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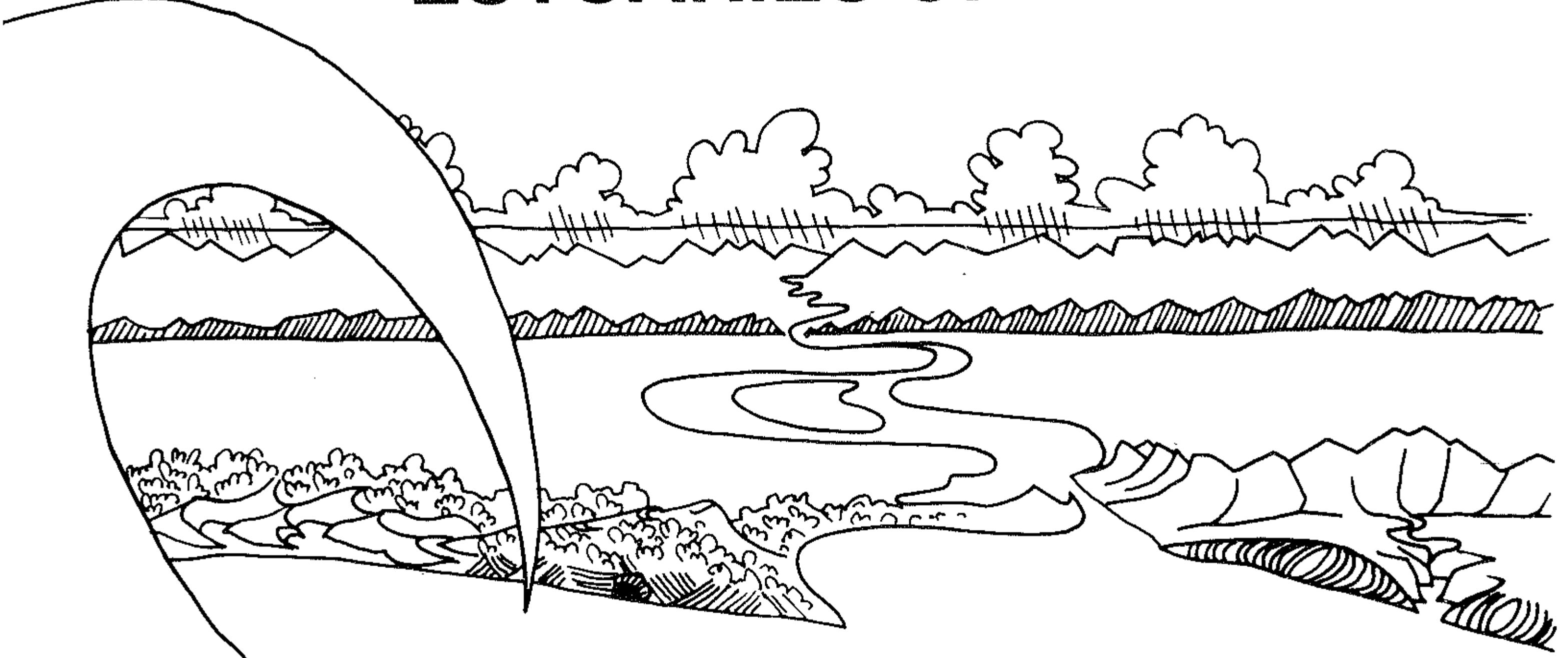
ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 34

KAFFERKUILS (CSW 24) and DUIWENHOKS (CSW 23)

CSIR RESEARCH REPORT 433

Stellenbosch, South Africa
October 1990

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

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REPORT NO. 34:
KAFFERKUILS (CSW 24)
DUIWENHOKS (CSW 23)

(CSW 24 and 23 — CSIR Estuary Index Numbers)

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DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE
AND TECHNOLOGY
CSIR, STELLENBOSCH

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PLATE I: Kafferkuils Estuary (87-02-21)

PLATE II: Duiwenhoks Estuary (79-10-16)

PREFACE

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

- to contribute information relevant to the development of a cohesive management policy for the South African coastline;

- to compile syntheses of all available knowledge on the 167 estuaries of the Cape from the Kei to the Orange rivers;

- to identify gaps in information, to conduct research to fill these and to stimulate Universities, Museums and other institutions to become involved in this kind of work;

- to undertake investigations on the impacts of proposed developments in the coastal environment, and especially in estuaries.

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

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

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

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

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KAFFERKUILS/DUIWENHOKS

1. LOCATION

Kafferkuils

The mouth of the Kafferkuils River is situated at 34°22'S, 21°25'E, about 30 km south of Riversdale (Figure 1).

Duiwenhoks

The mouth of the Duiwenhoks River is situated at 34°22'S, 21°00'E, about 40 km south west of Riversdale and 35 km from Heidelberg (Figure 1).

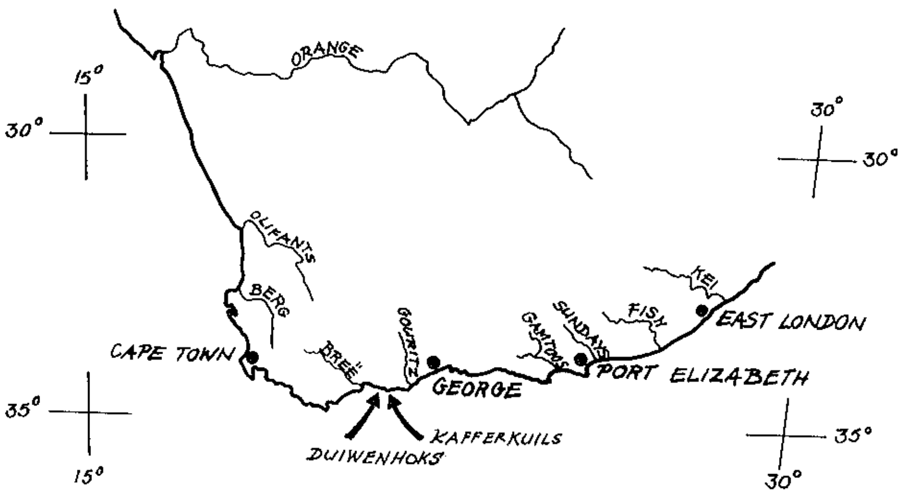


FIG. 1: Locality map showing the positions of the Duiwenhoks and Kafferkuils rivers

1.1 Accessibility

Kafferkuils

Access to Still Bay, situated at the mouth of the Kafferkuils River, is primarily via the tarred main road R323, a distance of some 25 km past the junction of R323 with the N2 just east of Riversdale. This road is situated to the east of the Kafferkuils River. An alternative route is the secondary road from Riversdale to Still Bay West via Vermaaklikheid and Jongensfontein. In addition, a scenic gravel road runs along the west bank of the Kafferkuils River and links up with the secondary road from Riversdale to Blombos (Centrespread). A municipal airstrip was opened in 1979, making Still Bay accessible by air.

Duiwenhoks

Secondary roads from Heidelberg or Riversdale to Vermaaklikheid continue to within 1 km of Puntjie (±30 kms from Heidelberg). From here there are gravel roads to the Kapsteilhuise and to the north along the east bank of the estuary. A secondary road from Still Bay to Vermaaklikheid intersects the afore-mentioned secondary road (Centrespread).

1.2 Managing Authorities

Kafferkuils

Still Bay and the immediate environs fall under the jurisdiction of the Still Bay Municipality, established in 1966. The remainder of the Kafferkuils River catchment is under the control of the Southern Cape Regional Services Council.

Duiwenhoks

The catchment of the Duiwenhoks River falls under the jurisdiction of the Southern Cape Regional Services Council.

2. HISTORICAL BACKGROUND

2.1 Synonyms and Derivations

KAFFIRKUYLS : Name on the Colonial Surveyor General's maps of Riversdale 1890 and 1901.

KAFFIRKUILS : Name on early maps of the area (Royal Navy Admiralty Chart 1855, Union of South Africa's Surveyor General's maps of Riversdale 1926); used frequently in Government Publications (State Forester (Mr Laver) at Still Bay (1936), Department of Water Affairs (1968-1969), on the Cape Provincial Administration's Town Planning Scheme for Still Bay (1977)), and more recently, eg Bulpin (1980), Oelofsen and Van Gass (1984).

KAFFERKUILS : This derivation first appeared in Zwamborn and Rossouw (1967) and has been used, as has Kaffirkuils, since (Cape of Good Hope Proclamation 357 of 1972, Department of Planning (1968), Steyn (1983), 1:50 000 Map Sheet 3421 AD Still Bay (1983).

'Kaffirkuils' appears to mean Native pools; 'kuils' meaning 'dam or pool'. It is possible, however, that Kaffirkuils is a distortion of 'Kaffirskuils' meaning reeds or rushes which grew along the river banks (Bulpin, 1980).

According to Raper (1987), the river is named after a type of plant (*Prionium palmita*) which grows along the banks of the river in the upper reaches. Literally 'Kaffir penis' which the inflorescence resembles, 'kuil' being derived from 'kul'.

DUIVENHOKS : This name was used on early maps of the area (Royal Navy Admiralty Chart (1867), Colonial Surveyor General's maps of Riversdale (1890, 1901), Union of South Africa's Surveyor

General's map of Riversdale (1926), and more recently (Bulpin, 1980; Bohnen, 1986).

DUIWENHOKS : 1:50 000 map sheet 3421 AC Vermaaklikheid (1964, 1983) Cape of Good Hope Proclamation 357 of 1972.

'Duivenhoks' meaning 'dovecote' was the name given to the river in 1689 by an explorer Izaak Schryver because of the large flocks of doves in the area (Bulpin, 1980). However, according to Raper (1987), the name is of Dutch origin and is encountered as early as 1676. Such cotes were built during the early years.

2.2 Historical Aspects

Kafferkuils

An interesting account of the history and development of Still Bay, at the mouth of the Kafferkuils River, can be found in Helene Steyn's book 'Stilbaai' (Steyn, 1983). The main events relevant to this report are outlined below.

There are few reliable records for the Kafferkuils Estuary prior to 1900 but it appears that the first Europeans to reach it overland were trekboers on the Great Trek in 1730 (Bohnen, 1986). The first map of the estuary and its approaches was that of Dayman (British Admiralty), drawn in 1855 and the name Still Bay, indicative of its relative calmness in westerly winds, first appeared on an 1899 map. Farmers from the Riversdale and Klein Karoo regions visited the estuary over the summer months from as early as the late 19th century. Families trekked there by oxwagon and up until 1902 generally camped on the east bank of the estuary in the area called Lappiesbaai. In 1902 the Kafferkuils came down in flood, washing away most of the vegetation in the Lappiesbaai area. Thereafter the campers moved to 'Die Braak" because of problems with driftsands. The site was used until as late as 1952.

Physical development at Still Bay started on the west bank of the Kafferkuils Estuary with the surveying (in 1873) and auctioning (in 1898) of 12 erven later known as Little England. The construction of an access road to Still Bay West started in 1895, encouraging further subdivision and sale of erven primarily on the farms Platbosch and Jagersbos, and on some State ground. The presence of freshwater springs facilitated development on land to the west of the estuary.

On the east bank physical development was slow, this being due to the scarcity of fresh water and inundation of the low-lying areas during large floods. The 1902 floods damaged the three houses which had been built at Lappiesbaai and although rebuilding started as early as 1904 development on the east bank was slow through to the 1950s.

Subsequent houses which were built at Lappiesbaai were erected on stilts for protection against the high spring tides and floods (Figures 2 and 15). Later development on the east bank occurred primarily on the farm Ellensrust and on some State ground.

Initially, transport between the east and west bank was by way of flat-bottomed craft ('platboomskuite'). In 1933 a pontoon began operating across the river about 5 km upstream from the mouth and in 1955 a road bridge, constructed upstream of development on both banks, was completed (Figure 3). The access road to Still Bay was tarred in 1965 and the village attained municipal status in 1966 (Raper, 1987).

FIG. 2: Lappiesbaai houses *circa* 1925. Note stilts, sand movement barriers and large, unvegetated sand area stretching towards the estuary mouth (Photo : Stilbaai Conservation Trust).

