratic run-off pattern with significant variation about the calculated mean value (Figure 5). Annual run-off figures do, however, tend to remain below the estimated mean for extended periods, such as between 1935 and 1953, after which floods of varying intensities compensated for the deficit (CSIR, 1987).

The generally low river flow indicates that the estuary is floodtide-dominated. Evidence of this is the presence of upstream-orientated sandbanks in the mouth area, which support the conclusion that a slow build-up of sediment generally takes place and that this is subsequently flushed out to sea during flood events.

Sediments

Sand samples were taken in the mouth area on 5 February 1987. Analysis of a sample taken in the mouth, next to the channel, shows the sand as being fine to medium grained (150-370 μ) and well sorted. The sample taken at the south side of the pocket beach, 300 m from the mouth, shows the sand as being fine (150-300 μ) and also well sorted. Because the sand is well sorted it can be assumed that the sand of the pocket beach is well worked and that much of the finer fraction (<150 μ) has been removed by wave action and longshore drift.

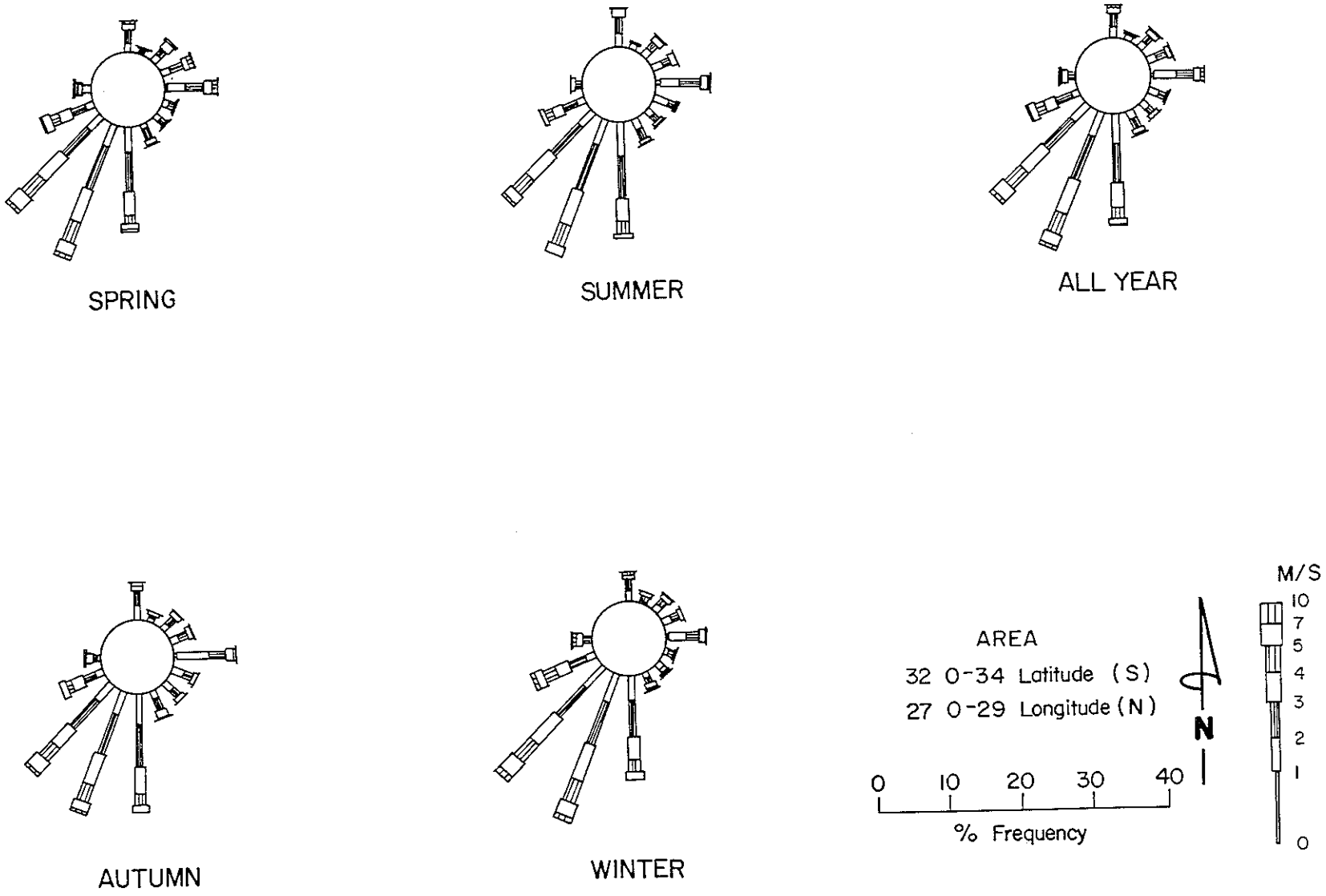

FIG. 7 : VOS swell roses for the south-eastern Cape

Wind and aeolian transport

Wind data obtained from Voluntary Observing Ships (VOS) (Figure 4) indicate that south-westerly winds predominate, with high velocities occurring throughout the year (see Section 3.1.4).

The "all year" diagram, illustrated in Figure 4, indicates that the aeolian transport will take place mainly alongshore from the south towards the mouth, depositing sand in the narrow flow channel from where it will be transported either into the estuary or to the sea depending upon the tide. The width of dry, open sand comprising the pocket beach is, however, relatively narrow (less than 100 m) and this implies that the volume of sand transported will be insignificant. Aeolian transport will thus be a minor source of sediment input to the mouth area of the estuary.

Bathymetry

The Quko mouth is situated on the northern side of a small pocket bay which is about 450 m long. A sandy beach stretches from the south side of this bay to the mouth channel which is trapped against a rocky shore on the northern side.

The mouth area was surveyed by the NRIO on 5 February 1987 (CSIR, in prep.). The bottom of the channel was on a level of about 0,5 m below land levelling datum (mean sea level), increasing in depth to a level of about -0,7 m nearer to the sea. The flat area on the beach was on a level of about two m, sloping upward to a level of about four m at the vegetation line. The slope of the beach was approximately 1 in 30, which is fairly steep and indicative of a medium energy beach.

Historical changes

An analysis of available historical maps (as far back as 1867) and aerial photographs shows that the configuration of the estuary with the two arms and pocket beach has not changed significantly. The aerial photographs since 1939 clearly show that the mouth is usually open with varying amounts of sediment trapped inside the estuary mouth in the form of a sandbank on the right bank, sometimes reaching the first bend in the main arm. From the available data it is concluded that the estuary is in a sedimentary equilibrium.

3.2.5 Physico-chemical Characteristics

Physico-chemical data for the estuary were recorded during the ECRU survey (February, 1987) at the five stations indicated in Figure 8 and are summarized in Table 4. No other information is available, apart from a series of surface salinity measurements taken during July 1984 which were used to identify the limit of marine influence in the estuary. All of the characteristics measured would tend to change both seasonally and under varying tidal conditions.

Temperature

The recorded surface and bottom temperatures measured during an ebb tide illustrate the expected gradient from the shallow, warmed head waters to the colder water at the mouth, where tidal exchange between the estuary and sea occur. The surface temperature range was 2,6°C while the range for the bottom temperatures was slightly higher at 3,7°C. The coldest bottom temperature was measured at station 3, which recorded a depth of 8 metres (Table 4).

FIG.8 : Physico-chemical sampling stations. ECRU survey, Feb. 1987

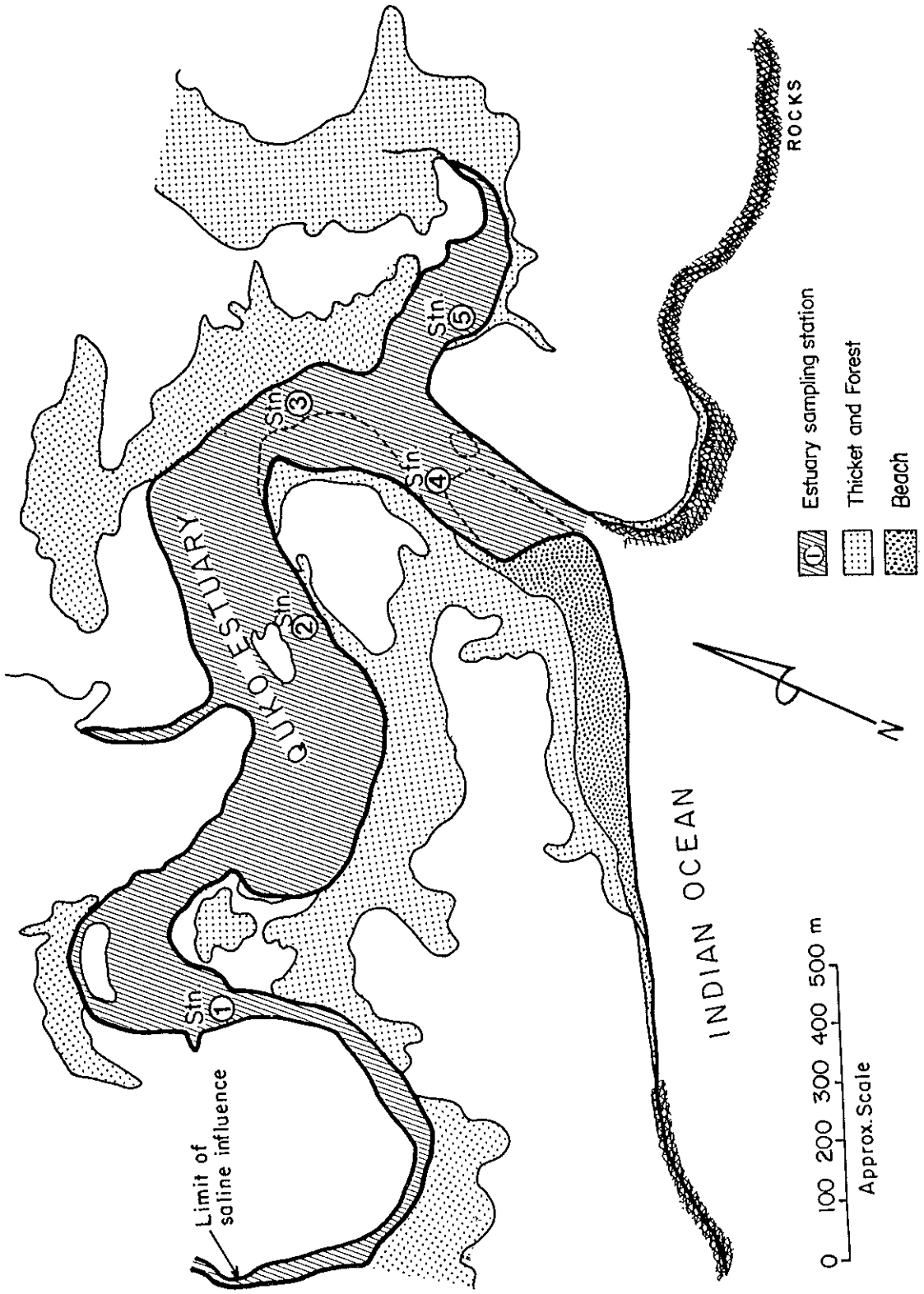

TABLE 4: Physico-chemical data for the Quko Estuary (mouth open) collected during the ECRU survey on 5 February 1987.

Station number (distance from mouth)	Time	State of the tide in the sea	Depth (m)	D.O. (mg/l)		Salinity (°/oo)		Temperature (°C)		Water transparency (Secchi) (m)	Water colour	Substratum type
				Top	Bottom	Top	Bottom	Top	Bottom			
Stn 1 (2 km)	11h15	Neap High at 08h14	1,4	7,4	7,4	32,0	32,0	24,1	23,7	1,0	Turbid greeny-brown	Fine dark silt
Stn 2 (0,8 km)	11h40	Neap Low at 14h18	3,0	7,2	7,6	35,0	35,0	23,4	22,4	0,8	Turbid greeny-brown	Fine black silt
Stn 3 (0,5 km)	12h00	Neap Low at 14h18	8,0	8,0	6,6	35,0	35,0	22,2	20,0	1,1	Light green	Sand
Stn 4 (0,2 km)	12h30	Neap Low at 14h18	1,5	7,2	7,2	35,0	35,0	21,5	21,4	1,15	Light green	Sand
Stn 5 (0,4 km)	12h55	Neap Low at 14h18	1,1	7,2	7,6	34,0	35,0	23,0	21,4	1,25	Turbid greeny-brown	Rock

Transparency

Water transparency, measured using the Secchi disc method, varied from 0,8 to 1,25 m (Table 4). The two upper stations, which were located above silt- and mudbanks recorded the lowest values due to the tidal reworking of these flood deposited sediments. High transparency values were recorded closer to the mouth over marine sand and above the rocky bottom of the short, eastern arm of the estuary. The station at the latter site is likely to experience the lowest tidal velocities due to the reduced head of water contained in this arm and this could also account for the high transparency.

Salinity

During the ECRU survey the freshwater input from the Quko and Mqotwane rivers was low. The marine-dominated state of the estuary is clearly reflected in the measured salinities (Table 4). The extent of mixing is evident in the almost identical bottom and surface salinities at all five stations. Periodic flooding would tend to drastically lower the salinity, particularly of the middle and upper reaches, and vertical and horizontal stratification gradients could be expected to become established for short periods under these conditions. The winter (dry season) limit of marine influence on the estuary, as established from salinity measurements, is approximately 3 km from the mouth (Figure 8).

Dissolved oxygen

As with salinity, the dissolved oxygen values reflect the well mixed state of the estuary water, brought about by the high degree of tidal exchange (Table 4). The values recorded throughout the estuary were close to, or somewhat higher than the expected saturation levels under the prevailing temperature and salinity regimes. The exception was the low value of 6,6 mg/l recorded for the bottom water at station 3, which is a feature of water depth (8 metres). The survey would seem to indicate that the estuary is in a relatively healthy state with little unnatural organic input to the system.

Nutrients

No data are available on the nutrient levels of the estuary. It could be expected, however, that enrichment through agricultural run-off could influence the system, although this is not manifested through the pronounced presence of filamentous algae such as, for example, *Enteromorpha*. The seasonal pattern of river flow, which would tend to flush high nutrient loads through the system during flood periods, and the strong tidal exchange which occurs, would ensure a short residence period of excessive nutrients in the estuary and thereby maintain acceptable levels. The apparent healthy state of the estuary would seem to reflect this situation but a monitoring program should ideally be initiated to confirm this.

3.2.6 Pollution and Public Health Aspects

Although no monitoring for pollution has been carried out, it is almost certain that significant quantities of agricultural chemicals (fertilizers and biocides) do get leached from the catchment area into the estuary. Some of the intensive and sustained chemical treatments applied to pineapple cultivation can include the following:

- The application of potassium chloride and superphosphate as fertilizers at the time of planting, followed by 10 to 15 aerial applications of urea (100 kg/ha/application), potassium sulphate (50 kg/ha), iron sulphate (5 kg/ha) and zinc sulphate (2,5 kg/ha).

- The use of effective and long-lasting weed-killers such as bromacil and diuron (15 kg/ha) which are applied at the time of planting and as boosters.

- Soil fumigation with pesticides such as ethylene dibromide at 60 l/ha or dibromopropane plus dibromopropene at 300 l/ha and the control of specific insects with isazophos at 10 l/ha during planting together with a follow-up treatment at 2 l/ha.

- The application of fungicides such as metalaxyl and/or alliette at 5 kg/ha for the control of *Phytophthera*.

No industrial pollutants enter the estuary but faecal bacteria could be introduced to the system from the "Sotho location" which is situated in the catchment.

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton

The status of phytoplankton within the Quko Estuary has not been established. A sheen of diatomaceous algae was, however, observed on the exposed tidal mud- and sandflats during the inspection in February 1987.

4.1.2 Algae

Macroscopic algae are not abundant and apart from at the mouth itself, apparently only occur as dislodged individuals which are transported into the estuary by tidal action. Species which have been noted either floating or deposited on the shore of the estuary include *Sargassum longifolium*, *Dictyota dichotoma* and *Codium duthieae*.

Filamentous algal species which were not identified but which probably belong to the genera *Cladophora*, *Polysiphonia* and *Rhizoclonium*, occur as epiphytes on *Zostera capensis*.

4.1.3 Aquatic Vegetation

Few macrophyte beds occur in the estuary and the only species of moderate significance is *Zostera capensis*. High salinity values throughout the estuary preclude elements such as *Ruppia* and *Potamogeton* species from becoming established. *Z. capensis* was observed in the eastern arm of the estuary in relatively shallow water (1 m) on a mixed silt and pebble substrate (Figure 9). Tidal reworking of flood-deposited silt could create relatively high water turbidity conditions and this is considered to be a possible factor limiting the distribution of aquatic macrophytes.

4.1.4 Terrestrial and Semi-aquatic Vegetation

(a) Terrestrial Vegetation

Acocks (1975) has broadly classified the terrestrial vegetation of the area as Transitional Coastal Forest (Veld Type No. 1c), occurring as it does between the more subtropical vegetation to the north and the drier coastal thicket which occurs southwards towards Alexandria.

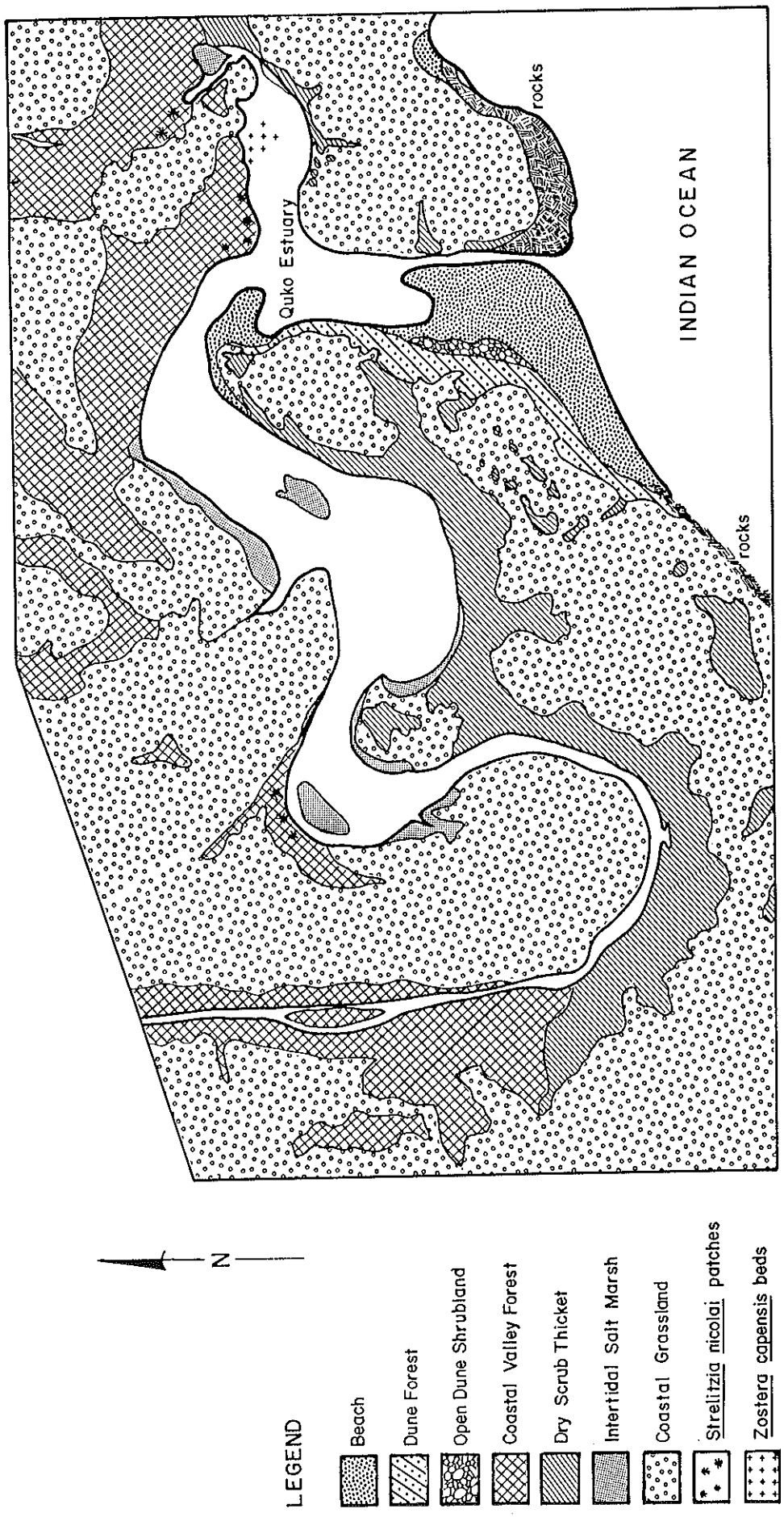

FIG. 9 - The vegetation of the Quko Estuary

The vegetation consists of a mosaic of grassland, forest and scrub-thicket communities which exhibit compositional and structural variations according to their topographical setting. Four mapping units have been used in Figure 9 to distinguish the major vegetation types, which include dune forest, coastal valley forest, dry scrub thicket and coastal grassland. In addition, a transitional or precursor community is shown in Figure 9 and is classified as open dune shrubland. Appendix I lists some of the physical features and more significant species comprising the mapping units, each of which are discussed briefly below.

Dune Forest

A relatively narrow belt of forest occurs on the frontal dune to the west of the estuary mouth, adjacent to the sandy beach (Figure 10). The forest measures between 5 and 7 m in height and consists of a dense canopy stratum above a poorly defined intermediate stratum and fairly open shrub and herb layers.

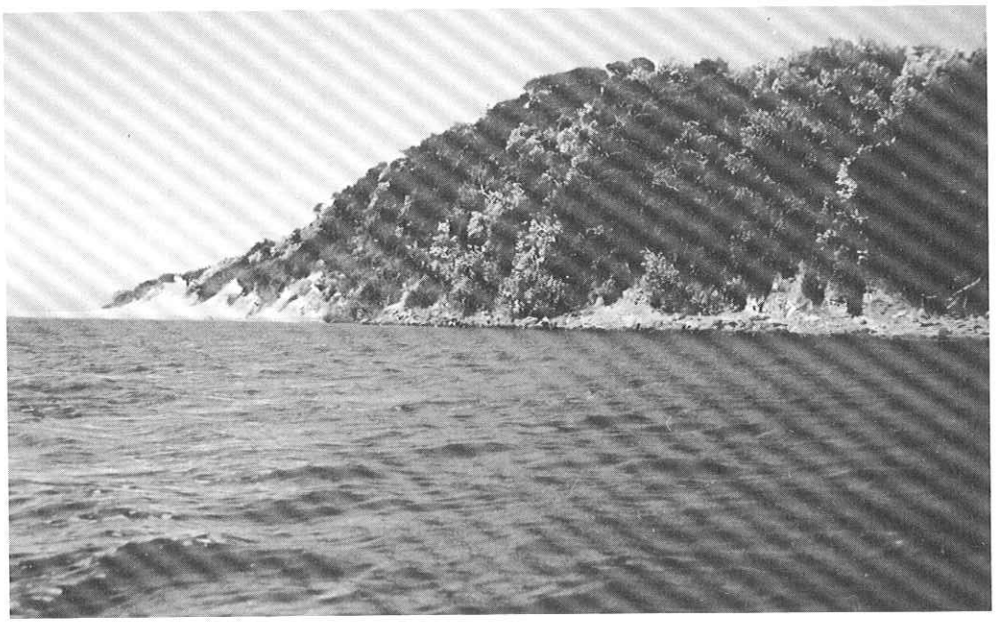

FIG. 10: Forest occupying the dunes to the west of the estuary mouth. The dominant species is *Mimusops caffra* (red milkwood).

Mimusops caffra (red milkwood) is the dominant canopy contributor, with *Maytenus heterophylla* and *Cassine aethiopica* in sub-dominant positions. *Euclea natalensis, Chionanthus foveolata, Allophylus natalensis* and *Acokanthera oblongifolia* occur commonly in the sub-canopy tree layer and support various lianes which extend up into the canopy. *Chironia baccifera* and two *Asparagus* spp were noted to be fairly common on the forest floor.

Coastal Valley Forest

As the name implies, the forest comprising this mapping unit is restricted to the valleys and riparian environs of the Mqotwane and Quko rivers and the small perennial stream which enters the estuary from the north, midway between the two latter rivers (Figure 11). A favourable microclimate and protection from grassland fires are the factors most likely to have permitted the development and

preservation of this forest. The wide species diversity and presence of a number of species at their southern distribution limit makes this forest type particularly interesting from both a phytosociological and biogeographical aspect and worthy of further study.

FIG. 11: Coastal valley forest extending up the course of the Mqotwane River. The transitional climatic environment has induced a complex floristic response.

On the northern bank, the forest margin merges into a *Scutia myrtina* and *Ficus sur* dominated thicket fringe which adjoins the estuary. The forest itself is well structured, with a clearly defined canopy up to 20 m in height and subordinate strata present. Detailed studies would be required to establish the dominance hierarchy in the canopy and other strata but common species recorded during the field inspection include: *Ficus natalensis* (wild fig), *Harpephyllum caffrum* (wild plum), *Schotia latifolia, Olea capensis, Cordia caffra, Protorhus longifolia, Clerodendrum glabrum* in the canopy and *Allophylus dregeanus, Diospyros natalensis, Zanthoxylum capense, Vitellariopsis marginata, Euclea natalensis, Acokanthera oppositifolia, Gardenia thunbergii* and *Dracaena hookerana* in the sub-canopy. The field layer is generally sparse (less than five percent cover) but patches with cover values of up to 80 percent occur. *Oplismenus hirtellus, Setaria* cf. *megaphylla* and *Panicum deustum* are relatively common forest grass elements, as well as an unidentified scandent grass species. Lianes include *Rhoicissus tomentosa* and *Rhoicissus digitata*. Although *Strelitzia nicolai* is found in a number of the vegetation mapping units, it occurs in almost monospecific patches in this forest type on the steep, moist slopes along the northern bank of the estuary. These patches are indicated in Figure 9. The cycad, *Encephalartos altensteinii,* commonly occurs on similar sites.

Some of the forest species reaching their southernmost distribution limit include *Cryptocarya woodii, Milletia grandis, Trichelia dregeana, Allophylus dregeanus, Strychnos henningsii* and *Tricalysia capensis*.

Dry Scrub Thicket

This vegetation type is shown to occur on the hotter, north-facing slopes along the southern margin of the estuary (Figure 12). Both compositional and structural variations occur within this unit and it varies, for instance, from low, open scrub to taller, dense thicket of up to 5 m in height. Typical species include *Diospyros whyteana, Strelitzia reginae, Olea europaea,* (wild olive), *Harpephyllum caffrum, Tarchonanthus camphoratus* (camphor bush), *Cussonia spicata* (cabbage tree), *Euphorbia triangularis* and *E. tetragona*. The transition between this vegetation type and the previous one (coastal valley forest) is not well defined and in places occurs as a continuum rather than across a clearly defined boundary. In this regard, Figure 9 should be interpreted somewhat schematically.