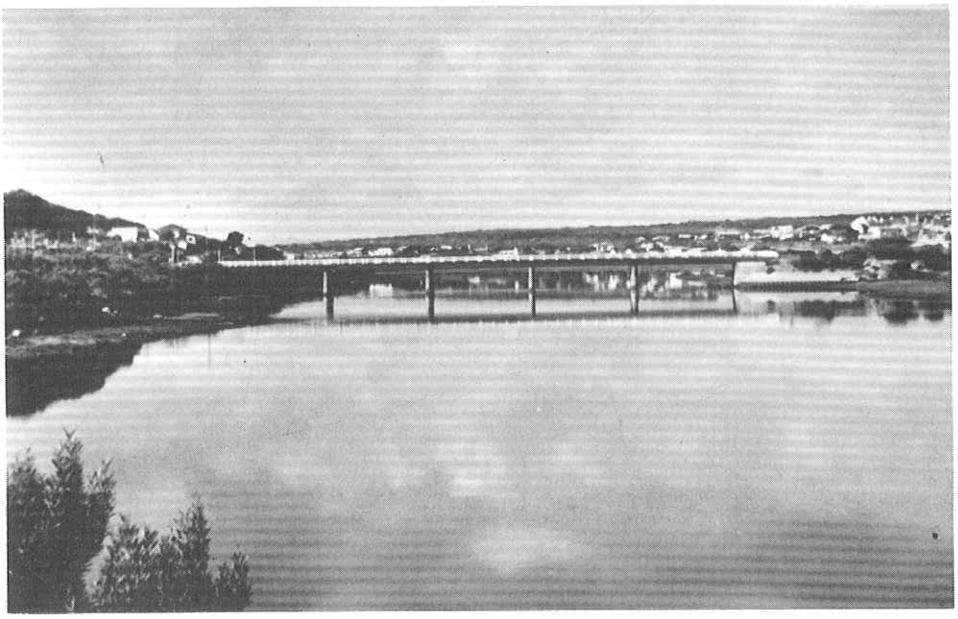


FIG. 3: Road bridge across the Kafferkuils Estuary at Still Bay (85-03-08).

Part of the attraction of Still Bay has always been deep sea fishing. Fishing boats were originally launched at the 'skuitpad', Still Bay West (Figure 4) but this was exposed to strong winds mainly from the south-east and was thus dangerous. Construction of a safer fishing harbour started in 1933 and was completed a few years later (Plate III).

FIG.4: The 'Skuitpad', Still Bay Harbour site, pre 1930. Note the mobile dune fields across the bay (Photo Mrs M-L Roux).

An interesting, albeit short-lived event in the history of Still Bay was the exploration for, and brief yield of oil on the 'Rooisandkoppie' to the north-west of Still Bay West in the early 1920s (Centrespread). This was a precursor of the far more intensive search for oil and gas deposits offshore from Still Bay over the last decade.

The popularity of Still Bay as a holiday resort and place in which to retire has grown steadily over the years. This is reflected in activity on the property market, particularly marked since the 1970s with the growth rate attaining 50 percent in recent years (1984 - 1988) (D de Villiers, former Town Clerk, Still Bay, pers. comm.). This development drive at Still Bay has, however, resulted in a change in the character of the town which, according to some of the older residents, is undesirable. At least one of the recent developments is thought to be visually obtrusive (Figure 5), and there is apparently some frustration regarding the seeming lack of consultation with, and consideration of ratepayers' and interest groups' views in the evaluation of proposals for new developments (Sowman, 1988). This has led to a number of incidents in past years where much publicity has been generated in opposition to proposals which have already been approved by the relevant authority (Letters to Editors of The Argus and Burger newspapers, 1987 -1988). The Still Bay Trust, which held its inaugural meeting in January 1985, was established in response to ratepayers' concerns, as a body to promote conservation and harmonious development of the area. Its aims are given in Appendix VIII (Rudd, 1985).

FIG. 5: Visually obtrusive development on the skyline of Still Bay West (85-06-18).

FIG. 6: The historic Puntjie settlement on the east bank of the Duiwenhoks Estuary (85-03-05).

Duiwenhoks

Early development at the Duiwenhoks Estuary followed a similar trend to that at the Kafferkuils. The first land grant was made in 1725 (farm 'Doornboom') and the region was likely to have been visited by trekboers on the Great Trek in 1730. The area was probably well settled by the third quarter of the 18th century (Bohnen, 1986).

Farmers and townsfolk from Heidelberg and surrounding areas utilised the estuary as a holiday retreat but, because of steep banks, a cliffed coastline to the east and direct exposure to south-west winds to the west, development was restricted. The only concentration of 'houses' in the estuary at the present time are at Puntjie, a privately run holiday resort on the east bank (Figure 6), and private houses at San Sebastian on the west bank (Plate IV). Puntjie is well known for its 'Kapsteilhuise' (truss-style houses, Figure 7) thought to have been originally built by shipwrecked Portuguese sailors in 1887 (Bulpin, 1980). The settlement presently consists of some 81 houses each built according to national monument specifications (see section 2.3 below). There are presently fewer than 15 houses at San Sebastian (Plate IV).

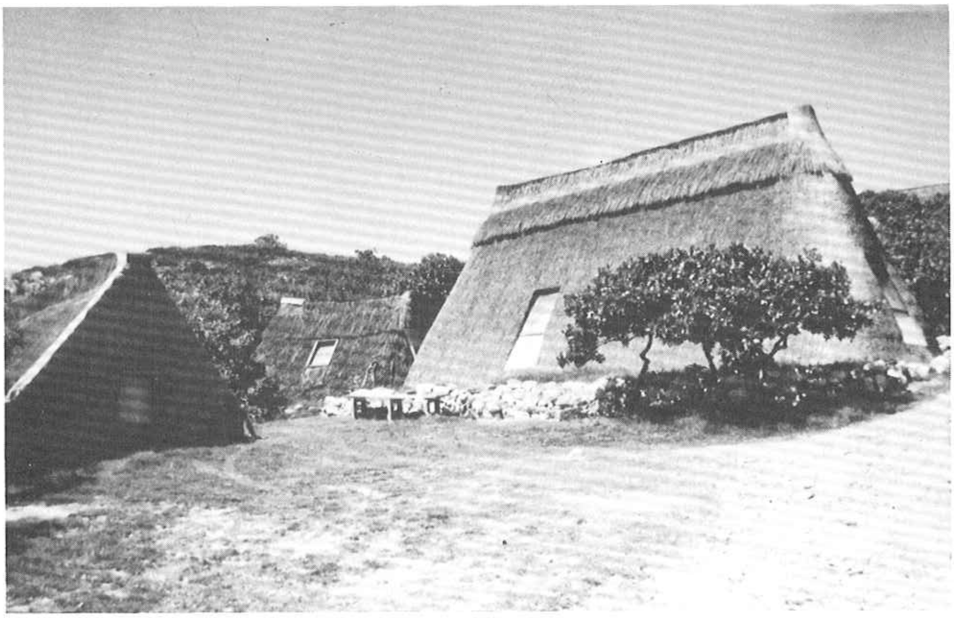


FIG. 7: Kapsteilhuise at Puntjie (85-03-05).

Apart from the above there were attempts to develop a caravan/camping resort on the floodplain of the farm Kleinefontein some 3 km upstream from the mouth (Centrespread). This failed, however, apparently because of difficult and restricted access to the beaches and the absence of safe swimming areas in the estuary because of strong currents.

2.3 Archaeology, Architecture, and Palaeontology

Kafferkuils

Numerous examples of implements and shell middens dating from the middle and late stone age have been found along the coast east and west of the Kafferkuils Estuary; these being widespread but not numerous around the Cape south and south-west coasts (Goodwin, 1946). The Stilbaai area itself has been designated as the type location of a stone age industry (Goodwin and Van Riet Lowe, 1929, quoted in Deacon, 1979) due to the type and abundance of artefacts recovered from the area. The evidence from Klasies River cave (Deacon, 1989) suggests that these artefacts may date from as early as 100 000 years B.P. This makes the area extremely important as far as South African archaeology is concerned. In 1972 a human skeleton with an estimated age of 2 000 years was discovered on an erf immediately west of the estuary mouth (Steyn, 1983). More dramatic reminders of prior inhabitants of the coastal strip are the 'visvywers' (stone packed fish traps) in Still Bay itself (Plate III) and at Noordkapper Point (Figure 8), west of Morris Point. These traps, although still in use, date back to the period of the Strandlopers and are historically valuable.

FIG. 8: Noordkapperpunt with 'visvywers'. Note houses overlooking the beach in the foreground (89-08-06).

Shell fragments (bivalve and gastropod molluscs) are widely distributed on the recent sediments found in the vicinity of the Kafferkuils River and estuary, a feature common to the entire southern Cape coastal plain (Rogers, 1985).

Apart from this, various 'fossil' formations occur eg on Klipfontein and Kransfontein farms, but little is known of their palaeontological value.

The architectural features of Still Bay have been addressed by Oelofsen and Van Gass (1984) in a report on the cultural assets of the region. These authors concluded that the wooden cottages constructed in the early 1900s merit preservation as they have a distinctive character of special interest as do the 'boat houses' at 'Die Braak' (Figure 9).

FIG. 9: Boat Houses at 'Die Braak' built out on to the east bank saltmarsh. Note retaining walls (89-08-06).

Duiwenhoks

In common with the Kafferkuils, shell middens have been found in the vicinity of the Duiwenhoks and shell fragments abound in the recent sediments, eg the driftsand area above the cliffs on the west bank of the estuary adjacent to Kleinefontein Farm. There are no visvywers in the vicinity of the estuary.

The Puntjie kapsteilhuise (Figure 7) have been proclaimed national monuments because of their historical significance. These houses have no walls as such, consisting of steeply pitched thatch 'roofs' that are set directly onto the ground. The roof beams of the original structures were made of tall *Agave* (sisal) stems.

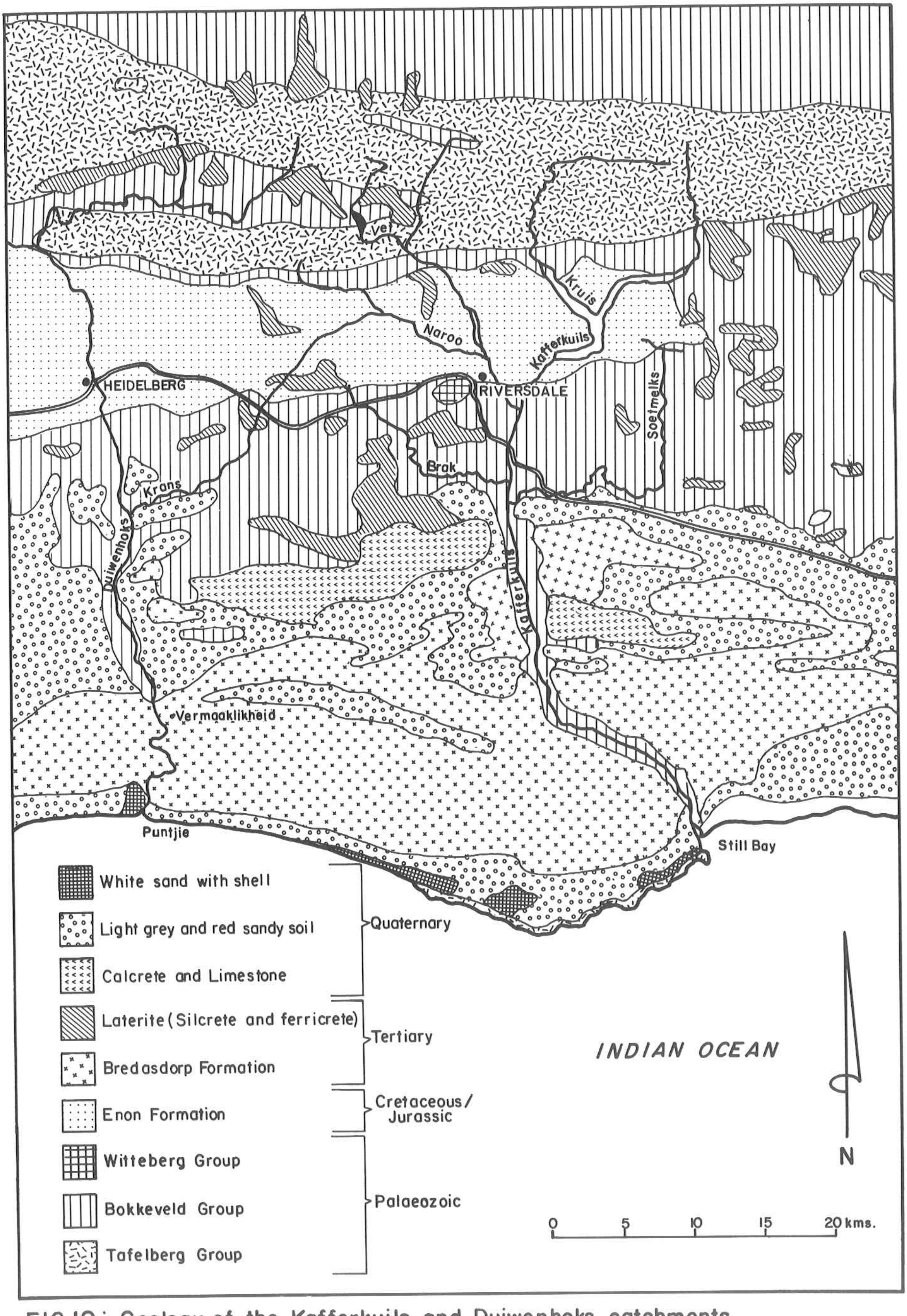


FIG.10: Geology of the Kafferkuils and Duiwenhoks catchments. (adapted from Sowman, 1988).