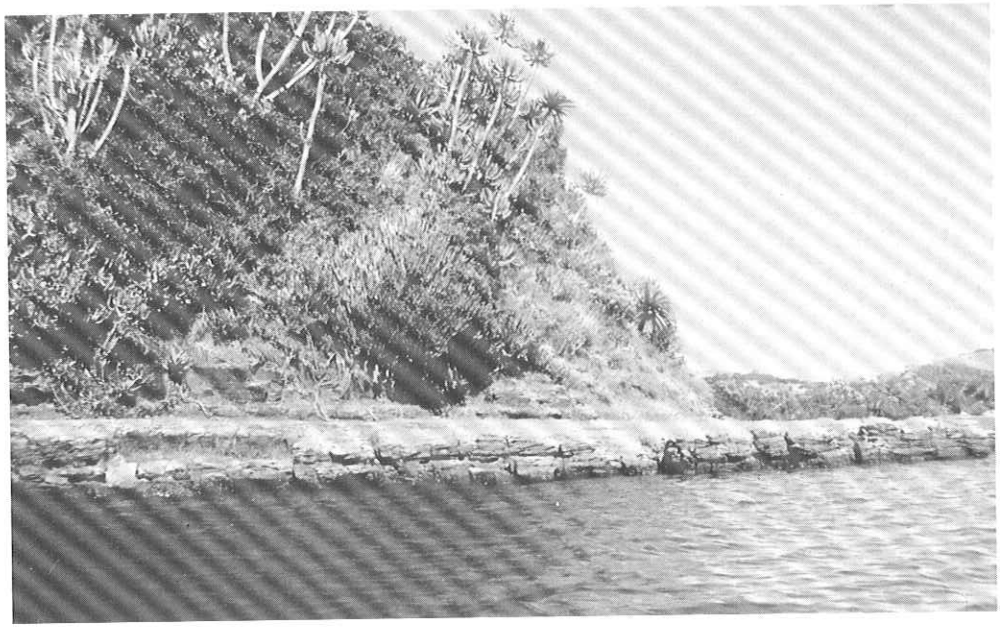

FIG. 12: Dry scrub thicket or valley bushveld which occurs on the hotter north-facing slopes. *Euphorbia triangularis* is a conspicuous component of this vegetation type.

Coastal Grassland

The grassland areas have been subjected to frequent fires, which occasionally may have been of natural origin but most of which are part of the local management prescriptions employed to maintain suitable pastures. The sharply defined forest boundaries and lack of a significant woody ecotone between the grassland and forest bear evidence of this.

The dominant grass species is *Themeda triandra,* with *Cymbopogon excavatus* being the most important sub-dominant species. The latter does, however, tend to form locally dense stands, particularly in the older areas of grassland, in the low-lying moist areas and around the forest margins. In the latter case it contributes towards a type of herbaceous ecotone, together with species such as *Senecio pterophorus, Berkheya bipinnatifida, Helichrysum ordoratissimum* and the shrub, *Diospyros dicrophylla*. Other grassland elements including *Cymbopogon validus, Chloris gayana* and a *Digitaria* species, together with numerous other herbs, contribute approximately 10 percent towards the total cover.

FIG. 13: *Cymbopogon excavatus* and *Acacia karroo* comprising part of the mapped grassland communities. *Themeda triandra* is the dominant grass species.

The successional trend within the grassland would be towards an *Acacia karroo* - *Cymbopogon excavatus* complex in the event of the fire frequency being decreased. This can be seen in the area enclosed by the oxbow made by the Quko at the head of the estuary, where *A. karroo* has become relatively well established (Figure 13). *Aloe ferox* is another locally common element occurring in patches within the grassland areas and is most noticeable on the hillside to the east of the estuary mouth.

Open Dune Shrubland

A narrow zone of open dune shrubland has developed along part of the eastern margin of the strip of dune forest at the mouth of the estuary (Figure 14). This vegetation represents an intermediate stage in the development towards thicket, on a site which has been subjected to flood erosion and which possibly comprises part of the slumped original fixed foredune slope. The dominant species are *Passerina rigida, Rhus crenata* and *Brachylaena discolor,* which have a combined ground cover of approximately 60 percent and a height of between two and four m. *Ipomoea brasiliensis* is the most important primary beach colonizer together with (to a much lesser extent) *Mariscus congestus* and *Arctotheca populifolia.*

Riparian Scrub Thicket

This vegetation, which has not been mapped, occurs as a narrow band on the left bank of the Quko at the head of the estuary. The development of the vegetation towards some climax status is inhibited by periodic flooding and a tangled complex of pioneers and more advanced species has become established. Some of the more common species noted include *Acacia karroo, Sideroxylon inerme* (white milkwood), *Podocarpus falcatus* (yellowwood), *Phoenix reclinata* (wild date palm), *Calodendrum capense* (Cape chestnut), *Dais cotinifolia, Diospyros natalensis, Grewia occidentalis, Senecio pterophorus, Azima tetracantha* and an *Asclepias* sp.

FIG. 14: The belt of open dune shrubland occurring to the west of the estuary mouth, between the dune pioneer vegetation and the established dune forest. The dominant species is *Passerina rigida*, while *Ipomoea brasiliensis* is an important beach colonizer species.

(b) Semi-aquatic Vegetation

The saltmarsh vegetation is relatively insignificant and for the most part, is restricted to a very narrow, discontinuous fringe around the margin of the estuary. Although this is largely due to the steepness of the banks, halophyte colonization has been poor, even where tidally exposed mudflats have developed.

Sporobolus virginicus is locally, the most abundant saltmarsh species and its range extends from a short distance above tidal influence to below the high water mark, where *Paspalum vaginatum* also occurs as a sub-dominant (Figure 15). The landward boundary of what can be regarded as the saltmarsh zone is defined in many places by a narrow, heavily grazed lawn of *Stenotaphrum secundatum*, which also contains other herbaceous elements such as *Falkia repens*. Where forest or thicket does not adjoin the estuary, the transition from *S. secundatum* to *Themeda-Cymbopogon* terrestrial grassland is fairly abrupt (Figure 16).

A clear zonation sequence of species is evident at only one site in the middle reach of the estuary on the north bank, east of the central tributary (see Figure 9). Here, *S. virginicus*, together with a few isolated individuals of *Salicornia meyerana* occur within the tidal range. The next, more elevated, zone is dominated by *Juncus acutus*, which is up to one m tall and also contains species such as *S. secundatum*, *P. vaginatum*, *S. virginicus* and *F. repens* (Figure 17). As elsewhere around the estuary, the true terrestrial vegetation (in this case, an *A. karroo - C. excavatus* complex) is separated from the semi-aquatic communities by an almost pure zone of grazed *S. secundatum*. Other saltmarsh elements noted at the estuary but which could not be placed within a specific zone include *Triglochin striatum*, *Juncellus laevigatus*, *Cyperus textilis*, *Pycreus polystachyos* and *Mariscus thunberghii*.

The mean wet, dry and ashfree mass values of samples collected in the tidal *S. virginicus* zone in February 1987 are given below. The figures include both above- and below ground biomass and an estimate of organic carbon.

Mean standing crop	(g/m^2)
Wet mass	1 842
Dry mass	608
Ashfree mass	527
Estimated organic carbon	292

FIG. 15: Lawn of *Sporobolus virginicus* on the north bank of the estuary. *Paspalum vaginatum* occurs within the lower range of tidal reach.

FIG. 16: Abrupt transition between a grazed lawn of *Stenotaphrum secundatum* and *Cymbopogon excavatus* grassland.

FIG. 17: *Juncus acutus* saltmarsh at the upper range of tidal reach.

4.2 Fauna

4.2.1 Zooplankton

No data are available on the zooplankton of the estuary. It is likely, however, that with the seasonal freshwater input to the system and with the mouth being generally open, the four typical zooplankton components of estuaries will be represented (stenohaline marine, euryhaline marine, estuarine and fresh water). Copepods, mysids, amphipods and isopods are all likely to occur.

4.2.2 Aquatic Invertebrates

Little information is available on the diversity of invertebrate species resident within the estuary. Although the absence of extensive macrophyte beds would tend to cause this diversity to be relatively low, the observed abundance of the dominant species *Callianassa kraussi* (sand prawn) and *Upogebia africana* (mud prawn) is, nevertheless, high.

The distribution of the fluvial mudbanks and the deposits of marine sediment within the estuary serves to delimit the presence of the above two prawn species. Few burrows of either species occur within the eastern arm of the estuary and only limited colonization by *C. kraussi* has occurred on the tidal sandbanks to the west of the main channel, close to the mouth. The middle reach of the estuary is characterized by the presence of both prawn species, with the northern bank supporting predominantly *U. africana* and the southern bank, a mixture of both. A similar mixed population occurs a short distance east of the small central tributary on the north bank. C Gaigher, Cape Department of Nature and Environmental Conservation, George (pers. comm.) has recorded densities of *U. africana* burrows of between 183 and 306 per square metre, while the total burrow densities of mixed species areas can vary between 566 and 667 per square metre on the north and south banks respectively.

It has been stated by local residents that the area of sandbanks, and therefore *C. kraussi* habitat, was more extensive in the past and that this has largely been replaced by mudbanks. While this cannot be confirmed, it is possible that the sand prawn population has become reduced.

Of the beam trawls carried out at Stations 1 to 4 during the ECRU survey, aquatic invertebrates were recorded only at Station 1, in the upper reaches of the estuary (see Figure 8). These were three individuals of the penaeid prawn, *Penaeus japonicus*, which is a species unlikely to become successfully established in the estuary. Other invertebrates observed during the field survey include: *Cleistostoma edwardsii* (a burrowing crab); *Crassostrea margaritacea* (oyster); *Ficopomatus enigmatica* (estuarine tubeworm); *Littorina africana* and an *Oxystele* sp. (periwinkles); *Musculus virgiliae* (estuarine mussel); *Palaemon pacificus* (sand shrimp); *Panulirus ornatus* (ornate crayfish); *Sesarma catenata* - (marsh crab); *Scylla serrata* (giant mud- or Knysna crab); *Siphonaria* sp. (limpet); *Tetraclita serrata* and *Octomeris angulosa* (barnacles) and *Pyura stolonifora* (red bait) on the rock platforms directly exposed to the sea.

A list of the macrobenthic species recorded for eastern Cape estuaries by Day (1981) is provided in Appendix II. It is certain that many of these species will occur in the Quko Estuary.

4.2.3 Insects

Appendix III lists a number of butterflies and Emperor Moths collected on the farm Holnek, which adjoins the estuary. Of the grassland and savanna species collected, *Eurema brigitta* (broad bordered yellow) is the most common, while *Byblia acheloia* (scarce joker), which is an exceptionally localized and rare species, was also recorded. The most conspicuous forest species which were observed include *Charaxes varanes* (pearl charax) and *Myrina ficudela* (fig tree blue). Eight species of Emperor Moths were collected in the area, of which the White Ringed Atlas *Epiphora mythimnia* was probably on the very southern extreme of its normal range.

4.2.4 Fish

The eastern Cape estuaries, which are classified as warm temperate, are located within the transition zone between the sub-tropical marine conditions of Natal and Transkei to the north and the colder, more temperate southern conditions (Bok, in prep.). As such, they support fish populations of interesting geographical affinities including tropical, sub-tropical, warm temperate and cold temperate (see Appendix IV). A number of species, such as the southern mullet, white stumpnose, white steenbras and sea catfish reach their northernmost distribution limit in the eastern Cape, while many of the tropical and sub-tropical fish which may be present in the region during the summer months, do not penetrate further southwards. In this respect, estuaries such as the Quko, which are in a relatively pristine state, represent important sites for establishing estuarine fish distribution patterns under transitional environmental/zoogeographical conditions.

Limiting factors for the recruitment of estuarine fish species to the Quko and their subsequent establishment are the highly variable seasonal salinities and temperatures which are likely to occur. Periodic summer floods can lower salinities significantly for short periods, while the occasional closure of the mouth during winter would tend to extend high salinity conditions. High salinities, however, tend to be maintained tidally throughout summer and much of the year under non-flood conditions when the mouth generally remains open. Salinity

gradients, which could be exploited by various estuarine fish species, do not appear to be a feature of the Quko due to the relatively short extent of tidal influence before completely freshwater conditions prevail. Fishes, which only seasonally enter the estuary under optimum conditions and juveniles with varying degrees of estuarine dependance, are therefore, likely to predominate (see Appendix IV).

The limited presence of aquatic macrophytes and tidal salt marshes tend to reduce their apparent significance as primary production agents within the estuary. Fluvial detritus, planktonic productivity and possibly imports of organic carbon and nutrients from upwelled marine water would, therefore, tend to initiate the trophic processes into which the fish species of the Quko Estuary are placed and to which they contribute. Comparatively high energy inputs from these sources are reflected in the catch data recorded during the ECRU survey and by Bok and King (CDNEC, East London, *in litt.)*.

The information presented in Appendix V cannot be regarded as comprehensive as it represents data collected on only two occasions during the summers of 1984 and 1987 but is the only reference source available. On both occasions the mouth was open and strong tidal action accounted for the uniform salinity of about 35 parts per thousand throughout the estuary. The various mullet species (Mugilidae) appear to favour the middle and lower reaches while the upper reaches of the estuary are dominated by the sea catfish *(Tachysurus feliceps)*. Species diversity of the catches indicate a decreasing trend with distance from the mouth.

4.2.5 Amphibians and Reptiles

A list of amphibians and reptiles occurring in the area or which are likely to occur there is provided in Appendix VI (De Villiers, CDNEC, *in litt.)*.

Poynton (1964) records the two frog species, *Kassina wealii* (rattling kassina) and *Ptychadena oxyrhynchus* (sharp nosed grass frog) as occuring in the area and a further two species, *Bufo rangeri* (raucous toad) and *Hyperolius semidiscus* (yellow striped reed frog) have been observed there by the authors. A L de Villiers (pers. comm.) lists an additional 17 species which are likely to occur in the region (Appendix VI).

Broadley (1983) includes records of only three snake species for the Quko area, namely, *Homoroselaps lacteus* (spotted harlequin snake), *Pelamis platurus* (yellow-bellied sea snake) and *Philothamnus semivariegatus* (spotted bush snake). Thirteen other species have also been observed there and De Villiers (pers. comm.) lists a further 10 likely species (Appendix VI).

The water leguaan, *Varanus niloticus* is a common species occuring in the fresh water pools, upstream of the estuary and the Cape terrapin, *Pelomedusa subrufa*, also occurs within this environment.

4.2.6 Birds

The rich avifaunal population of the Quko and its environs is a reflection of the diverse habitat types represented. Of the 243 species which have been observed, at least 52 can be considered as forest residents, 49 associated with water while the remainder occupy various other habitats such as grassland and thornveld (Appendix VII). Vernon *(in litt.)* groups the total estimated number of species into *c.* 150 as permanent residents, *c.* 50 as seasonal visitors and *c.* 100 as temporary visitors. The raptors are well represented and the 25 species noted, include the Crowned Eagle (resident), Fish Eagle, Martial Eagle (resident), various buzzards and owls.

The Quko is considered to be relatively insignificant as a wetland bird habitat due mainly to the lack of saltmarsh and aquatic macrophyte beds and the absence of extensive tidal mud- and sandflats. Seventeen species of waders have been observed there but never more than 60 individuals of a single species at any one time. No breeding colonies of waterbirds have become established and the closest is a colony of Whitebreasted Cormorants on the Morgan's Bay cliffs to the north-east (Vernon, pers. comm.). The estuary is, however, an important food source for a number of the recorded bird species, of which approximately 18 percent are totally dependent on it in this regard.

Appendix VIII lists a number of species likely to occur in the area which can be regarded as rare, endangered, of limited distribution or of restricted habitat preference. These birds include species which would not readily adapt to a modified habitat.

4.2.7 Mammals

A list of mammal species which have been recorded for the area (or thought to occur there) is provided in Appendix IX. The habitat preferences of the species are distributed between the forest, grassland, littoral and aquatic environments and some of the trophic groups within each of these are illustrated in Table 5.

TABLE 5: Trophic classification of the mammals occurring at the Quko Estuary.

	HERBIVOROUS NICHES	
Small	Medium-sized	Large
Grazers		
Vlei Rat	Scrub Hare	Sheep
	Natal Red Rock Rabbit	Cattle
Browsers		
	Porcupine	Common Duiker
	Tree Dassie	Bushbuck
	Blue Duiker	Goats
Mixed feeders (graze and browse)		
	Rock Dassie	Grysbok
Granivores		
Woodland Dormouse		
Striped Mouse		
Pygmy Mouse		
Frugivores		
Egyptian Fruit Bat		Vervet Monkey
Subterranean omnivores		
Hottentot Golden Mole		
Ground-dwelling omnivores		
House Mouse	Giant Golden Mole	Chacma Baboon
Multimammate Mouse		Bushpig
House Rat		

TABLE 5: (cont.)

CARNIVOROUS NICHES

Small	Medium-sized	Large
Terrestrial carnivores		
	African Wild Cat	Caracal
	Striped Weasel	Black-backed Jackal
	Striped Polecat	Domestic dogs
	Small-spotted Genet	
	Large-spotted Genet	
	Lage Grey Mongoose	
	Small Grey Mongoose	
	White-tailed Mongoose	
	Domestic cats	
Amphibious carnivores		
	Spotted-necked Otter	Cape Clawless Otter
	Water Mongoose	Cape Fur Seal
Aerial insectivores		
Banana Bat		
Cape Serotine Bat		
Yellow House Bat		
Ground-dwelling insectivores		
		Aardwolf
		Antbear

5. SYNTHESIS AND RECOMMENDATIONS

Present State of the System

The Quko Estuary represents an excellent example of a relatively undisturbed eastern Cape system. This is largely as a result of its isolated situation, the conservation status of the mouth area and adjacent land and the lack of development pressure to date. Aesthetically, it is one of the most strikingly beautiful estuaries within the region with the steep coastal forelands, coastal forests and the variety of other terrestrial habitats around its margins (amongst other attributes) having contributed towards this.

The catchment area, which is not particularly large, provides sufficient freshwater input to the system to maintain the mouth in an open state through most years. This differs from the situation at most of the other smaller estuaries in the region, where mouth closure during winter is a regular feature. The pattern of alternating flood and drought periods at regular intervals provides a characteristic influence on the salinity regime of the estuary. Almost completely freshwater conditions are likely to occur throughout for varying lengths of time during the rainy season, followed by a gradual salinization to essentially seawater conditions during low flow periods. The preservation of the catchment in a well managed state has, until recently, ensured the continued functioning of the system in the above manner. The inherent erosion potential of the catchment soils, compounded by the removal of extensive areas of grassland for cultivation and, to a lesser extent, through over-grazing, has, however, increased the risk of altering the natural hydrology. Evidence of a change to the system is manifested by the presence of extensive mudbanks in the middle and upper reaches, which have resulted through increased inputs of silt from the Quko River in recent years. Associated with this, is the likelihood

that the influence of floods on the system have been more intense and that the sustained flow of freshwater to the estuary during dry seasons has become reduced. The effect which this may have had on the biotic components of the estuary and its physical functioning cannot be quantified at present.

From the available physico-chemical information on the state of the water column, it would appear that a relatively healthy situation currently prevails within the estuary. Turbidity is not excessive, dissolved oxygen values are high and the lack of a pronounced presence of filamentous algae, for example, reflect a non-enriched nutrient status. It is almost certain, however, that large inputs of agricultural pollutants do occur and that this may have had negative consequences which have yet to be quantified. The short residence period of water within the estuary, mainly due to effective tidal flushing, is likely, however, to reduce the impact of such pollution.

In contrast to the terrestrial vegetation, which includes impressive and well preserved stands of biogeographically significant forest, the aquatic and semi-aquatic plant communities are of relatively little overall importance. The limited extent of *Zostera capensis* (eelgrass) within the estuary and very sparse salt marsh development around the perimeter, would seem to indicate that primary production within the estuary is not derived principally from these macrophyte communities. In order to sustain the resident fish, aquatic invertebrate and other faunal populations, it would, therefore, appear that the system is largely dependant upon phytoplankton productivity and/or imports of organic detritus from the sea and river. The fact that it is a productive system is evident from the diversity and abundance of consumer species, including birds, fish, mud prawns, etc.

Present State of Knowledge

Very little scientific information is available on the estuary. Besides fish capture data, which is being assimilated by the Cape Department of Nature and Environmental Conservation and an unpublished management plan compiled by Du Plessis and Verwoerd (1984) for Double Mouth, personal observations and the ECRU field survey data contained in this report constitute essentially the only baseline of information available.

Problems: Present and Foreseeable

The fact that the Quko Estuary presently exists in a relatively well preserved state, indicates that it has been subjected to fewer negative impacts than many systems elsewhere. However, agricultural practices (particularly pineapple cultivation) which are currently taking place within the catchment, have caused some deterioration of the estuary. Evidence of this is the accumulation of silt within the middle and upper reaches and it is reasonable to speculate that this has had certain negative environmental consequences.

Although much riparian vegetation has been retained along the water courses within the catchment, this has obviously not been entirely effective in preventing erosional sediment inputs to the Quko River. It is also certain that agricultural chemicals are leached into the estuary and that these could be detrimental to the system.

It is likely that the extent of cultivation within the catchment could increase and that the estuary will be subjected to greater loads of silt and inorganic pollutants. In addition, pressures on the estuary environs for recreational and resort development (which has not been a factor up to the present) are likely to increase in response to the demand for such facilities along the East London coast.

Recommendations

Of all the estuaries situated within the region of transitional sub-tropical and temperate climatic conditions, the Quko has been retained in the best preserved state and can, therefore, serve as a model system to which other regional estuaries can be related (see Heydorn, 1986). Its greatest single value lies in this feature and it is therefore essential that management of the estuary and catchment should be directed to ensuring its future preservation. Various options can be considered to achieve this objective.

Heydorn and Tinley (1980) have proposed that the estuary should be afforded *Category A* reserve status and their definition of the category is provided below:

> *"Rigidly protected reserves with limited public access. Restricted entry by permit. No exploitation of any form allowed. Representative habitat types to be kept in a natural state for conservation and research purposes."*

This proposal is strongly supported and could be accommodated with little difficulty, by, for example, upgrading the status of the Forest Reserve at the mouth to that of a Nature Reserve and extending the boundaries of the latter to include the tidal expanse of the estuary. The administration of such an estuarine reserve would require no changes to the existing management infrastructure.

It would be unrealistic to attempt to expand the above reserve status to the remainder of the catchment and the following two options *(inter alia)* could therefore be investigated:

- That a co-ordinated effort be undertaken to encourage property owners in the catchment area to offer voluntarily the affected portions of their farms for classification as *Natural Heritage Areas,* in consultation with the Department of Environment Affairs.

- That the catchment area be proclaimed a *Schedule 5* National Park in terms of the National Parks Act, No. 57 of 1976. This would imply that the estuary would also be included in the National Park, as well as a section of the coastline - as proposed by Heydorn and Tinley (1980). Here, the emphasis would also rest upon the voluntary co-operation of the riparian land-owners who should be convinced of the necessity for such action.

The responsibility for co-ordinating an investigation into the most feasible conservation option for the entire system should be delegated to the Provincial Conservation Authority.

Reference has been made in this report to the possible effect or presence of leached herbicides and pesticides on the estuary. This has not been quantified and it should, therefore, be made a priority to establish whether such inputs exist and to what extent they affect the system. This could be achieved by means of a water column monitoring programme combined with a study of the estuary to establish the water residence period, and other hydraulic parameters. To assist with the quantification of the results, it would be necessary to establish a gauging station on the lower reaches of the Quko River (and possibly on the Mqotwane River as well) in order to measure the freshwater input to the system. Actual river-flow data could be compared with the model predictions of Middleton *et al.* (1981) and this information could be used to gain a better understanding of the pattern of mouth closure and salinity fluctuations.

A programme should also be initiated to monitor and control the agricultural activities taking place within the catchment area. Of specific importance is the application of the regulations promulgated in terms of the Conservation of Agricultural Resources Act No. 43 of 1983, with reference to the preservation of riparian vegetation. The regulations prescribe that a strip of undisturbed vegetation of 10 metres in width should be retained along both banks of any natural water course. It is proposed that a survey should be undertaken by the Provincial Conservation Authority in consultation with the Department of Agriculture in order to establish whether the above prescription has been applied throughout the catchment. Where problem areas are identified, appropriate measures should be taken to rectify the situation. The guidelines proposed by Hartman *et al.* (1981) to prevent soil erosion in areas cultivated for pineapple production must be applied. Permits should not be issued for the extension of pineapple lands without a thorough site investigation and an analysis of the soils and terrain slope. Existing areas under pineapples should be withdrawn from production if they are found not to conform with the relevant specifications.

The present policy of maintaining a low intensity recreational facility, such as the caravan park at Double Mouth, is considered to be the best option for making the area accessible to the public. Effective control can be maintained over the activities of visitors to the estuary and few conflicts are likely to arise between recreational demands and the conservation objectives. Improved control over day visitors to the area is, however, considered to be necessary.

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GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

AEOLIAN (deposits): materials transported and laid down on the earth's surface by wind.

ALIEN: plants or animals introduced from one environment to another, where they had not occurred previously.

ALLUVIUM: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

BARCHANOID (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

BERM: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.

BIMODAL: having two peaks.

BIOGENIC: orginating from living organisms.

BIOMASS: a quantitative estimation of the total weight of living material found in a particular area or volume.

BIOME: major ecological regions (life zones) identified by the type of vegetation in a landscape.

BIOTIC: living (characteristics).

BREACHING: making a gap or breaking through (a sandbar).

CALCAREOUS: containing an appreciable proportion of calcium carbonate.

CALCRETE: a sedimentary deposit derived from coarse fragments of other rocks cemented by calcium carbonate.

CHART DATUM: this is the datum of soundings on the latest edition of the largest scale navigational chart of the area. It is -0,900 m relative to the land levelling datum which is commonly called Mean Sea Level by most land surveyors.

COLIFORMS: members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract.

COMMUNITY: a well defined assemblage of plants and/or animals clearly distinguishable from other such assemblages.

CONGLOMERATE: a rock composed of rounded, waterworn pebbles 'cemented' in a matrix of calcium carbonate, silica or iron oxide.

CUSP: a sand spit or beach ridge usually at right angles to the beach formed by sets of constructive waves.

"D" NET: a small net attached to a "D" shaped frame riding on skids and pulled along the bottom of the estuary, used for sampling animals on or near the bottom.

DETRITUS: organic debris from decomposing plants and animals.

DIATOMS: a class of algae with distinct pigments and siliceous cell walls. They are important components of phytoplankton.

DYNAMIC: relating to ongoing and natural change.

ECOLOGY: the study of the structure and functions of ecosystems, particularly the dynamic co-evolutionary relationships of organisms, communities and habitats.

ECOSYSTEM: an interacting and interdependent natural system of organisms, biotic communities and their habitats.

EDDY: a movement of a fluid substance, particularly air or water, within a larger body of that substance.

ENDEMIC: confined to and evolved under the unique conditions of a particular region or site and found nowhere else in the world.

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

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

EPISODIC: sporadic and tending to be extreme.

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

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

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

FLUVIAL (deposits): originating from rivers.

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

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

GEOMORPHOLOGY: the study of land form or topography.

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

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

HALOPHYTES: plants which can tolerate saline conditions.

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

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

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

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

INDIGENOUS: belonging to the locality; not imported.

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

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

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

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

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

LIMPID: clear or transparent.

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

LONGSHORE DRIFT: a drift of material along a beach as a result of waves breaking at an angle to the shore.

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

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

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

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

MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23°, 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.

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Aerial Photographs

Date	Job no.	Photo no.	Scale 1:	Type	Source
Feb. 1939	13439	17739	25 000	B&W	Trig. Survey
1966	558	234-235	20 000	B&W	Trig. Survey
Jul. 1972	704	728, 821	50 000	B&W	Trig. Survey
Jan. 1976	234	29-30	700	B&W	Trig. Survey
Apr. 1977	284	753-754	1 000	Col.	Univ. of Natal
Apr. 1979	326	115-116	9 000	Col.	Univ. of Natal
Dec. 1980	374	6-8	20 000	B&W	Trig. Survey
Dec. 1981	391	116	20 000	Col.	Univ. of Natal
Jun. 1986	896	221-223,164	30 000	B&W	Trig. Survey
Feb. 1987	-	1032	10 000	Col.	ECRU/NRIO

APPENDIX I: Plant species and physical features of the vegetation at the Quko Estuary.