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Characteristics

The catchment and tributaries of both the Kafferkuils and Duiwenhoks Rivers are shown on the Centrespread and Figure 10.

Area

The catchment area of the Kafferkuils River is given as 1 188 km^2 by Heydorn and Tinley (1980) while the gross and effective areas of catchment are given as 1 550 and 1 155 km^2 respectively by Pitman *et al.* (1981).

The catchment area of the Duiwenhoks River is given as 813 km^2 by Heydorn and Tinley (1980), and the gross and effective areas of catchment as 1 340 and 835 km^2 respectively by Pitman *et al.* (1981).

Figure 11 indicates the upper, lower and total catchment boundaries for the two rivers.

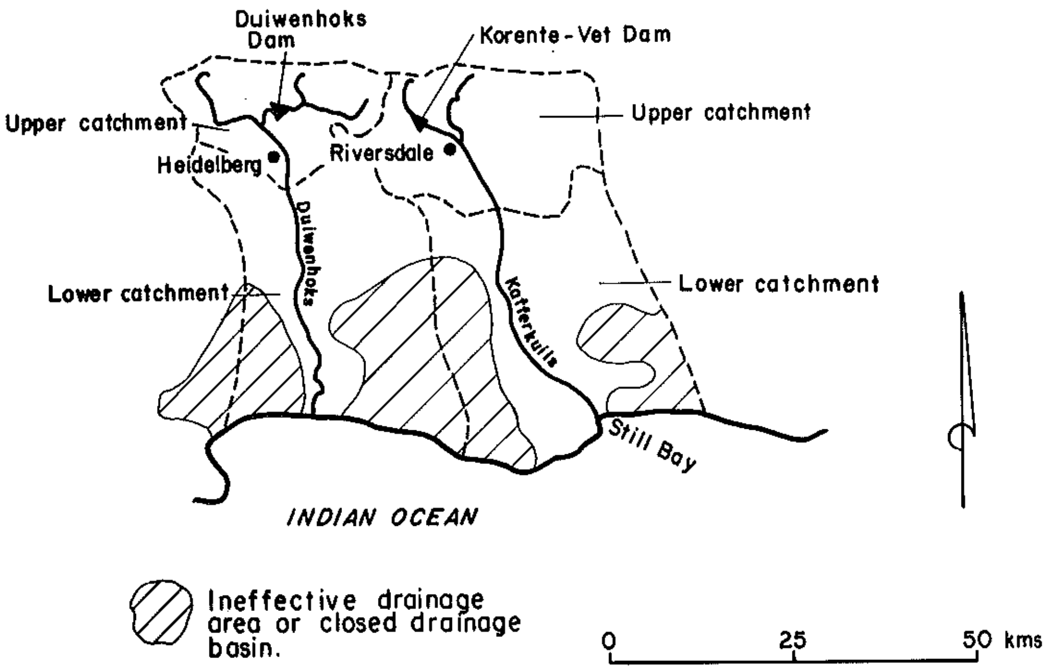


FIG. 11: Diagram showing the boundaries of the upper and lower catchments of the Kafferkuils and Duiwenhoks rivers.

River Origin and Length

Both the Kafferkuils and Duiwenhoks rivers originate on the south slopes of the Langeberg Mountains.

The length of the Kafferkuils River from its source to its mouth is 54 km; that of the Duiwenhoks is 48 km (Fromme, 1989).

Tributaries

Excluding minor streams, there are five major tributaries draining into the Kafferkuils River, namely the Soetmelks, Naroo, Brak, Vet and Kruis rivers.

The Pienaars, Krombeks, Krans and Hooikraal rivers are the main tributaries of the Duiwenhoks River.

These tributaries are shown on the Centrespread.

Geomorphology and Geology

(This section is based largely on a report by the former Sediment Dynamics Division of the NRIO (Fromme, 1989)).

The major geological features of the Kafferkuils and Duiwenhoks river catchments are shown in Figure 10. The two rivers originate in the 1 000 to 1 700 m high Langeberg Mountains of the Cape Fold Belt. These mountains are formed of Table Mountain Sandstone of the mid-Palaeozoic Cape Supergroup. From here, the rivers cut through a peneplain plateau of from 100 m to 300 m which slopes to the coast. The Kafferkuils and Duiwenhoks rivers pass through 10 and 13 km respectively of highly erosive Cretaceous sedimentary rocks of the Enon Formation (particularly clays and conglomerates), followed by roughly 40 and 20 km respectively of Palaeozoic Bokkeveld shales.

The Kafferkuils River opens at the coast in gently sloping surroundings of Tertiary aeolianites (dune rock) and coastal sands, with a few outcrops of Table Mountain Sandstone such as at Morris Point. At the west bank of the estuary mouth, bed erosion has reached the top of the Bokkeveld shales. Between Vermaaklikheid and the coast, the Duiwenhoks River cuts through some 7 km of calcarenite (limestone containing more than 50 percent calcium carbonate) of the Bredasdorp Formation, overlain by Quaternary sands. In this section of its course the river flows through a 100 to 150 m deep canyon-like valley to emerge in a wide but steep-sided basin at the coast.

Climate

The Kafferkuils and Duiwenhoks river catchments fall into climatic region A (Schulze, 1965) which receives rain almost equally in all seasons, with peaks in autumn and spring. The mean annual precipitation (MAP) for the Kafferkuils River catchment is 482 mm; in the upper catchment the MAP is 634 mm (Pitman *et al.*, 1981).

The MAP for the Duiwenhoks River catchment is 485 mm; in the upper catchment the MAP is 750 mm (Pitman *et al.*, 1981).

Wind roses for the Kafferkuils - Duiwenhoks coastal region are presented in Figure 12. In terms of frequency of occurrence westerly to south-westerly winds predominate especially in the winter to spring period. Velocities can be high with the average of the daily maximum strength being 15 m/s (54 km/h). Although secondary in frequency of occurrence, easterly to south-easterly winds have a greater maximum average speed of 18 m/s (64,8 km/h). They thus play an important role in aeolian sand transport, especially as their occurrence and strength peaks occur in the summer - autumn period when sands are dry.

The average daily maximum temperature is about 22°C in January and 16°C in July, extremes reaching 42°C and 32°C respectively. Average daily minimum temperatures are about 15°C in January and 7°C in July, whilst extremes can occasionally drop to 4°C and -4°C respectively. Frosts are rare as are thunderstorms and hail is infrequent (Schulze, 1965). Snow falls occasionally on the Langeberg Mountains in winter and spring.

3.1.2 Land Ownership and Uses

The major part of both river catchments is made up of privately-owned farms, where mixed farming is practised. Cultivation of small grain cereals (mainly wheat) and dryland pasture, in combination with wool sheep and dairy cattle farming are the predominant activities. Tobacco is grown on a small scale and a few ostriches are kept for their feathers. Bee farming in the dune areas is an important economic activity. Agricultural productivity is generally higher in the middle and upper catchments than near the coast where soils are poorer.

In 1981 approximately 12 km^2 of the Kafferkuils catchment were afforested with 25,5 km^2 under irrigation (Pitman *et al.*, 1981). There is one game reserve in the upper catchment area, the 320 ha Werner Frehse Reserve which is owned by the Municipality of Riversdale and has just been leased for an eight year period to a game farmer who may also run cattle there. The mountain catchment of the Langeberg, forming part of the Kafferkuils and Duiwenhoks upper catchments, is managed by the CPA Chief Directorate: Nature and Environmental Conservation (CDNEC) while the Forestry Branch of the Department of Environment Affairs controls the Garcia forest plantations.

In 1981 approximately 4 km^2 of the Duiwenhoks River catchment were afforested with 30 km^2 under irrigation (Pitman *et al.*, 1981).

3.1.3 Obstructions and Impoundments

Kafferkuils

There is one large reservoir, the Korente-Vet Dam (Centrespread) on the Vetrivier in the Kafferkuils River catchment. It is situated north-west of Riversdale (34°00'S, 21°10'E), 350 m above MSL, has a storage capacity of 9,46 x $10^6 m^3$ and was constructed in the period 1963-1965. This dam supplies the Korente-Vette River Irrigation canals north-east of Riversdale and the town of Riversdale.

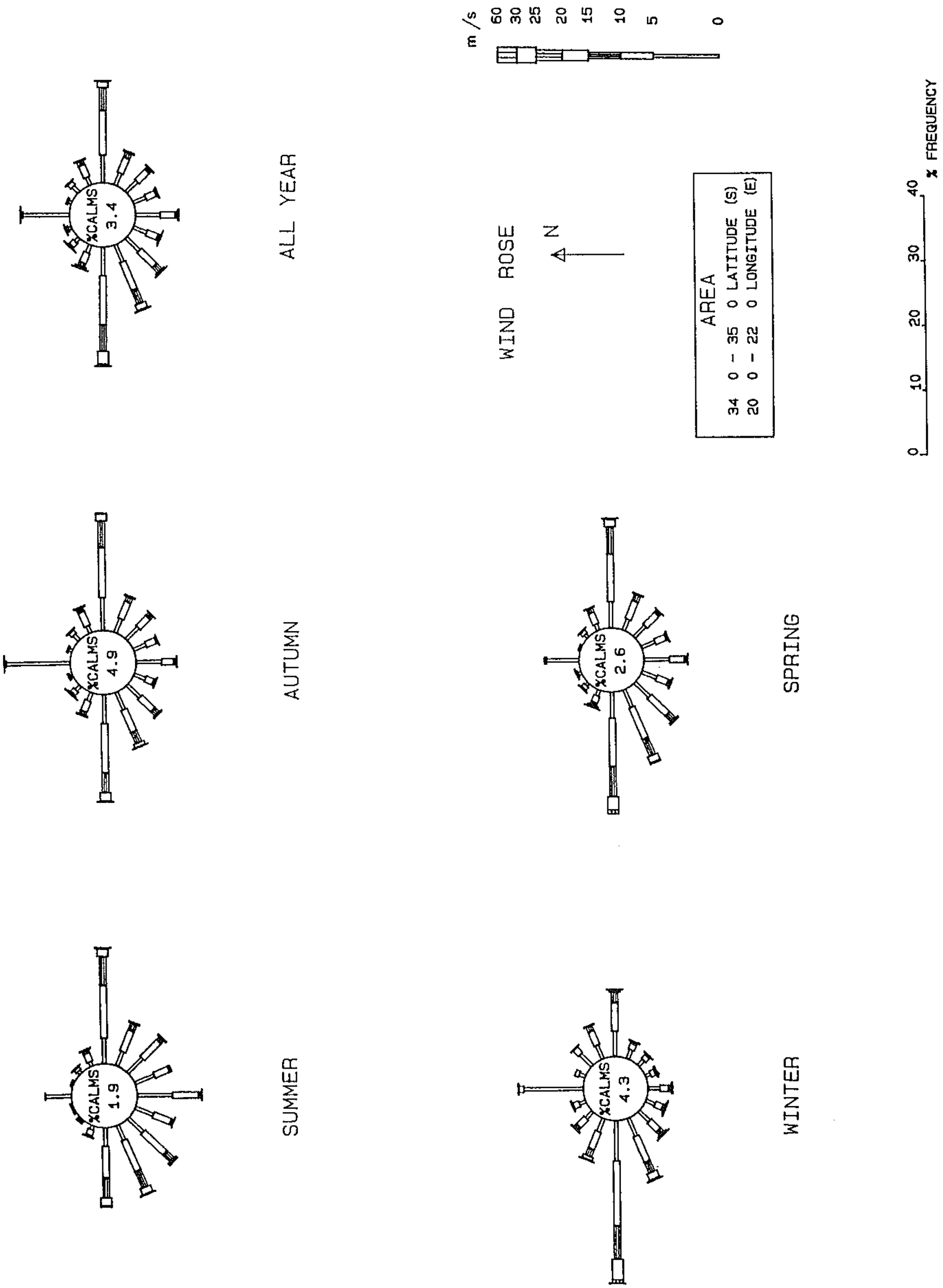


FIG. 12: VOS wind roses for the Kafferkuils / Duiwenhoks coastal region.