Mapping Unit	Estimated area (ha)	% of area studied	Cover (%)	Average height (m)
Dune Forest	24,0	10,5	80	5-7
Coastal Valley Forest	40,9	17,8	80	20
Dry Scrub Thicket	24,0	10,5	50-80	2-5
Coastal Grassland	155,9	68,0	100	0,3-1,5
Open Dune Shrubland	0,6	0,3	60	2-4
Semi-Aquatic Vegetation	3,9	1,7	60-90	0,2
Total	229,2			

Dune Forest

Acokanthera oblongifolia (+); *Allophylus natalensis* (+); *Asparagus* sp. (r); *Brachylaena discolor* (+); *Cassine aethiopica* (+); *Chionanthus foveolata* (+); *Chironia baccifera* (r); *Euclea natalensis* (+); *Eugenia capensis* (r); *Maytenus heterophylla* (+); *Mimusops caffra* (2); *Psychotria capensis* (r); *Scolopia zeyheri* (r); *Sideroxylon inerme* (+).

Coastal Valley Forest

The dominance hierarchy was not established and Braun-Blanquet cover abundance values have not therefore been allocated. The following species list has been compiled by C J Vernon *(in litt.)*.

Acacia caffra
Acokanthera oppositifolia
Allophylus natalensis
Anastrabe integerrima
Bersama lucens
Buxus macowanii
Canthium inerme
Canthium spinosum
Cassine papillosa
Cassipourea flanaganii
Chionanthus foveolata
Clerodendrum glabrum
Colpoon compressum
Commiphora woodii
Cussonia sphaerocephala
Deinbollia oblongifolia
Diospyros simii
Dovyalis sp.
Encephalartos altensteinii
Erythroxylum pictum
Euphorbia grandidens
Ficus burtt-davyi
Ficus sur
Grewia lasiocarpa
Harpephyllum caffrum
Homalium rufescens
Acacia karroo
Allophylus decipiens
Aloe bainesii
Apodytes dimidiata
Brachylaena sp.
Calodendrum capense
Canthium mundianum
Carissa bispinosa
Cassine tetragona
Celtis africana
Chrysanthemoides monilifera
Clutia pulchella
Combretum kraussii
Cordia caffra
Cussonia spicata
Diospyros lyciodes
Diospyros villosa
Ehretia rigida
Entada spicata
Euclea natalensis
Euphorbia tetragona
Ficus ingens
Gardenia amoena
Grewia occidentalis
Heteromorpha arborescens
Maerua racemulosa
Acalypha glabrata
Allophylus dregeanus
Aloe ferox
Azima tetracantha
Burchellia bubalina
Calpurnea aurea
Canthium obovatum
Cassine aethiopica
Cassinopsis ilicifolia
Chaetachme aristata
Clausena anisata
Coddia rudis
Commiphora harveyi
Cryptocarya woodii
Dalbergia obovata
Diospyros natalensis
Diospyros whyteana
Ekebergia capensis
Erythrina caffra
Eugenia capensis
Euphorbia triangularis
Ficus natalensis
Gardenia thunbergia
Halleria lucida
Hippobromus pauciflorus
Margaritaria discoidea

APPENDIX I: (cont.)

Maytenus acuminata
Milletia grandis
Monanthotaxis caffra
Olea capensis
Ozoroa mucronata
Peddiea africana
Pleurostylia capensis
Psychotria capensis
Putterlickia verrucosa
Rhus chirindensis
Salix mucronata
Scutia myrtina
Strychnos henningsii
Tarchonanthus camphoratus
Trichalysia capensis
Trimeria grandifolia
Turraea obtusifolia
Vepris lanceolata
Maytenus heterophylla
Mimusops caffra
Ochna arborea
Olea europaea subsp. *africana*
Pappea capensis
Phoenix reclinata
Podocarpus falcatus
Ptaeroxylon obliquum
Rapanea melanophloeos
Rhus natalensis
Schotia latifolia
Sideroxylon inerme
Suregada africana
Teclea natalensis
Trichelia dregeana
Trimeria trinervis
Urera tenax
Vitellariopsis marginata
Maytenus peduncularis
Mimusops obovata
Ochna natalitia
Olinia ventosa
Pavetta lanceolata
Pittosporum viridiflorum
Protorhus longifolia
Pterocelastrus sp.
Rawolfia caffra
Rothmannia capensis
Scolopia zeyheri
Strelitzia nicolai
Strelitzia reginae
Syzygium cordatum
Tecomaria capensis
Trichocladus ellipticus
Turraea floribunda
Uvaria caffra
Zanthoxylum capense

Dry Scrub Thicket

Aloe ferox (+); *Brachylaena discolor* (1); *Cussonia spicata* (+); *Diospyros villosa* (+); *Euphorbia tetragona* (+); *Euphorbia triangularis* (+); *Harpephyllum caffrum* (+); *Olea europaea* (+); *Strelitzia nicolai* (1); *Strelitzia reginae* (+); *Tarchonanthus camphoratus* (1).

Coastal Grassland

Acacia karroo (+); *Aloe ferox* (+); *Cymbopogon excavatus* (3); *Cymbopogon validus* (+); *Themeda triandra* (4); *Chloris gayana* (r).

Open Dune Shrubland

Allophylus natalensis (+); *Arctotheca populifolia* (r); *Brachylaena discolor* (1); *Cynanchum natalitium* (r); *Ipomoea brasiliensis* (+); *Mariscus congestus* (+); *Mimusops caffra* (+); *Passerina rigida* (3); *Rhus crenata* (2).

Riparian Scrub Thicket

Acacia karroo (+); *Acacia mearnsii* (+); *Asclepias* sp. (+); *Azima tetracantha* (+); *Calodendrum capense* (+); *Combretum caffrum* (+); *Crinum* sp. (r); *Dais cotinifolia* (+); *Dietes bicolor* (r); *Diospyros dicrophylla* (+); *Ficus sur* (r); *Grewia occidentalis* (+); *Maytenus heterophylla* (+); *Phoenix reclinata* (+); *Podocarpus falcatus* (r); *Schotia latifolia* (+); *Scolopia zeyheri* (r); *Scutia myrtina* (+); *Senecio pterophorus* (1); *Sideroxylon inerme* (+); *Teclea natalensis* (+); *Ricinus communis* (+); *Crassula* sp. (+).

Semi Aquatic Vegetation

Cyperus textilis (+); *Juncus acutus* (3); *Mariscus thunberghii* (+); *Paspalum vaginatum* (+); *Salicornia meyerana* (r); *Juncellus laevigatus* (+); *Sporobolus virginicus* (4); *Stenotaphrum secundatum* (2); *Triglochin striatum* (+); *Falkia repens* (1).

APPENDIX I: (cont.)

Symbols in brackets following each species name, represent Braun-Blanquet classes as follows:

r - 1/few individuals, cover less than 0,1 percent of area
+ - occasional plants, cover less than 1 percent of area
1 - abundant, cover 1 - 5 percent of area
2 - any number, cover 6 - 12 percent of area
3 - any number, cover 26 - 50 percent of area
4 - any number, cover 51 - 75 percent of area
5 - any number, cover 76 - 100 percent of area.

APPENDIX II: Macrobenthic species recorded for the Eastern Cape (after Day, 1981).

CNIDARIA
Hydractinia kaffraria Millard

NEMERTEA
Polybrachiorhynchus dayi Gibson

POLYCHAETA: ERRANTIA
Ceratonereis erythraeensis Fauvel
Ceratonereis keiskama Day
Glycera tridactyla Schm.
Lumbrineris tetraura (Sch.)
Nephtys capensis Day
Nephtys tulearensis Fauvel

POLYCHAETA: SEDENTARIA
Capitella capitata (Fabr.)
Cirriformia tentaculata (Mont.)
Desdemona ornata Banse
Ficopomatus enigmatica (Fauvel)
Orbinia angrapequensis (Aug.)
Pomatoleios kraussii (Baird)
Prionospio sexoculata Aug.
Thelepus plagiostoma Schm.

CIRRIPEDIA
Balanus amphitrite Darwin
Balanus elizabethae Baird
Balanus algicola Pilsbry
Chthamalus dentatus Krauss

AMPHIPODA
Austrochiltonia subtenuis (Sayce)
Corophium triaenonyx Stebb.
Grandidierella lignorum (Brnrd.)
Melita zeylanica Stebb.
Orchestia ancheidos (Brnrd.)
Orchestia rectipalma (Brnrd.)
Urothoe pulchella Costa

ISOPODA
Cirolana fluviatilis Stebb.
Cyathura estuaria (Brnrd.)
Exosphaeroma hylecoetes (Brnrd.)
Sphaeroma terebrans Bate

ANOMURA
Callianassa kraussi Stebb.
Upogebia africana (Ortm.)

BRACHYURA
Cleistostoma algoense Brnrd.
Cleistostoma edwardsii McLeay
Cyclograpsus punctatus M. Edw.
Dotilla fenestrata Hilg.
Hymenosoma orbiculare Desm.
Rhyncoplax bovis Brnrd.
Scylla serrata Forsk.
Sersama catenata Ortm.
Uca lactea f. annulipes (M. Edw.)
Uca chlorophthalmus (M. Edw.)
Varuna litterata (Fabr.)

MOLLUSCA: BIVALVIA
Dosinia hepatica (Lam.)
Eumarcia paupercula (Holten)
Lamya capensis (Kr.)
Loripes clausus Phil.
Macoma litoralis (Kr.)
Mactra lilacea Lam.
Musculus virgiliae Brnrd.
Ostrea algoensis Sow.
Perna perna (Linn.)
Psammotellina capensis (Sow.)
Solen capensis Fisher
Solen corneus Lam.
Crassostrea margaritacea (Lam.)

MOLLUSCA: GASTROPODA
Assiminea bifasciata (Nevill)
Assiminea? globulus (Conolly)
Cerithidea decollata (Linn.)
Littorina africana var. knysnaensis Phil
Littorina scabra Linn.
Natica gualteriana Rechluz
Natica tecta Anton
Nerita albicilla Linn.
Notarchus leachii Blainv.
Oxystele variegata (Anton)
Siphonaria aspera Kr.
Siphonaria capensis Q. & G.

APPENDIX II: (cont.)

MACRURA
Alpheus crassimanus Heller
Metapenaeus monoceros (Fabr.)
Palaemon pacificus (Stimps.)
Penaeus indicus M. Edw.
Penaeus japonicus Bate

Siphonaria oculus Kr.

ECHINODERMATA
Amphipholis squamata (D. Ch.)
Patiriella exigua (Lam.)
Echinocardium cordatum Pennant
Echinodiscus bisperforatus Leske

APPENDIX III: Lepidoptera collected at the Quko Estuary.

PAPILIONIDAE

Papilio demodocus - Christmas butterfly
Papilio leonidas - Veined swallowtail
Papilio nireus lyaeus - Green-banded swallowtail

LYCAENIDAE

Lampides boeticus - Lucerne blue
Myrina ficudela - Fig tree blue
Syntarucus telicanus - Common blue

PIERIDAE

Belenois aurota - Brown veined white
Belenois creona - African common white
Belenois gidica - African veined white
Catopsilia florella - African vagrant
Colias electo - African clouded yellow
Colotis danae - Scarlet tip
Colotis enippe - Smoky orange tip
Eurema brigitta - Broad bordered yellow
Mylothris chloris - Dotted border
Pontia helice - Meadow white

ACRAEIDAE

Acraea encedon - White-barred Acraea
Acraea horta - Garden Acraea
Acraea rahira - Marsh Acraea

NYMPHALIDAE

Byblia acheloia - Scarce joker
Charaxes varanes - Pearl charax
Precis archesia - Garden inspector
Precis cebrene - Yellow pansy
Precis clelia - Blue pansy
Pyrameis cardui - Painted lady

SATYRIDAE

Dira oxylus - Pondoland widow
Melampias cassius - Rainforest brown

DANAIDAE

Danaus chrysippus - African monarch

APPENDIX III: (cont.)

HESPERIDAE

Celeanorrhynis mokeezi - Christmas forester

SATURNIIDAE (Emperor Moths)

Bunaea alcinoë - Common Emperor
Cirina forda - Pallid Emperor
Epiphora mythimnia - White Ringed Atlas
Gynanisa maia - Speckled Emperor
Heniocha apollonia - Southern Marbled Emperor
Imbrasia cytherea - Pine Emperor
Ludia goniata - Black Prince
Melanocera menippe - Chestnut Emperor

APPENDIX IV: Common estuarine-associated fishes of the eastern Cape, which are likely to occur in the Quko Estuary (after Bok, in prep.). Geographical affinities of each species are given, where: c = cold temperate; w = warm temperate; S = sub-tropical and T = tropical.

Species	Geographical distribution	Estuarine dependance category*
Caffrogobius multifasciatus (prison goby)	w-S	I
Caffrogobius natalensis (baldy)	w-S	I
Caffrogobius nudiceps (barehead goby)	c-S	I
Gilchristella aestuaria (estuarine round herring)	c-S	I
Oligolepis keiensis (Kei goby)	S	I
Psammogobius knysnaensis (Knysna sand goby)	c-S	I
Acanthopagrus berda (river bream)	w-T	IIa
Caranx sexfasciatus (bigeye kingfish)	w-T	IIa
Chanos chanos (milk fish)	w-T	IIa
Elops machnata (ten pounder)	w-T	IIa
Hyporhamphus capensis (Knysna halfbeak)	w-S	IIa
Lichia amia (Leer fish)	c-S	IIa
Lithognathus lithognathus (white steenbras)	c-w	IIa
Monodactylus falciformis (Cape moony)	w-T	IIa
Mugil cephalus (flathead mullet)	c-T	IIa
Myxus capensis (freshwater mullet)	w-S	IIa
Pomadasys commersonnii (spotted grunter)	w-T	IIa
Rhabdosargus holubi (Cape stumpnose)	w-S	IIa
Rhabdosargus sarba (Natal stumpnose)	T-w	IIa
Terapon jarbua (thornfish)	w-T	IIa
Atherina breviceps (Cape silverside)	c-S	IIb
Heteromycteris capensis (Cape sole)	c-S	IIb
Liza dumerilii (groovy mullet)	w-S	IIb
Liza tricuspidens (striped mullet)	w-S	IIb
Pomadasys olivaceum (piggy)	w-S	IIb
Solea bleekeri (black hand sole)	c-S	IIb
Argyrosomus hololepidotus (kob)	c-S	IIc
Diplodus sargus (blacktail)	c-T	IIc
Galeichthys feliceps (sea catfish)	w	IIc
Hemirhamphus far (spotted halfbeak)	w-T	IIc
Liza richardsonii (southern mullet)	c-S	IIc

APPENDIX IV: (cont.)