Duiwenhoks

The Duiwenhoks Dam (34°00'S, 20°57'E) is situated in the upper catchment of the Duiwenhoks River, some 8 km north of Heidelberg. It has a storage capacity of 5,76 x $10^6 m^3$ and its construction was completed in 1965 (Centrespread). The dam supplies the Duiwenhoks Irrigation Board with water for irrigation and also the Duiwenhoks Water Board which supplies potable water to Heidelberg, Askraal, Witsands and also some 240 farms totalling 147 000 ha with potable water for man, sheep and cattle.

There are a large number of farm dams scattered throughout the catchments of the Kafferkuils and Duiwenhoks rivers. Data on the numbers and capacities of these dams are not available, but field observation indicates that the rate of *ad hoc* farm dam construction, often on drainage lines, has increased rapidly in recent years and has the potential to reduce run-off to those rivers significantly (Braune and Wessels, 1981). This is exacerbated by the large abstractions by pumping for irrigation purposes that are also made from the Kafferkuils River.

Bridges on roads crossing the Kafferkuils and Duiwenhoks rivers and their tributaries do not appear to impede water flow to any great extent.

3.1.4 Sedimentation

Kafferkuils

Although the Kafferkuils River cuts through highly erosive geological formations (Enon Sediments, Bokkeveld shales and coastal limestones (Figure 10)), sedimentation is not excessive because most of the eroded material is fine and is carried out to sea in suspension (Fromme, 1989). A dramatic example of this is depicted in Figure 13.

According to Rooseboom and Coetzee (1975) the sediment yield for this catchment is 150 tons per km^2 per year, which is low. Most of the sediment entering the river from terrestrial sources probably originates from hilly areas in the upper catchment where there is said to be quite an erosion problem (J W du Preez, Riversdale Agricultural Extension Officer, pers. comm.). The Korente-Vet Dam will retain a large part of the inland sediment yield but, as the catchment of this dam is only 8,8 percent of the upper catchment (or 4,1 percent of the total catchment) unchecked erosion on agricultural lands downstream of the dam, may cause sedimentation problems in the lower river and estuary in the future. In the lower catchment there are clear signs of erosion in kloofs feeding the estuary, particularly where livestock have been allowed to graze on newly-burned veld or crop stubble

Although land on the flood plain of the estuary has been cultivated to grow vegetables or pasture, this appears to have had minimal effect on sedimentation.

Fears that the lower reaches of the Kafferkuils River and estuary were silting up have been expressed since the 1960s, but investigations by Zwamborn and Rossouw in 1967, and later by Fromme (1989) have concluded that a sanding up of the estuary is highly unlikely if the historic flood regime is maintained. On the contrary, the estuary channel has become deeper rather than shallower over the past 130 years (Fromme, 1989).

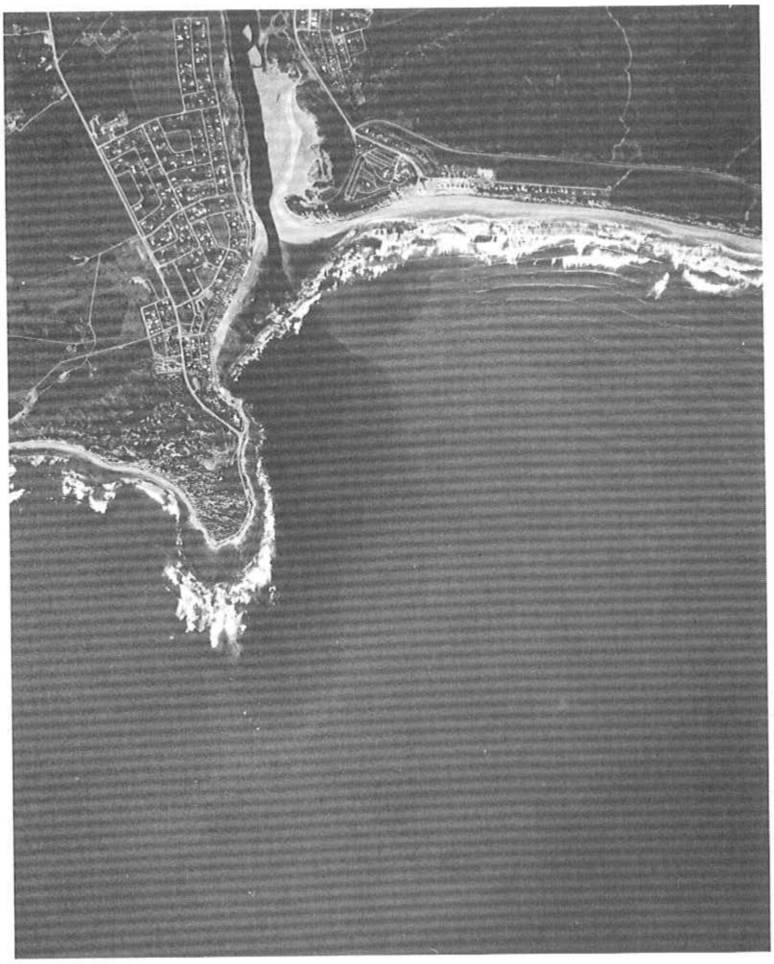


FIG. 13: Kafferkuils Estuary showing eroded material in suspension being carried out to sea (90-05-11).

Duiwenhoks

Ellis (1973) states that the Duiwenhoks River receives large volumes of silt from the catchment. According to Rooseboom and Coetzee (1975), the Duiwenhoks catchment falls into an area of medium sediment production, from 150 to 200 tons per km^2 per year. Most of the eroded sediment is fine clay and silt washed from the middle and upper catchment where large tracts of highly erodible Enon and Bokkeveld clays and shales (Figure 10) have been cultivated for cropping. Although the Duiwenhoks Dam will retain some of the eroded material from the upper catchment (the dam's catchment area constitutes roughly 45 percent of the upper catchment area, or 18 percent of the total catchment), almost all of the remaining sediment will be washed out to sea in suspension by river floods and strong tidal currents. There is thus no apparent danger of these sediments silting up the estuary or closing the mouth (Fromme, 1989).

3.1.5 River Flow Patterns

Kafferkuils

According to Pitman *et al.* (1981) the mean annual run-off (MAR) for the Kafferkuils catchment is 106,42 x $10^6 m^3$. Years with run-off greater than 150 x $10^6 m^3$ ('big floods') have an average interval of occurrence of 3,2 years and years with run-off exceeding the MAR occur on average every 2,8 years. Figure 14a gives the simulated annual run-off for the Kafferkuils River catchment from 1924-1979 (Fromme, 1989).

There have been a number of floods in the Kafferkuils. The first recorded flood, probably because of its effect on property, was that of 1902 when the traditional campsite on the eastern sandspit at the estuary mouth was washed away and the houses built on the dunes at Lappiesbaai were severely damaged.

Since then, there have been no reported flood incidents of a similar magnitude, although stormy conditions in 1978 prompted home-owners on the east bank of the estuary to build protective walls against flood waters, and in 1981 high flow in the estuary was noted by residents to have flushed out sand at the mouth. The most recent of such events was August 1986 where increased river flow, high local rainfall and high seas led to backflooding in the estuary and inundation of the surrounding low lying areas (Figure 15).

The biggest flood peak on record for the Kafferkuils River, 358 cumecs, was measured on 25 January 1981, having an estimated return period of 20 years (Z Kovàcs, Department of Water Affairs, pers. comm.). The volume flow of a 100-year flood has been estimated at about 1 400 cumecs.

A number of sources, including local residents, state that either the flow of water in the estuary, or flooding, has decreased over the past 20 to 30 years (Department of Planning, 1968; Oelofsen and Van Gass, 1984; Walsh, 1968). This has been attributed to impoundments in the catchment generally, and to the Korente-Vet Dam specifically. Although there are no detailed analyses of run-off, flow and land-use for the Kafferkuils River catchment, it is unlikely that the Korente-Vet Dam (which can hold roughly eight percent of the mean annual run-off for the whole catchment) and other dams will have a marked effect on river flow or major flood incidents. A likely effect of these dams, however, would be to damp flooding, particularly if they were relatively empty at the time of high rains or run-off, which has consequences for the hydraulic stability of the estuary. The high pump extraction (above) also has a bearing here.

With the growth of the sandspit at the mouth of the estuary (Section 3.2.2) and the continued stabilization thereof, it is feared that in any abnormal flood events in future, water could back-up behind the spit, leading to high flood waters over the low-lying areas of the campsite and Lappiesbaai properties (Figure 15), as well as properties higher up on either side of the river.

Duiwenhoks

The mean annual run-off (MAR) for the Duiwenhoks catchment is 89,73 x $10^6 m^3$ Pitman *et al.*, 1981). Years with run-off greater than 120 x $10^6 m^3$ ('big floods') have an average interval of occurrence of 4,25 years, and years having a run-off exceeding the MAR occur on average every 2,1 years.

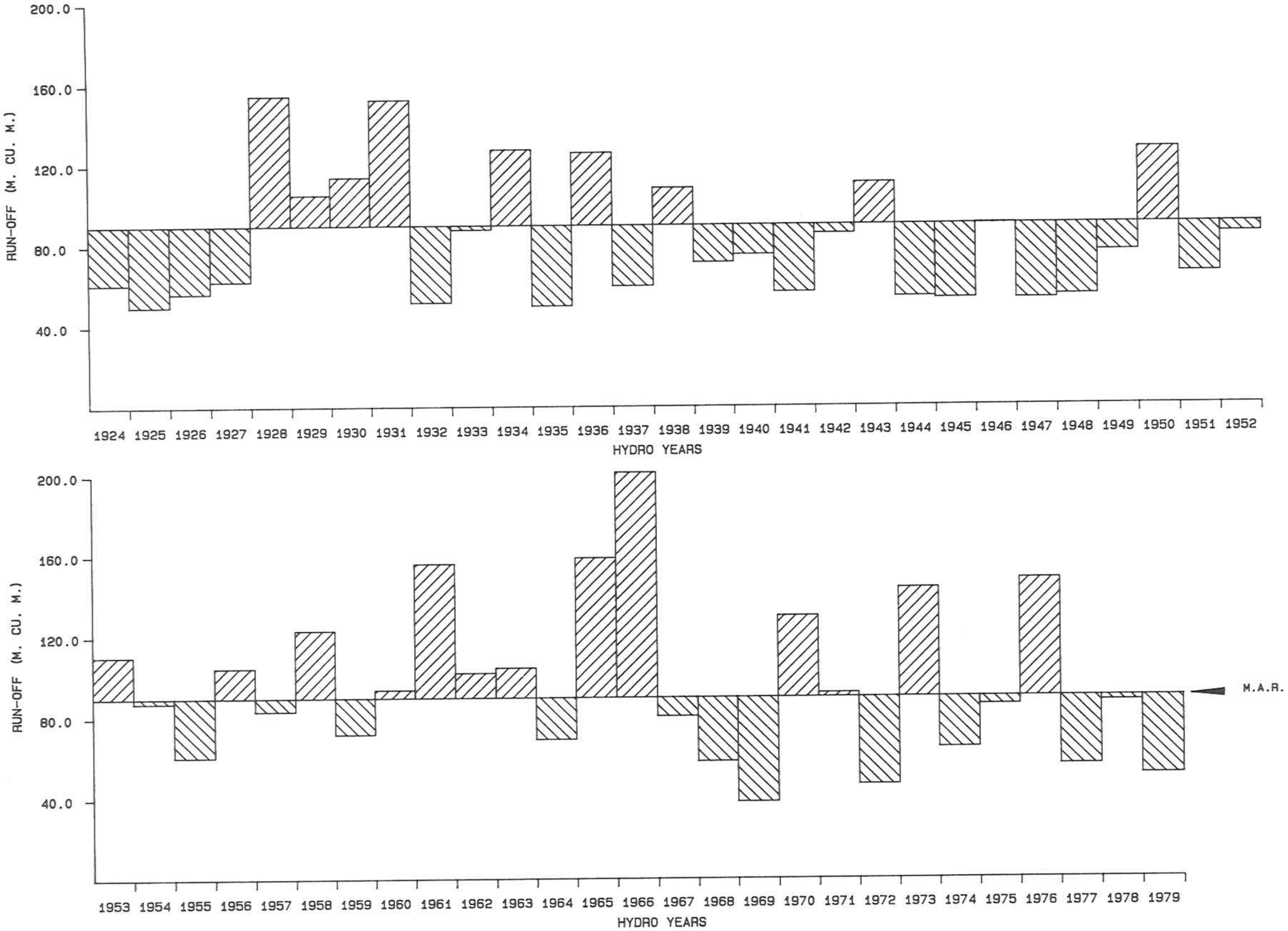


FIG. 14a: Simulated run-off for the Kafferkuils River catchment for the period 1924 - 1979.