Species	Geographical distribution	Estuarine dependance category*
Lutjanus fulviflamma (dory snapper)	w-T	IIc
Platycephalus indicus (bartail flathead)	w-T	IIc
Pomatomus saltatrix (elf)	c-T	IIc
Rhabdosargus globiceps (white stumpnose)	c-w	IIc
Syngnathus acus (pipefish)	c-S	IIc
Torpedo sinuspersici (marbled electric ray)	w-T	IIc
Valamugil buchanani (bluetail mullet)	w-T	IIc
Myliobatis aquila (eagle ray)	c-S	III
Glossogobius callidus (river goby)	w-T	IV
Oreochromis mossambicus (Mossambique tilapia)	w-T	IV

* Estuarine dependance categories (after Bok (in prep.)).

I Truly estuarine species, which breed and spend their entire life cycle in estuaries.

II Species usually breeding at sea with juveniles showing varying degrees of dependance on estuaries. Adults seasonally enter estuaries.

- IIa Entirely dependant on estuaries when juveniles.
- IIb Juveniles also found at sea, but mainly occur in estuaries.
- IIc Juveniles usually more abundant at sea, also occur in estuaries.

III Stenohaline marine species which stray into estuaries, usually occur close to mouth and not dependant on estuaries.

IV Euryhaline freshwater species whose salinity tolerance determines degree of penetration into estuaries; also includes species which breed in both freshwater and estuaries. This group is not dependant on estuaries.

APPENDIX V: Fish species recorded in the Quko Estuary in 1984 by Bok and King *(in litt.)* and in 1987 during the ECRU survey. (The catch data were collected over 12 hr periods using gill nets comprised of a range of mesh sizes (35-118 mm). Quantitative comparison between the two data sets recorded at Station 2 is not possible due to the difference in net length used).

Station	1 (200 m from mouth)				2 (800 m from mouth)				2 (800 m from mouth)				3 (1 300 m from mouth)			
Salinity (‰)	35				35				35				35			
Date sampled	31.1.84 - 1.2.84				31.1.84 - 1.2.84				4.2.87 - 5.2.87				31.1.84 - 1.2.84			
Species	No.	Total mass (kg)	Mean mass (g)	% freq.	No.	Total mass (kg)	Mean mass (g)	% freq.	No.	Total mass (kg)	Mean mass (g)	% freq.	No.	Total mass (kg)	Mean mass (g)	% freq.
Mugil capensis (Cape mullet)	1	0,452	452	2	1	0,209	209	1	-	-	-	-	-	-	-	-
Mugil cephalus (Flathead mullet)	17	3,839	225,8	33	4	1,887	471,8	5	31	6,110	197	43	-	-	-	-
Liza richardsonii (Southern mullet)	8	1,368	171	16	5	1,133	226,6	6	-	-	-	-	1	0,165	165	2
Liza dumerilii (Groovy mullet)	13	2,024	155,7	26	2	0,385	192,5	3	1	0,058	58	1	-	-	-	-
Liza tricuspidens (Striped mullet)	2	0,334	167	4	5	2,437	487,4	6	-	-	-	-	-	-	-	-
Liza macrolepis (Large scale mullet)	3	0,370	123,33	6	-	-	-	-	-	-	-	-	-	-	-	-
Valamugil buchanani (Bluetail mullet)	-	-	-	-	3	2,519	839,7	4	-	-	-	-	2	1,117	558,5	4
Monodactylus falciformis (Cape moony)	2	0,067	33,5	4	-	-	-	-	3	0,151	50	4	-	-	-	-
Galeichthys feliceps (Sea catfish)	1	0,580	580	2	37	18,3	494,6	47	7	4,831	690	10	44	21,859	496,8	80
Rhinobatos annulatus (Sand shark)	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Torpedo sinuspersici (Electric ray)	2	2,677	1338	4	-	-	-	-	-	-	-	-	-	-	-	-
Pomadasys commersonnii (Spotted grunter)	1	0,037	37	2	-	-	-	-	5	0,700	140	7	2	0,414	212	4
Lichia amia (Leerfish)	-	-	-	-	10	12,0	1200	13	1	2,400	2400	1	1	1,204	1204	2
Argyrosomus hololepidotus (Kob)	-	-	-	-	9	3,368	374,2	12	8	3,150	394	11	4	2,927	731,8	7
Elops machnata (Tenpounder)	-	-	-	-	1	1,574	1574	1	15	3,920	260	20	-	-	-	-
Lutjanus argentimaculatus (Red snapper)	-	-	-	-	1	1,663	1663	1	-	-	-	-	1	1,357	1357	2
Rhabdosargus holubi (Cape stumpnose)	-	-	-	-	-	-	-	-	1	0,102	102	1	-	-	-	-
TOTAL	51	11,748	-	101	78	45,475	-	99	72	21,422	-	98	55	29,043	-	101

Additional species captured during ECRU beam net trawls or observed near the rocky eastern bank of the estuary in the lower reaches, are listed below:

Abudefduf vaigiensis (sergeant major)
Acanthurus sp. (surgeon)
Caffrogobius multifasciatus (prison goby)
Caranx ignobilis (giant kingfish)
Chaetodon auriga (threadfin butterflyfish)
Chaetodon dolosus (blackedged butterflyfish)
Chaetodon lunula (halfmoon butterflyfish)
Chaetodon marleyi (doublesash butterflyfish)
Diplodus sargus capensis (blacktail)
Gilchristella aestuaria (estuarine round herring)
Glossogobius callidus (river goby)
Heteromycteris capensis (Cape sole)
Ostracion cubicus (boxy)
Plagiotremus tapeinosoma (wrasse)
Pomacanthus semicirculatus (semicircle angelfish)
Psammogobius knysnaensis (Knysna sand goby)
Pterois miles (devil firefish)
Rhinecanthus sp. (triggerfish)
Rhinobatos annulatus (lesser guitarfish)
Solea bleekéri (blackhand sole)

APPENDIX VI: Amphibians and reptiles which have been recorded or can be expected to occur in the Quko Estuary and adjacent environs (De Villiers (CDNEC) pers. comm.). R = recorded by authors (1981-1988).

AMPHIBIANS

PLATANNAS

Xenopus laevis - Common platanna

TOADS

Bufo pardalis - Leopard toad
Bufo rangeri - Raucous toad (R)

RAIN FROGS

Breviceps adspersus pentheri - Bushveld rain frog

SAND FROGS

Tomopterna cryptotis - Tremolo sand frog
Tomopterna natalensis - Natal sand frog

RIVER AND STREAM FROGS

Rana angolensis - Common river frog
Rana fasciata - Striped stream frog
Rana grayii - Clicking stream frog

GRASS FROGS

Ptychadena oxyrhynchus - Sharp-nosed grass frog
Ptychadena porosissima - Striped grass frog

PUDDLE FROGS

Phrynobatrachus mababiensis - Dwarf puddle frog
Phrynobatrachus natalensis - Snoring puddle frog

CACOS

Cacosternum boettgeri - Common caco
Cacosternum nanum - Bronze caco

KASSINAS

Kassina senegalensis - Bubbling kassina
Kassina wealii - Rattling kassina

LEAF-FOLDING FROGS

Afrixalus brachycnemis - Golden leaf-folding frog

REED AND LILY FROGS

Hyperolius marmoratus - Painted reed frog
Hyperolius pusillus - Water lily frog
Hyperolius semidiscus - Yellow-striped reed frog (R)

APPENDIX VI: (cont.)

REPTILES

CHELONIA (terrapins)

Pelomedusa subrufa - Cape terrapin (R)

SERPENTES (snakes)

Amplorhinus multimaculatus - Cape reed snake
Aparallactus capensis - Cape centipede-eater
Bitis arietans - Common puff-adder (R)
Causus rhombeatus - Common night adder (R)
Crotaphopeltis hotamboeia - Herald snake
Dasypeltis scabra - Common egg-eater (R)
Dispholidus typus - Boomslang (R)
Duberria lutrix - Common slug-eater
Hemachatus haemachatus - Rinkals (R)
Homoroselaps lacteus - Spotted Harlequin Snake
Lamprophis aurora - Aurora house snake
Lamprophis fuliginosus - Brown house snake (R)
Lamprophis guttatus - Spotted house snake
Lamprophis inornatus - Black house snake
Leptotyphlops conjuncta - Cape worm snake
Lycodonomorphus laevissimus - Black water snake (R)
Lycodonomorphus rufulus - Common water snake
Lycophidion capense - Cape wolf snake (R)
Macrelaps microlepidotus - Natal black snake
Pelamis platurus - Common yellow-and-black sea snake (R)
Philothamnus natalensis occidentalis - Western Natal green snake (R)
Philothamnus semivariegatus - Spotted bush snake (R)
Psammophis crucifer - Cross-marked grass snake (R)
Psammophylax rhombeatus - Spotted grass snake (R)
Pseudaspis cana - Common mole snake (R)
Typhlops bibronii - Bibron's blind snake (R)

APPENDIX VII: Bird species observed at the Quko Estuary between June 1981 and June 1984 (after Du Plessis and Verwoerd, 1984).

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
8	Dabchick	*(Tachybaptus ruficollis)*
53	Cape Gannet	*(Morus capensis)*
55	Whitebreasted Cormorant	*(Phalacrocorax carbo)*
58	Reed Cormorant	*(Phalacrocorax africanus)*
60	Darter	*(Anhinga rufa)*
62	Grey Heron	*(Ardea cinerea)*
63	Black-headed Heron	*(Ardea melanocephala)*
65	Purple Heron	*(Ardea purpurea)*
67	Little Egret	*(Egretta garzetta)*
71	Cattle Egret	*(Bubulcus ibis)*
78	Little Bittern	*(Ixobrychus minutus)*
81	Hamerkop	*(Scopus umbretta)*
84	Black Stork	*(Ciconia nigra)*

APPENDIX VII: (cont.)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
91	Sacred Ibis	*(Threskiornis aethiopicus)*
94	Hadeda	*(Hagedashia hagedash)*
95	Spoonbill	*(Platalea alba)*
116	Spurwinged Goose	*(Plectropterus gambensis)*
102	Egyptian Goose	*(Alopochen aegyptiacus)*
105	Black Duck	*(Anas sparsa)*
104	Yellowbilled Duck	*(Anas undulata)*
108	Redbilled Teal	*(Anas erythrorhyncha)*
116	Spurwinged Goose	*(Plectropterus gambensis)*
118	Secretary bird	*(Saggitarius serpentarius)*
122	Cape Vulture	*(Gyps coprotheres)*
172	Lanner	*(Falco biarmicus)*
181	Rock Kestrel	*(Falco tinnunculus)*
126	Yellow-billed Kite	*(Milvus nigrans)*
127	Blackshouldered Kite	*(Elanus caeruleus)*
128	Cuckoo Hawk	*(Aviceda cuculoides)*
139	Long-crested Eagle	*(Lophactus occipitalis)*
140	Martial Eagle	*(Polemaetus bellicosus)*
141	Crowned Eagle	*(Stephanoaetus coronatus)*
142	Brown Snake Eagle	*(Circaetus cinereus)*
148	Fish Eagle	*(Haliaeetus vocifer)*
152	Jackal Buzzard	*(Buteo rufofuscus)*
149	Steppe Buzzard	*(Buteo buteo)*
150	Forest Buzzard	*(Buteo oreophilus)*
157	Little Sparrowhawk	*(Accipiter minullus)*
158	Black Sparrowhawk	*(Accipiter melanoleucus)*
160	African Goshawk	*(Accipiter tachiro)*
165	African Marsh Harrier	*(Circus ranivorus)*
169	Gymnogene	*(Polyboroides typus)*
170	Osprey	*(Pandion haliaetus)*
192	Redwing Francolin	*(Francolius levaillantii)*
198	Red-necked Francolin	*(Pternistis afer)*
200	African Quail	*(Coturnix coturnix)*
203	Crowned Guinea-fowl	*(Numida meleagris)*
218	Buffspotted Flufftail	*(Sarothrura elegans)*
221	Striped Flufftail	*(Sarothrura affinis)*
226	Moorhen	*(Gallinula chloropus)*
228	Red-knobbed Coot	*(Fulica cristata)*
229	Finfoot	*(Podica senegalensis)*
209	Crowned Crane	*(Balearica regulorum)*
231	Stanley's Bustard	*(Otis denhami stanleyi)*
240	African Jacana	*(Actophilornis africanus)*
244	African Black Oystercatcher	*(Haematopus moquini)*
245	Ringed Plover	*(Charadrius hiaticula)*
246	Whitefronted Plover	*(Charadrius marginatus)*
248	Kittlitz's Plover	*(Charadrius pecuarius)*
249	Threebanded Plover	*(Charadrius tricollaris)*
254	Grey Plover	*(Pluvialis squatarola)*
255	Crowned Plover	*(Vanellus coronatus)*
257	Blackwinged Plover	*(Vanellus melanopterus)*
258	Blacksmith Plover	*(Vanellus armatus)*