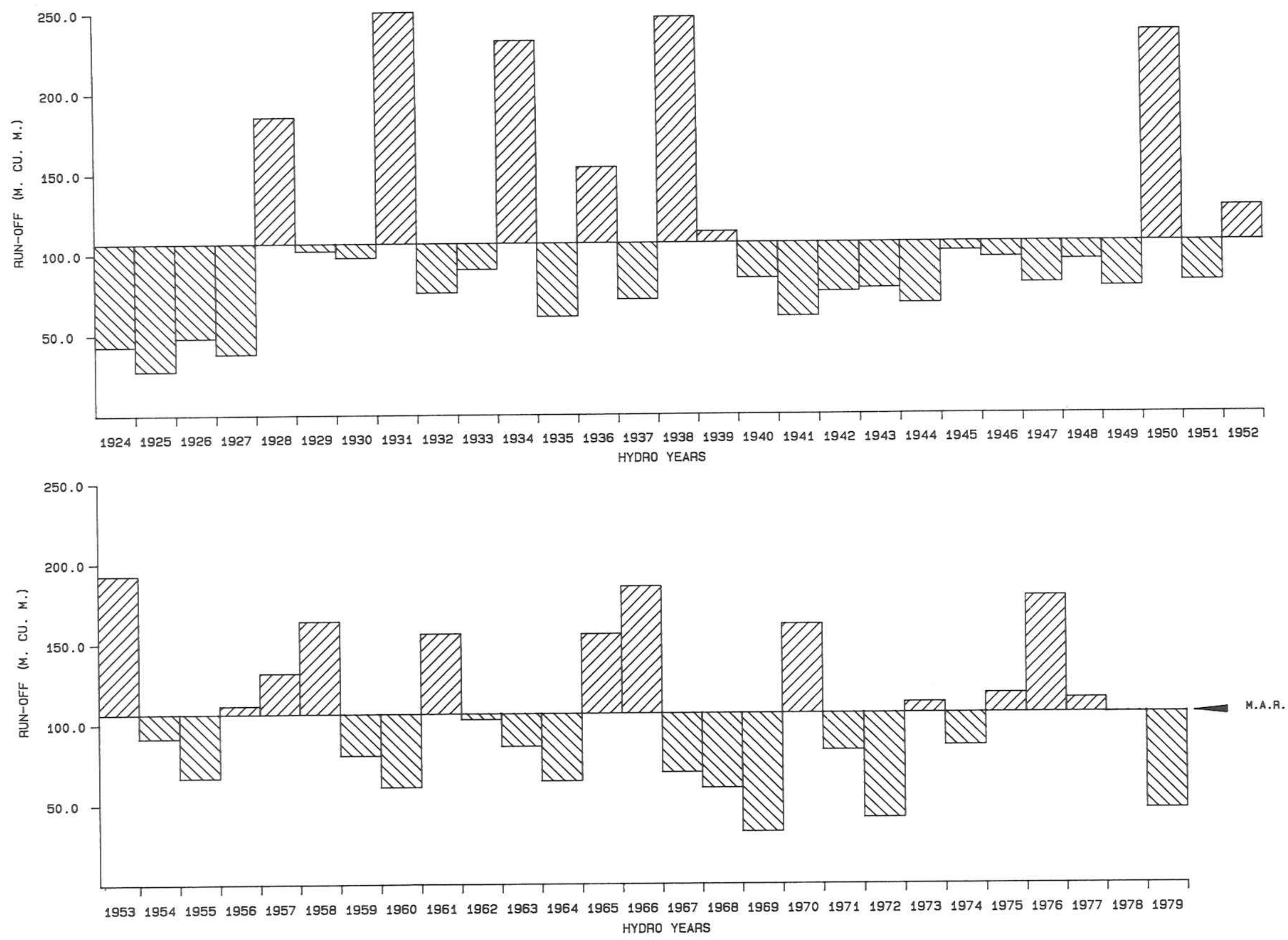


FIG.14b: Simulated run-off for the Duiwenhoks River catchment for the period 1924 - 1979.

FIG. 15: Backflooding of Lappiesbaai and the east bank camp site area during the minor flood of August, 1986. Note the Lappiesbaai houses on stilts (86-03-30).

Figure 14b depicts the simulated run-off for the Duiwenhoks River catchment for the period 1924-1979. From 1939 to 1956 the annual run-off for the Duiwenhoks River catchment was continuously below the MAR, allowing large sand banks of marine origin to build up in the estuary mouth (Fromme, 1989). This dry spell was relieved in the early 1960s. The biggest flood peak on record for the Duiwenhoks River was measured as 194 cumecs at the Duiwenhoks Dam on 25 January 1981, having an estimated return period of 10 years (Z Kovàcs, Department of Water Affairs, pers. comm.). However, similar to the Kafferkuils, the biggest observed flood event occurred in 1902 when water levels rose to the attic level on the Kleinefontein farmhouse at the estuary (E Dicey, present owner of Kleinefontein Farm, pers. comm.).

TABLE 1: Water depths recorded in the Kafferkuils and Duiwenhoks estuaries (Fromme, 1989). Note : water depths are not related to chart datum levels.

A: Kafferkuils Estuary (Measured during HWST, 85-06-30)

Distance from mouth (m)	Water depth (m)		Remarks
	Average	Maximum	
200	1,29	2,60	max. in inlet channel
1 300	1,74	2,20	
2 150	1,52	2,50	shallowing probably as a result of bridge

B: Duiwenhoks Estuary (Measured during HWST, 85-08-01)

Distance from mouth (m)	Water depth (m)		Remarks
	Average	Maximum	
300	1,20	3,90	deep sections confined
1 000	1,36	3,95	to narrow V-shaped channels
1 700	1,51	4,20	usually along a rocky bank
3 700	~4,0	~5,0	uniformly deep box shaped
5 100	~4,5	~5,0	cross sections
10 000	~5,0	~5,6	

3.2 Estuary

This summary of the Kafferkuils and Duiwenhoks estuaries is partly based on a detailed report by the former Sediment Dynamics Division of the NRIO (Fromme, 1989).

3.2.1 Estuary characteristics

Kafferkuils

The Kafferkuils Estuary is embedded in a deep valley cut into the surrounding coastal plateau of calcarenite which drops to less than 50 m at the mouth. Here the estuary emerges in a funnel-shaped opening about 1 km wide and 1 km long in a sheltered bay. The estuary is permanently open, but has a constricted tidal inlet.

The open water surface of the tidal area is calculated to be 108 ha. The tidal reach is 19 km, of which 17 km are navigable by small boat.

FIG. 16: Aerial photo of the Kafferkuils Estuary taken in 1942, showing extensive dune fields east of the estuary and absence of the east bank vegetated sand spit (Photo: Trig. Survey, 1942).

At present the mouth channel scours along the west bank, where erosion has reached the top of the Bokkeveld shales. These shales dip slightly towards the east, in this way restricting further westward erosion. The east bank is an area of extensive accretion of sand and was previously continuous with an inland sand 'sink' (Figure 16 and cf Breë Estuary, Carter, 1983). Consolidation of this 'sink' plus the building of houses and a road across the sediment transport route have led to increased sediment transport to the estuary mouth region. This has resulted in the development of a 600 to 700 m long sandspit on the eastern bank. This has 'trapped' the estuary outflow channel on the western bank. In the hydraulic 'dead space' behind the spit, a large beach and mudflat area has consolidated over the past four decades. The sandspit itself and adjacent beach of Still Bay east were artifically stabilized with rooikrans during this period and a water slide, mini golf course, cafe, access road and parking area were established on the sandspit after 1982 (Plate V). These developments are below the 1925 high-water mark. Effectively, the cover of rooikrans and presence of artificial structures have transformed what was a dynamic, temporary feature into a more permanent one.

The maximum water depth in the estuary (Table 1A), measured over a distance of 2,15 km from the mouth at high-water spring tide, is 3,55 m at a spot 1,7 km from the mouth. The inlet channel has a maximum depth of 2,6 m.

Duiwenhoks

The Duiwenhoks Estuary flows through a 100 to 150 m deep canyon-like valley of calcarenite to emerge in a coastal basin 700 m long and 500 m wide. Like the Kafferkuils Estuary, the Duiwenhoks Estuary is permanently open with a constricted tidal inlet. The total surface area of the Duiwenhoks Estuary is 96 ha, of which 72 ha are open water. The tidal reach is 14 km.

At present the eastern side of the coastal basin has a rigid boundary in the form of the 50-80 m high dune rock promontory of the 'Puntjie'. An intertidal, heavily eroded platform of dune rock extends westwards from the foot of the promontory, becoming subtidal in the tidal inlet.

The west bank of the estuary is formed by a sandy beach which runs as a narrow seam along the foot of the steep limestone plateau from Witsand to the Duiwenhoks River mouth. At the mouth, the beach (including its backshore dune area) broadens from 40 to 50 m to form a blunt sandspit roughly 100 m wide between the high- and low-water lines. Partly vegetated hummock dunes range from 5-10 m in height to 20-30 m towards the upper border of the backshore area.

The estuary basin is filled by an intertidal sandbank surrounded by a shallow channel (Figure 17). During ebb-tide the mouth channel was only 15-20 m wide and an estimated 2 m deep, according to an ECRU Survey on 5 March 1985. With rising tide, the width of the channel increases roughly tenfold and its average depth - including the then inundated shoals, intertidal sandbank and spit - is about one metre. The average and maximum water depths measured in the Duiwenhoks Estuary are given in Table 1B.

3.2.2 Mouth Dynamics

The sediment and hydrodynamics at the Kafferkuils and Duiwenhoks river mouths are controlled by an interaction of four variables:

* longshore currents in the surf zone
* tidal currents in the estuary mouth
* river floods and
* aeolian sand movement

FIG. 17: The large intertidal sandbank and channels in the Duiwenhoks Estuary. Note the broad, blunt western sandspit and the skiboat channel in the wave cut platform below the Puntjie promontory on the eastern side (89-08-06).

Kafferkuils

Longshore currents in the surfzone are primarily generated as a result of approaching deep-sea waves. These undergo various changes as they become influenced by coastal features such as headlands and the shallowing bottom topography. These changes and modifications of waves are reflected in the surfzone current regime as the velocities and direction of longshore currents are governed by the wave approach angle together with features such as wave set up due to refraction ('bending'), diffraction (absorption) and wave damping around capes and by shoal areas.

The VOS southern Cape wave data (Figure 18) shows that the swell regime in the vicinity of Still Bay is dominated by swells in the south to west (180-270°T) sector with a smaller peak in the east to south east (90-112°T) sector. As the waves in the latter sector are associated with south-easterly winds they occur least frequently in winter. The Kafferkuils Estuary is protected from the direct onslaught of high energy waves in the south to west sector by Morris Point. However, as these waves are refracted around the point, the estuary mouth area does receive some residual energy from these swells, which, because of further refraction due to the shoaling bottom, approach at an angle of almost 90° to the beach.

The reduction of wave energy due to wave refraction and diffraction at Morris Point decreases eastward of the Kafferkuils Estuary. Thus waves originating from the south to western sector that strike the beach at Preekstoel have more energy than those that strike the beach at the estuary. This results in higher water levels in the former area which causes a longshore current flowing westwards from Preekstoel to the estuary to be set up. Westward flow will also be set up in this region by waves from the easterly-south-easterly sector due to their oblique approach to the beach and consequent alongshore energy flux. These westward flowing currents transport sediment, churned up by breaking waves, with them and deposit it in the vicinity of the Kafferkuils Estuary mouth. The result is that the Preekstoel beach, and the beaches immediately to the east of it, are constantly being denuded of sediments and the estuary mouth area replenished. Thus the beaches in the former area are narrow and unstable and the Lappiesbaai beach is wide and more stable.