APPENDIX VII: (cont.)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
262	Turnstone	*(Arenaria interpres)*
264	Common Sandpiper	*(Tringa hypoleucos)*
266	Wood Sandpiper	*(Tringa glareola)*
269	Marsh Sandpiper	*(Tringa stagnatilis)*
270	Greenshank	*(Tringa nebularia)*
272	Curlew Sandpiper	*(Calidris ferruginea)*
274	Little Stint	*(Calidris minuta)*
281	Sanderling	*(Calidris alba)*
284	Ruff	*(Philomachus pugnax)*
288	Bartailed Godwit	*(Limosa lapponica)*
290	Whimbrel	*(Numenius phaeopus)*
298	Water Dikkop	*(Burhinus vermiculatus)*
297	Spotted Dikkop	*(Burhinus capensis)*
310	Subantarctic Skua	*(Catharacta antarctica)*
312	Kelp Gull	*(Larus dominicanus)*
315	Greyheaded Gull	*(Larus cirrocephalus)*
322	Caspian Tern	*(Hydroprogne caspia)*
324	Swift Tern	*(Sterna bergii)*
326	Sandwich Tern	*(Sterna sandvicensis)*
327	Common Tern	*(Sterna hirundo)*
335	Little Tern	*(Sterna albifrons)*
349	Rock Pigeon	*(Columba guinea)*
350	Rameron Pigeon	*(Columba arquatrix)*
352	Redeyed Dove	*(Streptopelia semitorquata)*
354	Cape Turtle Dove	*(Streptopelia capicola)*
355	Laughing Dove	*(Stigmatopelia senegalensis)*
359	Tambourine Dove	*(Turtur tympanistria)*
358	Emeraldspotted Dove	*(Turtur chalcospilos)*
360	Cinnamon Dove	*(Aplopelia larvata)*
361	Green Pigeon	*(Treron australis)*
362	Cape Parrot	*(Poicephalus robustus)*
370	Knysna Loerie	*(Tauraco corythaix)*
377	Redchested Cuckoo	*(Cuculus solitarius)*
378	Black Cuckoo	*(Cuculus clamosus)*
385	Klaas's Cuckoo	*(Chrysococcyx klaas)*
386	Diederik Cuckoo	*(Chrysococcyx caprius)*
391	Burchell's Coucal	*(Centropus superciliosus)*
392	Barn Owl	*(Tyto alba)*
393	Grass Owl	*(Tyto capensis)*
394	Wood Owl	*(Ciccaba woodfordii)*
401	Spotted Eagle Owl	*(Bubo africanus)*
405	Fierynecked Nightjar	*(Caprimulgas pectoralis)*
412	Black Swift	*(Apus barbatus)*
415	Whiterumped Swift	*(Apus caffer)*
416	Horus Swift	*(Apus horus)*
417	Little Swift	*(Apus affinus)*
418	Alpine Swift	*(Apus melba)*
424	Speckled Mousebird	*(Colius striatus)*
426	Redfaced Mousebird	*(Urocolius indicus)*
427	Narina Trogon	*(Apaloderma narina)*
428	Pied Kingfisher	*(Ceryle rudis)*
429	Giant Kingfisher	*(Megaceryle maxima)*
430	Halfcollared Kingfisher	*(Alcedo semitorquata)*

APPENDIX VII: (cont.)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
431	Malachite Kingfisher	*(Corythornis cristata)*
432	Pygmy Kingfisher	*(Ispidina picta)*
435	Brownhooded Kingfisher	*(Halcyon albiventris)*
446	European Roller	*(Coracias garrulus)*
451	Hoopoe	*(Upupa epops)*
452	Redbilled Woodhoopoe	*(Phoeniculus purpureus)*
455	Trumpeter Hornbill	*(Bycanistes bucinator)*
460	Crowned Hornbill	*(Tockus alboterminatus)*
463	Ground Hornbill	*(Bucorvus leadbeateri)*
464	Blackcollared Barbet	*(Lybius torquatus)*
469	Redfronted Tinker Barbet	*(Pogoniulus pusillus)*
474	Greater Honeyguide	*(Indicator indicator)*
476	Lesser Honeyguide	*(Indicator minor)*
484	Knysna Woodpecker	*(Campethera notata)*
486	Cardinal Woodpecker	*(Dendropicos fuscescens)*
488	Olive Woodpecker	*(Mesopicos griseocephalus)*
489	Redthroated Wryneck	*(Jynx ruficollis)*
494	Rufousnaped Lark	*(Mirafra africana)*
518	European Swallow	*(Hirundo rustica)*
520	Whitethroated Swallow	*(Hirundo albigularis)*
526	Greater Striped Swallow	*(Cecropis cucullata)*
527	Lesser Striped Swallow	*(Cecropis abyssinica)*
529	Rock Martin	*(Ptynoprogne fuligula)*
530	House Martin	*(Delichon urbica)*
533	Brownthroated Martin	*(Riparia paludicola)*
536	Black Sawwing Swallow	*(Psalidoprocne holomelaena)*
538	Black Cuckooshrike	*(Campephaga phoenicea)*
540	Grey Cuckooshrike	*(Coracina caesia)*
541	Forktailed Drongo	*(Dicrurus adsimilus)*
542	Squaretailed Drongo	*(Dicrurus ludwigii)*
543	European Golden Oriole	*(Oriolus oriolus)*
545	Blackheaded Oriole	*(Oriolus larvatus)*
548	Pied Crow	*(Corvus albus)*
547	Black Crow	*(Corvus capensis)*
550	Whitenecked Raven	*(Corvultur albicollis)*
554	Southern Black Tit	*(Parus niger)*
568	Blackeyed Bulbul	*(Pycnonotus barbatus)*
569	Terrestrial Bulbul	*(Phyllastrephus terrestris)*
572	Sombre Bulbul	*(Andropadus importunus)*
578	Spotted Thrush	*(Turdus fischeri)*
577	Olive Thrush	*(Turdus olivaceus)*
581	Cape Rock Thrush	*(Monticola rupestris)*
595	Anteating Chat	*(Myrmecocichla formicivora)*
596	Stonechat	*(Saxicola torquata)*
598	Chorister Robin	*(Cossypha dichroa)*
600	Natal Robin	*(Cossypha natalensis)*
601	Cape Robin	*(Cossypha caffra)*
606	Starred Robin	*(Pogonocichla stellata)*
616	Brown Robin	*(Tychaedou signata)*
613	Whitebrowed Robin	*(Erythropygia leucophrys)*
635	Cape Reed Warbler	*(Acrocephalus gracilirostris)*

APPENDIX VII: (cont.)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
638	African Sedge Warbler	*(Bradypterus baboecala)*
639	Barratt's Warbler	*(Bradypterus barratti)*
645	Barthroated Apalis	*(Apalis thoracica)*
648	Yellowthroated Apalis	*(Apalis flavida)*
657	Bleating Warbler	*(Camaroptera brachyura)*
661	Grassbird	*(Sphenoeacus afer)*
664	Fantailed Cisticola	*(Cisticola juncidis)*
666	Cloud Cisticola	*(Cisticola tetrix)*
681	Neddicky	*(Cisticola fulvicapilla)*
677	Levaillant's Cisticola	*(Cisticola tinniens)*
678	Croaking Cisticola	*(Cisticola natalensis)*
679	Lazy Cisticola	*(Cisticola aberrans)*
683	Tawnyflanked Prinia	*(Prinia subflava)*
686	Spotted Prinia	*(Prinia maculosa)*
690	Dusky Flycatcher	*(Muscicapa adusta)*
694	Black Flycatcher	*(Melaenornis pammelaina)*
698	Fiscal Flycatcher	*(Sigelus silens)*
708	Blue-mantled Flycatcher	*(Trochocercus cyanomelas)*
710	Paradise Flycatcher	*(Terpsiphone viridus)*
637	Yellow Warbler	*(Chloropeta natalensis)*
644	Yellowthroated Warbler	*(Seicercus ruficapilla)*
700	Cape Batis	*(Batis capensis)*
701	Chinspot Batis	*(Batis molitor)*
711	African Pied Wagtail	*(Motacilla aguimp)*
713	Cape Wagtail	*(Motacilla capensis)*
712	Longtailed Wagtail	*(Motacilla clara)*
716	Richard's Pipit	*(Anthus novaeseelandiae)*
717	Longbilled Pipit	*(Anthus similus)*
720	Striped Pipit	*(Anthus lineiventris)*
727	Orangethroated Longclaw	*(Macronyx capensis)*
728	Yellowthroated Longclaw	*(Macronyx croceus)*
732	Fiscal Shrike	*(Lanius collaris)*
733	Redbacked Shrike	*(Lanius collurio)*
736	Southern Boubou	*(Laniarius ferrugineus)*
740	Puffback	*(Dryoscopus cubla)*
742	Southern Tchagra	*(Tchagra tchagra)*
744	Blackcrowned Tchagra	*(Tchagra senegala)*
750	Olive Bush Shrike	*(Chlorophoneus olivaceus)*
748	Orangebreasted Bush Shrike	*(Chlorophoneus sulphureopectus)*
746	Bokmakierie	*(Telephorus geylonus)*
751	Greyheaded Bush Shrike	*(Malaconotus blanchoti)*
757	European Starling	*(Sturnus vulgaris)*
764	Glossy Starling	*(Lamprotornis nitens)*
768	Blackbellied Starling	*(Lamprotornis corruscus)*
769	Redwinged Starling	*(Onychognathus morio)*
785	Greater Doublecollared Sunbird	*(Nectarinia afra)*
783	Lesser Doublecollared Sunbird	*(Nectarinia chalybea)*
789	Grey Sunbird	*(Nectarinia veroxii)*
790	Olive Sunbird	*(Nectarinia olivacea)*
793	Collared Sunbird	*(Anthreptes collaris)*
792	Black Sunbird	*(Nectarinia amethystina)*
796	Cape White-eye	*(Zosterops pallidus)*

APPENDIX VII: (cont.)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name
801	House Sparrow	*(Passer domesticus)*
804	Greyheaded Sparrow	*(Passer griseus)*
805	Yellowthroated Sparrow	*(Petronia superciliaris)*
808	Forest Weaver	*(Symplectes bicolor)*
810	Spectacled Weaver	*(Ploceus ocularis)*
813	Cape Weaver	*(Ploceus capensis)*
817	Yellow Weaver	*(Ploceus subaureus)*
807	Thickbilled Weaver	*(Amblyospiza albifrons)*
824	Red Bishop	*(Euplectes orix)*
831	Redcollared Widow	*(Euplectes ardens)*
832	Longtailed Widow	*(Euplectes progne)*
828	Redshouldered Widow	*(Euplectes axillaris)*
827	Yellowrumped Widow	*(Euplectes capensis)*
850	Swee Waxbill	*(Estrilda melanotis)*
840	Bluebilled Firefinch	*(Lagonosticta rubricata)*
846	Common Waxbill	*(Estrilda astrild)*
852	Quail Finch	*(Ortygospiza atricollis)*
857	Bronze Mannikin	*(Spermestes cucullatus)*
860	Pintailed Whydah	*(Vidua macroura)*
869	Yelloweyed Canary	*(Serinus mozambicus)*
872	Cape Canary	*(Serinus canicollis)*
873	Forest Canary	*(Serinus scotops)*
877	Bully Canary	*(Serinus sulphuratus)*
881	Streakyheaded Canary	*(Serinus gularis)*
884	Goldenbreasted Bunting	*(Emberiza flaviventris)*

APPENDIX VIII: Birds occurring at the Quko estuary which are regarded as rare or endangered (or potentially so) and for which the Quko habitats are important (Vernon, *in litt.*).

Listed as rare or endangered in the Red Data Book (Birds) (Brooke, 1984)

Cuckoo Hawk +
Martial Eagle +
African Finfoot +
Stanley Bustard *
Cape Parrot
Ground Hornbill +
Spotted Thrush

Species requiring monitoring, according to the Red Data Book (Birds)

Longcrested Eagle *
African Fish Eagle +
Forest Buzzard +
Black Sparrowhawk *
Knysna Woodpecker +

Tropical species, with the Quko as southern distribution limit

Green Pigeon +
Squaretailed Drongo *
Natal Robin +
Spotted Thrush
Croaking Cisticola
Yellow Warbler
Yellowthroated Longclaw
Olive Sunbird
Barratts Warbler
Striped Pipit

APPENDIX VIII (cont.)

South African endemic species

Forest Buzzard +
Knysna Woodpecker +
Knysna Warbler +
Brown Robin +
Chorister Robin +
Olive Woodpecker +
Southern Tchagra +
Cape White-eye +
Greater Doublecollared Sunbird +

Forest species which breed or overwinter at the Quko

Longcrested Eagle*
Crowned Eagle+
Forest Buzzard+
African Goshawk+
Black Sparrowhawk*
Little Sparrowhawk+
Cuckoo Hawk+
Gymnogene*
Rameron Pigeon+
Cinnamon Dove+
Green Pigeon+
Knysna Lourie+
Wood Owl+
Narina Trogon+
Trumpeter Hornbill+
Crowned Hornbill+
Ground Hornbill+
Knysna Woodpecker+
Olive Woodpecker+
Black Sawwing Swallow+
Grey Cuckoo Shrike+
Squaretailed Drongo+
Chorister Robin+
Spotted Thrush
Natal Robin+
Brown Robin+
Starred Robin
Barratts Warbler
Knysna Warbler
Yellow Warbler
Yellowbreasted Apalis+
Bluemantled Flycatche+r
Yellowthroated Warbler+
Cape Batis+
Longtailed Wagtail+
Striped Pipit
Olive Bush Shrike+
Blackbellied Starling+
Grey Sunbird+
Olive Sunbird+
Collared Sunbird+
Forest Weaver+
Swee Waxbill+

Grassland species for which the Quko is important

Stanley Bustard+
Croaking Cisticola+
Wailing Cisticola
Yellowthroated Longclaw+
Redwing Francolin+
Blackwinged Plover
Ground Hornbill+
Yellow Warbler

Riverine species for which the Quko is important

Fish Eagle+
Osprey
Hamerkop+
Black Duck+
Finfoot+
Halfcollared Kingfisher+
Longtailed Wagtail+

* = may breed in area
+ = known to breed in area.

APPENDIX IX: Mammal species of the Quko Estuary and surrounding area. (Topo Sheets: 3228 CB & CD and 3228 CA). Compiled from information supplied by P H Lloyd, CDNEC, Stellenbosch and R L Wingate, Kaffrarian Museum, King Williams Town.