R T Rudd (*in litt.*) has observed that, after prolonged blows of south-easterly winds, and associated easterly to south-easterly swells, rock ledges are exposed at Preekstoel and the Still Bay harbour silts up with sand. Under these conditions quite strong west-flowing longshore currents obviously develop. Due to the seasonal nature of the south-easterly winds the sanding up of the harbour area occurs more frequently in the summer period than in winter. Rudd (*in litt.*) states that the sediment deposited in the harbour generally disappears in the winter/spring period. The mechanism that removes sediment from the harbour area is a net northward flowing longshore current between the harbour area and the Kafferkuils Estuary mouth. These currents are driven by high energy waves approaching from the west to south-western sector, being refracted and diffracted at Morris Point. Morris Point is not large (cf. Cape Infanta) and there is no extensive shoaling reef offshore of it (cf. Struispunt). Thus a considerable amount of wave energy can bypass the Point and impact on the wave shadow area of the harbour. The amount of energy reaching this area is directly dependent upon wave height. Thus under high swell conditions strong northward flowing currents occur; eg Vonk (1977) measured a northward flow of 0,9 m/sec under these conditions. Such strong currents flush sediment out of the harbour and transport it back to the estuary mouth where it is deposited on the ebb-tide delta.

In summary, in the region between Preekstoel and the Kafferkuils Estuary mouth there is a persistent westward flowing current induced by wave set-up during the winter months. The westward flow is accelerated by easterly and east-south-easterly swells during south-easterly wind events predominantly during summer. Under these latter conditions the westward flowing current extends to the harbour area. This is particularly well illustrated in Figure 13. Under high south to western sector waves a strong northward flowing longshore current from the harbour to the estuary mouth is set up primarily by diffracted wave energy.

The hydrodynamics of the Kafferkuils River estuary is governed mainly by the sea tides, leading to slight flood-tide domination. Although marine sand banks can extend to 2,5 km upstream, ebb-tides have sufficient energy to return most of the marine sediments washed into the estuary back into the sea. This is due to the tidal asymmetry in the Kafferkuils Estuary being strongly in favour of the outflowing component. The rate of net influx of marine sand is thus low. However, marine sand that is dumped or transported away from the channels can be trapped in the estuary region. A prime example of this is sand trapping in the eastern bank salt marsh behind the sand spit. The tidal range is reduced from 2,07 m at the sea to 1,2 m inside the mouth and to 1,1 m at the road bridge 2,5 km upstream. Sand transported out of the estuary by this mechanism is initially dumped on the ebb-tide delta.

River floods have been addressed above in Section 3.1.5. In flood events, the coast from the mouth to the harbour is likely to receive both marine and terrestrial sediment flushed out of the estuary which will then be scoured and transported back to the mouth by longshore drift.

High-speed easterly to south-easterly winds cause a displacement of sand along the beach from Preekstoel to the mouth of the Kafferkuils Estuary. Some of this sand was previously transported into the inland sand sink. The aeolian sand movement together with a west-going longshore component has led to the formation of the blunt sandspit at the east bank of the mouth. It is evident from a comparison of Royal Navy Charts (1855, 1890) and aerial photographs (1942 to 1987) that there has been progressive deposition of sand at the eastern bank of the estuary immediately upstream of the mouth. This process caused the closure of a previous eastern arm of the estuary and the later establishment of saltmarsh on what had been an island surrounded by this arm in the past century (Fromme, 1989). The westward drift of sand also supplies sand to the surf zone of the mouth, affecting the sediment balance at the west beach and harbour.

The shape and situation of the ebb-tidal delta offshore from the estuary mouth is influenced by the interplay of longshore currents, aeolian sand supply and river floods. Sand deposited on the delta is incorporated into the nearshore circulation system, following the route from the delta to the beach east of the mouth and then into the mouth area and back to the ebb-tide delta. This appears to be a more or less closed circulations as there are no significant supplies of new sediments to the system. The supply from the sea appears to be small as there is no evidence of a sand pathway across the Morris Point peninsula as is the case in St Francis Bay. However, marine sand will move around Morris Point during stormy conditions to augment the supply of sand to the beaches east of Still Bay. The supply from the Kafferkuils River itself is also not large (above).

Fears that the Kafferkuils River estuary is silting up and that the mouth might close have been expressed repeatedly since 1966, but this is thought to be improbable under the present river flow and flood regime for the following reasons:

- With the exception of growth in the sandbank in the shelter of the sandspit, which does not affect the mouth channel, there seems to be no increase in sand volumes inside the mouth.
- The tidal prism of the estuary is sufficiently large to keep the mouth open.
- The base rock ledges in the mouth increase turbulent flow thereby also increasing sand transport rates.
- Water depths in the lower estuary have not changed significantly over the past 130 years.

A number of activities at Still Bay have interfered with the natural dynamics at the mouth of the Kafferkuils Estuary.

(i) The Department of Forestry started to stabilize dunes at Still Bay with Marram Grass from as early as 1901 (Gohl, 1944) (Figure 19) and began using rooikrans in 1928 (Walsh, 1968). In the period

1942/43 to 1961 the coastal dunes east of the estuary and a large part of the sandspit were colonized by rooikrans, and by 1981 the stabilized area of the spit had extended as far as the mouth channel.

Aeolian creep diagrams (Figure 20) show that the dominant net movement of sand, over all seasons, at the Kafferkuils Estuary is to the north-east despite a strong westerly component in summer and autumn. Historically this net north-eastward sand transport was absorbed into the dune fields north of the estuary mouth (Figure 16). However, with the disruption of the transport link between the beaches and the dune fields by dune stabilization, house, road and parking area construction, the sand is now retained in the beach area. This has led to a steepening of the beach itself and, of course, there being more sand available for transport to the west. Direct consequences of this are the build out of the eastern sand spit at the estuary mouth and periodic sand inundation problems at the car park and across the road.

(ii) Progressive development on the sandspit (Plate V) including the caravan-park, water slide, mini golf course, cafe and access road, together with its stabilization with rooikrans, have decreased the probability of the sandspit being washed away in a large flood. This has implications for back-flooding behind the spit in the event of heavy flow in the estuary (Section 3.1.5). In addition, analysis of Royal Navy charts and aerial photographs has shown that historically the mouth channel underwent long-term migrations between the eastern sandspit and the west-bank (in 1855 a distance of 300 m.) The mouth channel has been restricted to a distance of less than 200 m against the west bank since stabilization of the spit in the early 1940s. The increasingly 'permanent' nature of the sandspit has resulted in its acting as a barrier to the flushing out of sediment being deposited in the hydraulic 'dead space' behind it. In time, continued deposition of sediment is likely gradually to smother the saltmarsh situated upstream of the spit. There is evidence that this process is already underway (Rudd, pers. comm.).

(iii) The coastal fore dunes on the eastern side adjacent to the mouth of the estuary, which are involved in the dynamics of aeolian sand movement, apart from being artificially stabilized, have been interfered with by being bulldozed repeatedly in the early 1970s. This was done to create parking facilities on the Lappiesbaai beach front and to flatten the surroundings of seven houses constructed in the dunes at Lappiesbaai. These actions, as well as influencing patterns of aeolian sand movement in the vicinity of the estuary, have resulted in problems with vortex erosion around beach houses (Figure 21) and encroachment of driftsand on the municipal roads; Gordon Street in particular.

Duiwenhoks

VOS swell data for the southern Cape (Figure 18) show that the Duiwenhoks mouth receives deep-sea waves from a restricted direction sector only, namely, the south south-west. This results in an eastward longshore drift in the surf zone, which is largely supported by the predominant south-westerly winds (Figure 12). Aeolian sand transport is also to the east as indicated by sand

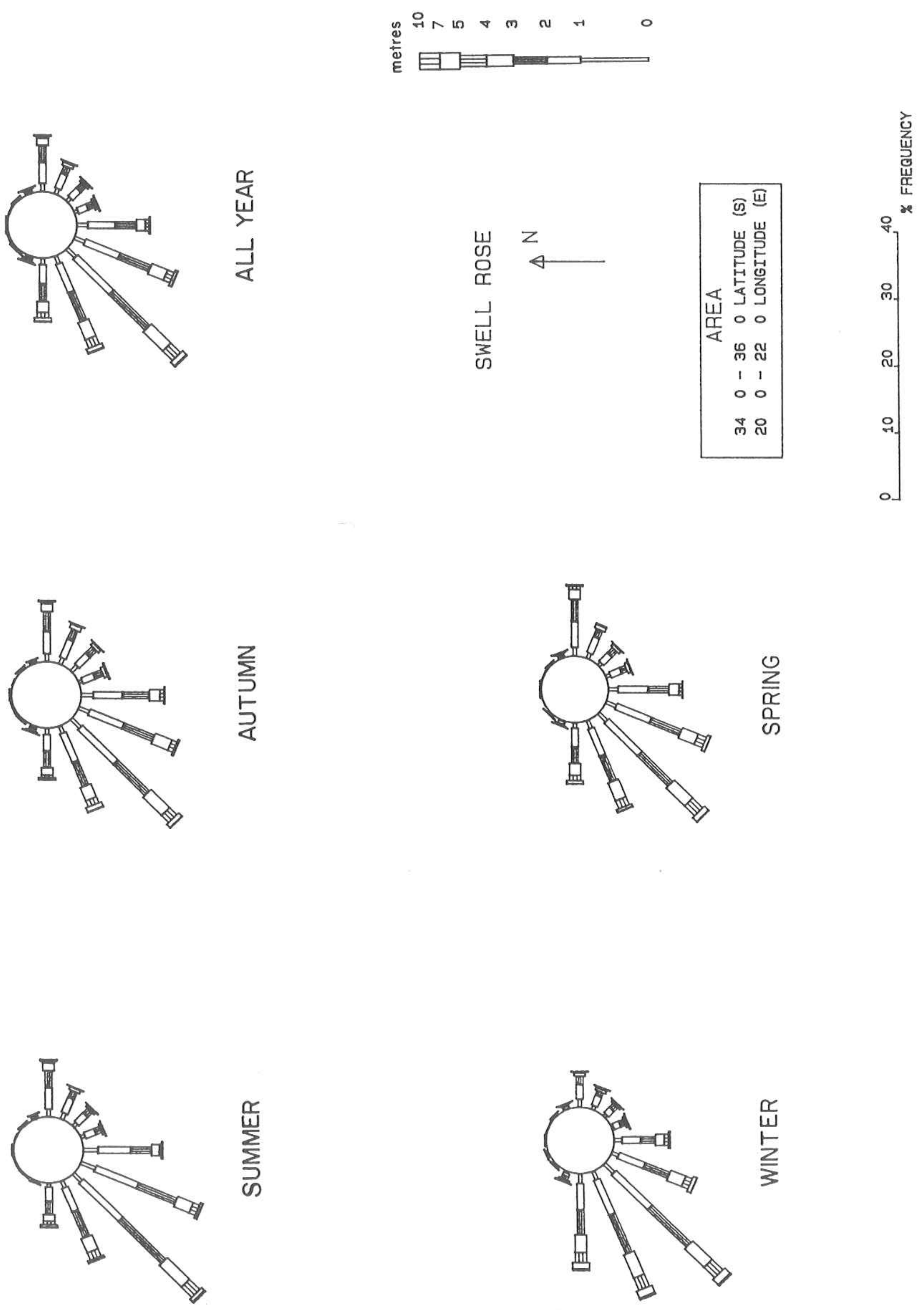


FIG. 18: VOS swell roses for the Kafferkuils / Duiwenhoks coastal region

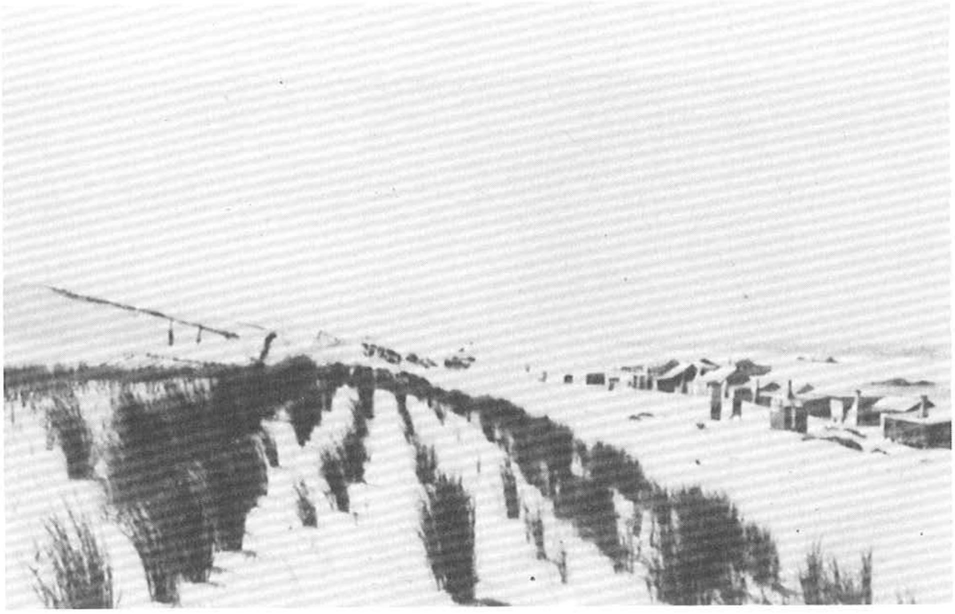


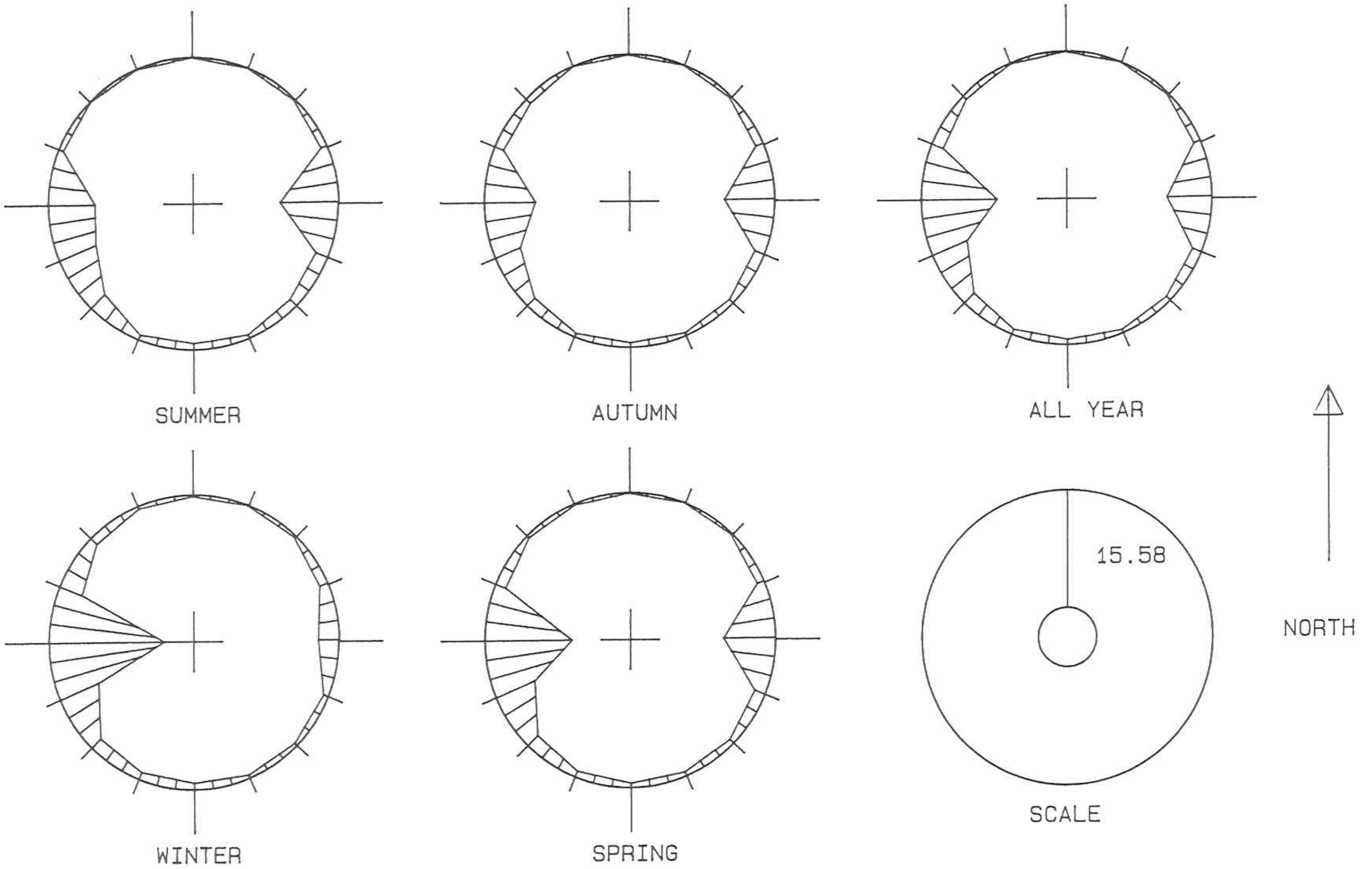
FIG 19: Lappiesbaai, October 1937, showing western end of the littoral barrier dune being raised by Marram grass (Photo: J J Kotze).

creep diagrams (Figure 22). There is thus a moderate net eastward transport of marine sediment longshore adjacent to the estuary, reflected in the widening of the beach over time, build up of dunes and the formation of a blunt sandspit west of the estuary mouth.

Measurements made during the ECRU survey of March, 1985 show that there is a marked asymmetry of the tidal currents flowing in and out of the constricted tidal inlet at the estuary mouth. Outgoing currents have only about 60 percent of the speed of the incoming tide and last for 7 hours as opposed to 5,5 hours for the incoming tide.

The tidal range is reduced from 1,46 m at sea at ordinary spring tide to 0,9 m inside the mouth and 0,85 m at Oshoek 4,5 km upstream of the mouth. The Duiwenhoks Estuary is flood-tide dominated and there is a net ingress of marine sediment. This is reflected in the estuary bed which changes from being a wide shallow basin of clean marine sand to a deeper box-shaped bed with a bottom substrate of muddy sand to mud approximately 3 km upstream of the mouth. The influx of marine sand in each tidal cycle is largely countered by edge and bank erosion of flood-tide shoals by the ebb-tide currents. The system is an approximate sedimentary equilibrium.

River floods have been addressed in Section 3.1.5 above. During floods, huge silt plumes are pushed out to sea and silt coats rocks and beaches in the lower estuary. These floods are particularly important in playing a supporting role to ebb-tides in flushing marine sand out of the lower reaches of the estuary.



AEOLIAN TRANSPORT RATES ARE GIVEN IN FRACTIONS OF 10000 CUBIC METRES/YEAR/KILOMETRE WITH DUE COGNIZANCE FOR FREQUENCY OF OCCURRENCE OF WIND EVENTS

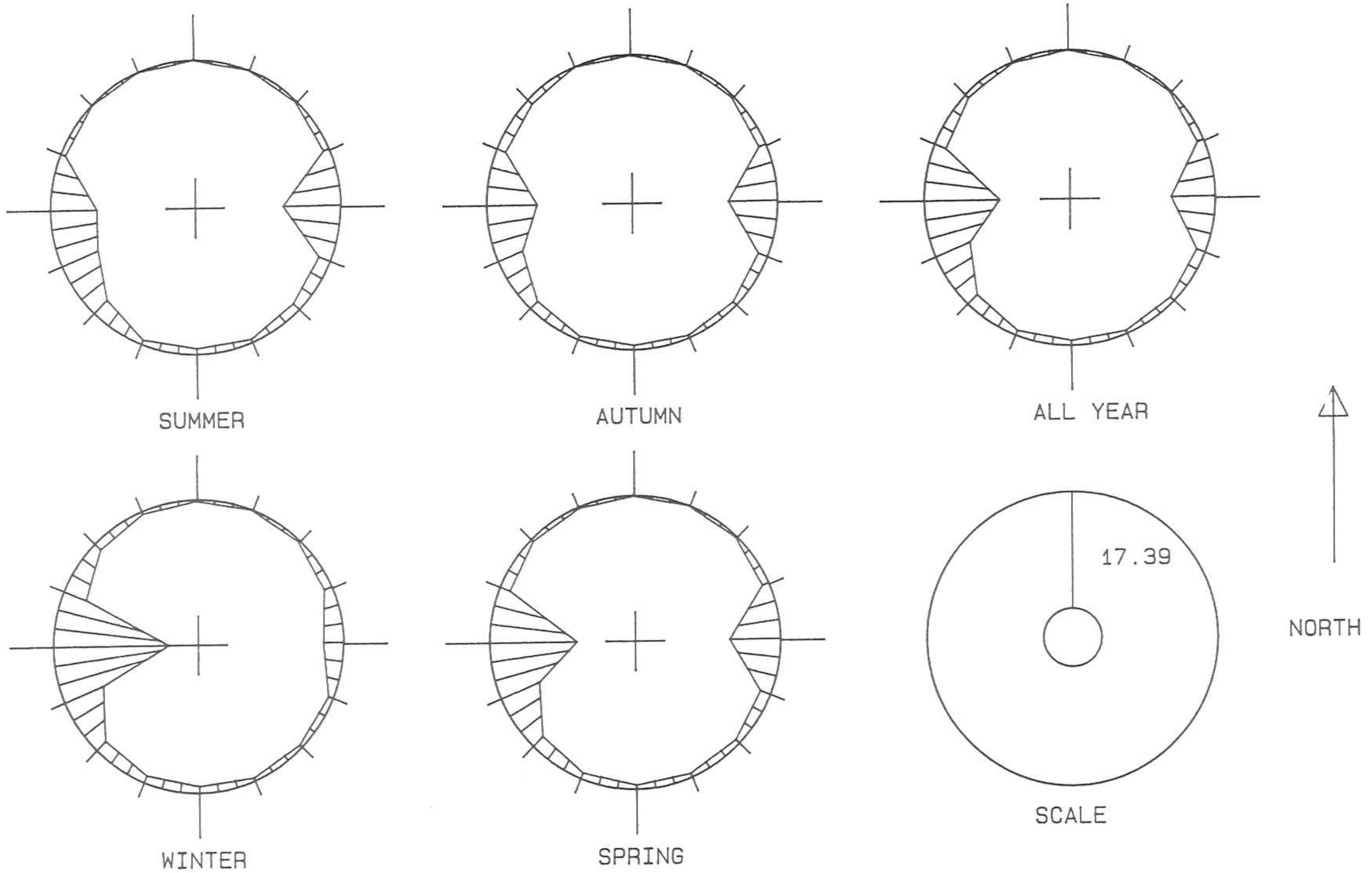
FIG. 20: Aeolian creep diagram for the Kafferkuils.

FIG. 21: Sand encroachment and vortex erosion around beachfront houses of Lappiesbaai (1988).

The highest frequency winds, from the south-west, blow sand into the Duiwenhoks Estuary from a large barren sand dune-field of some 16 ha which is perched on top of the 100 m high limestone plateau at the west bank of the estuary, 1 km upstream of the mouth (Figure 23). This is in accordance with the creep diagrams (Figure 22). The annual influx of sand from this dune-field can amount to as much as 22 500 m^3 (Schoonees and Swart, in prep.) and relies on ebb-flow currents and flash floods to be removed from the estuary.

According to Fromme (1989) the Duiwenhoks Estuary is unlikely to suffer seriously from problems of sand accumulation. The exposure of a gravel bed in the ebb-tide channel strongly indicates erosion in the estuary mouth, which precludes tendencies of sanding up.

A 10 m wide channel was blasted through the rock terrace on the east bank in 1971 to facilitate the passage of seagoing ski-boats (Figures 17 and 24). However, because of concurrent variations in rainfall (see below) it is presently unclear whether this channel has significantly altered the mouth hydraulics. Historical changes in the Duiwenhoks Estuary and mouth were gauged from old maps (1867 to 1926), the 1:50 000 map of South Africa (1962) and from aerial photographs (1942 to 1981). From 1867 to 1954, one of two estuary channels which surrounded saltmarsh islands in the estuary closed, resulting in the disappearance of these islands. The estuary basin at the west bank near the mouth appears to have increased in size during this period.