INSECTIVORA

**Amblysomus hottentotus* (Hottentot golden mole) - (R)
Chrysospalax trevelyani (Giant golden mole) - (R)
Crocidura cyanea (Reddish-grey musk shrew) - (P)
Crocidura flavescens (Red musk shrew) - (P)
Myosorex cafer (Dark-footed forest shrew) - (P)
Myosorex varius (Forest shrew) - (P)
Suncus infinitesimus (Dwarf shrew) - (P)

CHIROPTERA

Eptesicus capensis (Cape serotine bat) - (R)
Nycteris phebaica (Common slit-faced bat) - (P)
Pipistrellus nanus (Banana bat) - (R)
Rhinolophus capensis (Cape horseshoe bat) - (P)
Rhinolophus clivosus (Geoffroys' horseshoe bat) - (P)
Rousettus aegyptiacus (Egyptian fruit bat) - (R)
Scotophilus dinganii (Yellow house bat) - (R)
Tadarida aegyptiaca (Egyptian free-tailed bat) - (P)

PRIMATES

**Cercopithecus mitis labiatus* (Samango monkey) - (P)
**Cercopithecus pygerythrus* (Vervet monkey) - (R)
Papio ursinus (Chacma baboon) - (R)

LAGOMORPHA

Lepus saxatilis (Southern bush hare) - (R)
**Pronolagus crassicaudatus* (Red rock hare) - (R)

RODENTIA

Dendromus mesomelas (Bants' climbing mouse) - (P)
**Graphiurus murinus* (Woodland dormouse) - (R)
Hystrix africaeaustralis (Porcupine) - (R)
Mus minutoides (Pygmy mouse) - (R)
Mus musculus (House mouse) - (R)
Otomys irroratus (Vlei rat) - (R)
Praomys natalensis (Multimammate mouse) - (R)
Rattus norvegicus (Brown house rat) - (P)
**Rattus rattus* (Black rat) - (R)
Rhabdomys pumilio (Striped mouse) - (R)
Thamnomys dolichurus (Woodland mouse) - (R)
Thryonomys swinderianus (Greater cane rat) - (R)

CARNIVORA

Aonyx capensis (Cape clawless otter) - (R)
Atilax paludinosus (Water mongoose) - (R)
Canis mesomelas (Black-backed jackal) - (R)
**Crocuta crocuta* (Spotted hyaena - historical record)
Felis caracal (African lynx) - (R)
**Felis lybica* (African wild cat)- (R)
Felis serval (Serval) - (P)

APPENDIX IX: (cont.)

Galerella pulverulenta (Small grey mongoose) - (R)
Genetta genetta (Small-spotted genet) - (R)
Genetta tigrina (Large-spotted genet) - (R)
Herpestes ichneumon (Large grey mongoose) - (R)
Hyaena brunnea (Brown hyaena - historical record)
Ichneumia albicauda (White-tailed mongoose) - (R)
Ictonyx striatus (Striped polecat) - (R)
Lutra maculicollis (Spotted-necked otter) - (R)
Lycaon pictus (Cape wild dog - historical record)
Poecilogale albinucha (White-naped weasel) - (P)
Proteles cristatus (Aardwolf) - (R)

TUBULIDENTATA

Orycteropus afer (Antbear) - (R)

HYRACOIDEA

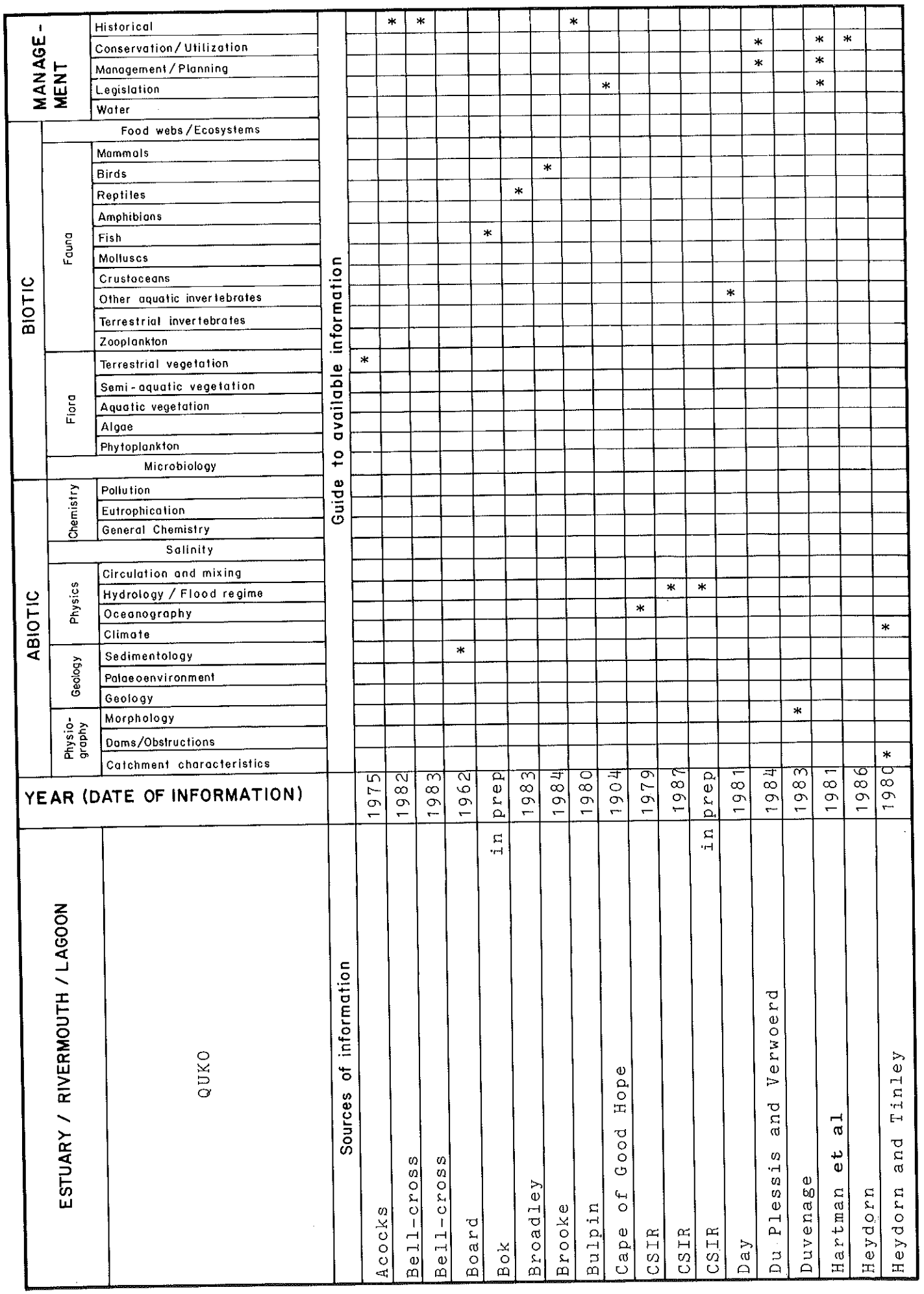
Dendrohyrax arboreus (Tree dassie) - (R)
Procavia capensis (Rock dassie) - (R)

ARTIODACTYLA

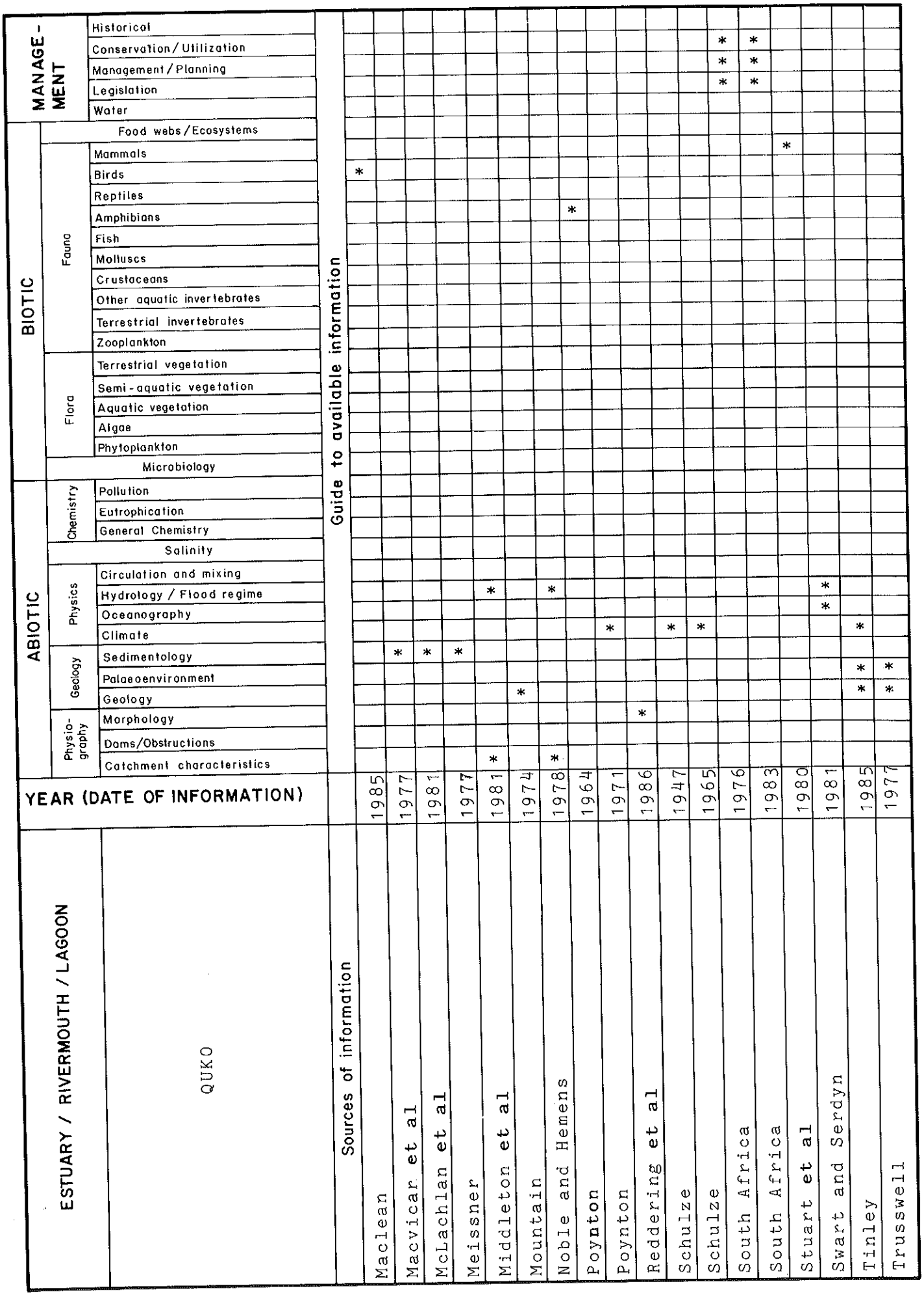
Cephalophus monticola (Blue duiker) - (R)
Potamochoerus porcus (Bushpig) - (R)
Raphicerus melanotis (Cape grysbok) - (R)
Redunca fulvorufula (Mountain reedbuck) - (P)
Sylvicapra grimmia (Grey duiker) - (R)
**Tragelaphus scriptus* (Bushbuck) - (R)

* = Species recorded for the area by Stuart *et al.* (1980) or for which regional voucher specimens are lodged in the Kaffrarian Museum, King William's Town.
P = Probably occur in the area at present.
R = Recorded by the authors (1981-1988).

APPENDIX X: Guide to available information



APPENDIX X: (Continued)



APPENDIX X: (Continued)

ESTUARY / RIVERMOUTH / LAGOON		Sources of information	Van der Merwe	Walter and Leith		MAPS	SA 1:50 000 3228 CA	SA 1:50 000 3228 CB & CD	SA 1:125 000 3227 C & D Geological Series	SA 1:250 000 3228 Geological Series
YEAR (DATE OF INFORMATION)			1962	1960			1965	1965	1975	1979
MANAGE-MENT		Historical								
MANAGE-MENT		Conservation/Utilization								
MANAGE-MENT		Management/Planning								
MANAGE-MENT		Legislation								
MANAGE-MENT		Water								
BIOTIC		Food webs/Ecosystems								
BIOTIC	Fauna	Mammals								
BIOTIC	Fauna	Birds								
BIOTIC	Fauna	Reptiles								
BIOTIC	Fauna	Amphibians								
BIOTIC	Fauna	Fish								
BIOTIC	Fauna	Molluscs								
BIOTIC	Fauna	Crustaceans								
BIOTIC	Fauna	Other aquatic invertebrates								
BIOTIC	Fauna	Terrestrial invertebrates								
BIOTIC	Fauna	Zooplankton								
BIOTIC	Flora	Terrestrial vegetation								
BIOTIC	Flora	Semi-aquatic vegetation								
BIOTIC	Flora	Aquatic vegetation								
BIOTIC	Flora	Algae								
BIOTIC	Flora	Phytoplankton								
BIOTIC		Microbiology								
ABIOTIC	Chemistry	Pollution								
ABIOTIC	Chemistry	Eutrophication								
ABIOTIC	Chemistry	General Chemistry								
ABIOTIC		Salinity								
ABIOTIC	Physics	Circulation and mixing								
ABIOTIC	Physics	Hydrology / Flood regime								
ABIOTIC	Physics	Oceanography								
ABIOTIC	Physics	Climate		*						
ABIOTIC	Geology	Sedimentology	*							
ABIOTIC	Geology	Palaeoenvironment								
ABIOTIC	Geology	Geology							*	*
ABIOTIC	Physiography	Morphology					*	*		
ABIOTIC	Physiography	Dams/Obstructions								
ABIOTIC	Physiography	Catchment characteristics					*	*	*	*

Guide to available information

PLATE I:

Steep coast foreland at Double Mouth, just north of the Quko Estuary. (Photo: ECRU 86-01-31).

PLATE II:

View westward across the eastern arm of the Quko Estuary. The Mqotwane River enters the estuary in the upper reaches of this arm. (Photo: ECRU 87-02-05).

PLATE III:

Aerial view of the estuary and Double Mouth campsite - alt. 180 m. (Photo: ECRU 86-01-31).