AEOLIAN TRANSPORT RATES ARE GIVEN IN FRACTIONS OF 10000 CUBIC METRES/YEAR/KILOMETRE WITH DUE COGNIZANCE FOR FREQUENCY OF OCCURRENCE OF WIND EVENTS

FIG. 22: Aeolian creep diagram for the Duiwenhoks

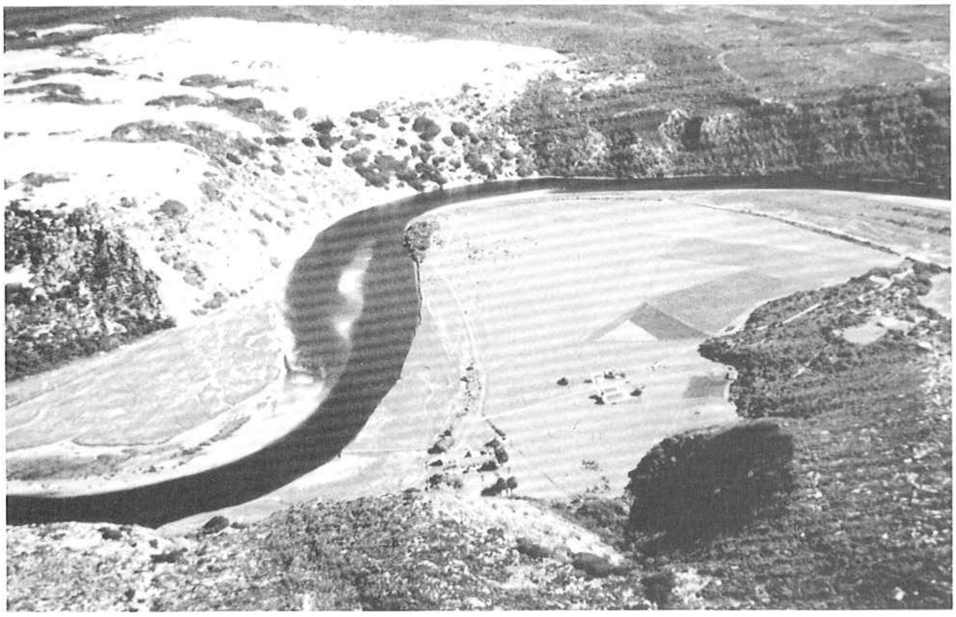


FIG. 23: Perched dune field on the west bank of the Duiwenhoks Estuary opposite the historic Kleinefontein Farm. Note the sand fans at the base of the west bank which indicate sand return to the estuary (89-08-06).

FIG. 24: Artificial channel in wave-cut terrace at the mouth of the Duiwenhoks Estuary (85-07-31).

From 1942, large sand banks built up in the eastern part of the mouth area (where the main mouth channel is presently situated) pushing the mouth channel towards the west bank. This build-up of sand coincided with the prolonged period of below average annual rainfall (1939 to 1956) and low river flow. By 1966 a secondary mouth channel had breached these sand banks, running along the dune rock base of the Puntjie as it does (as the main channel) today. The western channel has progressively sanded up (Figure 17) and now carries water at high tides only.

3.2.3 Land Ownership and Uses

Kafferkuils

The municipal area of Still Bay covers approximately 1 190 ha on both sides of the Kafferkuils River estuary. Of this, 666 ha has been set aside for State purposes; the remainder is in private ownership. A structure plan has recently been prepared for Still Bay, and is being circulated for comment (midyear, 1990). A Town Planning Scheme by the Cape Provincial Administration was drawn up and approved in 1977, but this has not been updated since; presumably the new structure plan will lead to an updated Town planning scheme. Table 2 shows the calculated level of development for respective land uses in proclaimed urban areas within the Still Bay Municipality as at 1984 (De la Bat, 1986). Thirty four percent of proclaimed erfs had been developed by 1982 and 50 percent by 1988 (J H Veldsman, Town Clerk, *in litt.*) which gives an indication of the pace of development at Still Bay. Water supplies from existing sources should meet the expected water needs at Still Bay for roughly the next decade (Scott and De Waal Inc., 1984).

Land-use adjacent to the estuary and in Still Bay is primarily focused on holiday accommodation and recreation and this has a strong seasonal component. This is evidenced by the fact that only 24 percent of the ratepayers at Still Bay are permanent residents, the remainder being seasonal visitors (Sowman, 1988). An estimated 80 percent of the business sector is directed at these holiday-makers (Sowman, 1988). Demand for holiday housing is increasing at approximately six percent annually whilst demand for camp sites is increasing at nine percent annually (De la Bat, 1986). In the summer holiday season the white population of Still Bay increases from roughly 1 000 to 25 000 people (R T Rudd, pers. comm.), placing a huge strain on the existing infrastructure.

Upstream of the road bridge, land next to the estuary has been cultivated for vegetable growing and for pasture; both dry and irrigated land.

The Kafferkuils Estuary itself is renowned for its angling and is also used for boating, swimming and sailing. The usual estuarine fish are present and some large Leervis and Kabeljou have been caught over the years. Kabeljou in excess of 45 kg (100 lbs) have been landed from the estuary. This is becoming an increasingly rare event (Steyn, 1983). Bait organisms abound in the estuary (Gaigher CDNEC, *in litt.*) and bait collection is an integral part of angling. Both angling and bait collection are controlled by the CDNEC; Appendix IX lists the regulations applicable to the Kafferkuils Estuary.

For boating there are public launching ramps on the east and west banks of the estuary about 2 km upstream from the mouth. Apart from jet-skis and jet-propelled craft all boats are permitted on the estuary. There are speed restrictions between the mouth and beacons placed approximately 1 km upstream

TABLE 2: Existing development and land-usage for the proclaimed area of the township of Still Bay (De la Bat, 1986)

Area	Proclaimed plots and usage (excluding caravan parks)				Total number of proclaimed erfs	Total number of developed erfs up to 1982**
	Special Residential	Business*	General Residential	Openspace		
Still Bay West Extension 12,6	542	18	3	17	580	277
Platbosrand	551	19	1	16	587	167
Extension 5	365	-	4	2	371	3
Still Bay East (North)	178	11	1	10	200	112
Still Bay East (South)	69	-	-	1	70	46
Total	1 705	48	9	46	1 778	605

* Includes hotels and light industries

** Includes schools, sports fields and public areas from the mouth and between the hours of 20h00 and 08h00 (Appendix IX). During peak holiday season considerable congestion of all sorts of craft presently occurs (Rudd, pers. comm.). The inherent problems with this are exacerbated as some forms of boating, ie speedboats and waterskiing, exclude other boating and water based recreational activities such as swimming. In this regard Van Riet (1990) has calculated that the total carrying capacity for speed boating and water skiing in the estuary is 15 - 30 boats. This is far exceeded in the peak holiday periods. The Still Bay Town Council are in the process of promulgating regulations to solve these problems (J H Veldsman, *in litt.*)

The coast adjacent to the estuary is mainly utilised for recreational purposes with commercial components being represented by the harbour and erstwhile sand mining on Morris Point (Figure 25).

Lappiesbaaistrand is the main bathing beach whilst Morris Point delivers some of the best surfing waves on the Cape south coast. The entire stretch of coast from Mossel Bay west to the Breë River estuary is justifiably renowned for its rock angling. A further recreational use aspect is shell collecting (Klonus, 1987), the frequently stormy seas casting up considerable amounts of shells and the occasional rarity.

Still Bay harbour (Plate III) situated west of the estuary mouth on the eastern side of Morris Point, was built in response to the demand for a safe launching site for commercially oriented line fishing boats. The harbour is controlled by the CDNEC, with use being subject to the approval of the harbour master. The harbour used to handle 30 or so commercial fishing boats regularly but in recent years this has dropped to nine commercial and ten semi-commercial boats. At present there is a very strong seasonal pattern in the use of the harbour slipway with upwards of 80 ski boats (mostly recreational fishing) being launched daily during the summer holiday season. This is causing congestion problems on the access road and in parking boat trailers at Morris Point (see below).

Sand from Morris Point (Figure 25) was removed for use as building material. This operation has encroached upon some of the unique dune forest that occurs on Morris Point itself. Sand removal operations have recently been curtailed and the area is being revegetated.

There are two Nature Reserves in the vicinity of the estuary (Centrespread). The largest is the Geelkranz Reserve which comprises 700 ha of dune fynbos and strandveld and is controlled by the CDNEC. The Still Bay Municipality manages the smaller Pauline Bohnen Nature Reserve, which consists of approximately 147,5 ha of limestone fynbos. This reserve was proclaimed in 1982.

Duiwenhoks

Human encroachment in the vicinity of the Duiwenhoks Estuary is minimal. Most of the land bordering the estuary is used for mixed farming, and development is presently limited to private holiday accommodation, including the Kapsteilhuisie private resort at Puntjie.

Recreational activities at this estuary are similar to those at the Kafferkuils, although at lower intensities. No speed-boats, water-skiing and/or aqua-planing are allowed but the estuary is used as a transit for ski boats launched up river at Vermaaklikheid. Appendix IX outlines restrictions on the use of the Duiwenhoks Estuary and its resources.

3.2.4 Obstructions

Kafferkuils

The road bridge connecting Still Bay East to Still Bay West (Figure 3) seems to have had minimal effect on the estuary, although Fromme (1989) recorded a reduction in water depth here (Table 1A) which he attributed to this obstruction.

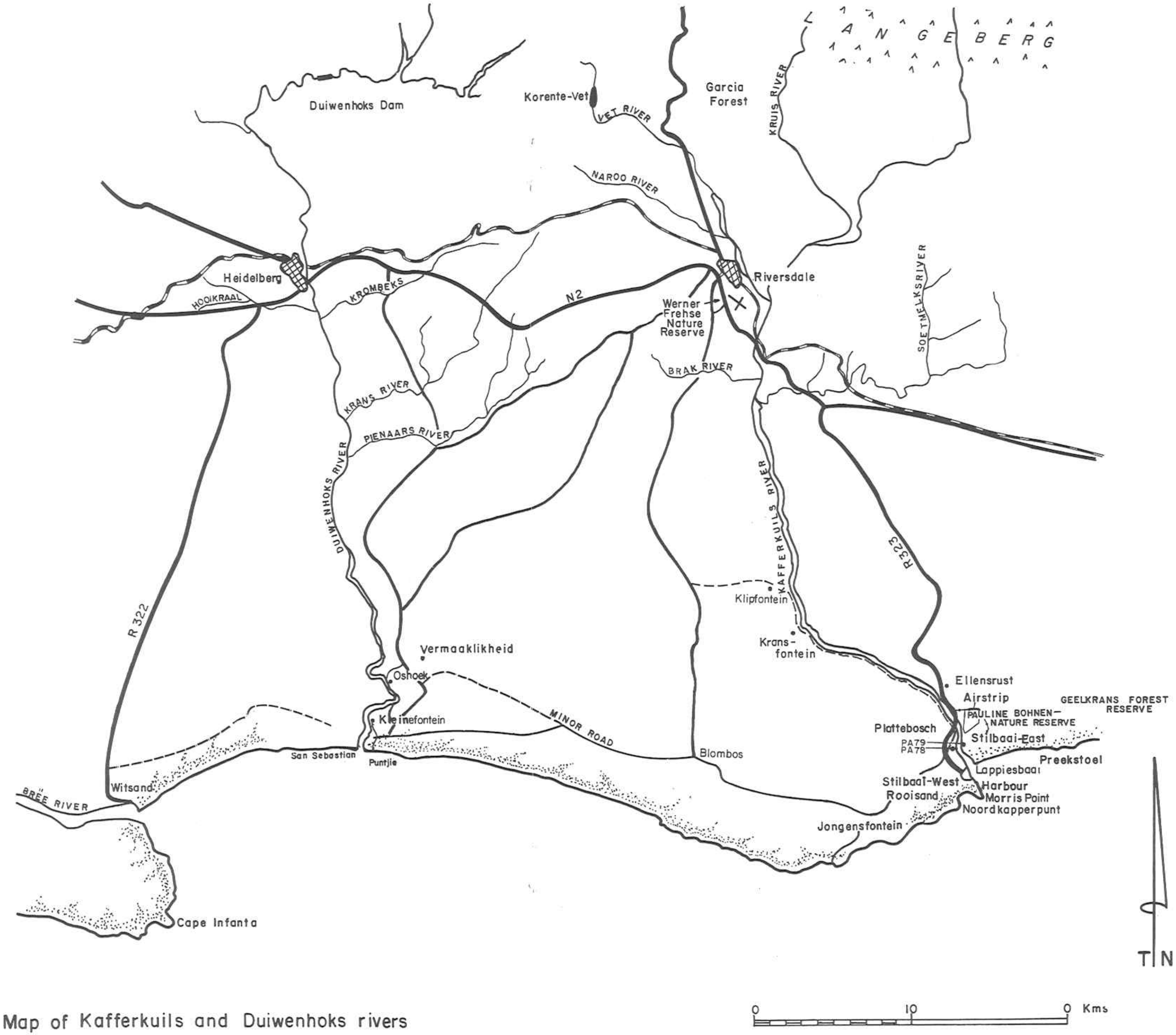
FIG. 25: Sand mining on Morris Point (July 1987).

There have been a number of activities on the flood plain of the estuary and below the high-water mark (HWM) which constitute obstructions to the normal flow of water to and in the estuary.

(i) It is estimated that 0,5 km of road along the west bank of the estuary and 2,5 km along the east bank, largely to the south of the road bridge, have encroached within the flood plain of the Kafferkuils Estuary. Culverts have been incorporated into the roads' structure to allow for the passage of water. At high-tide, water laps against stretches of road on the east bank.

(ii) The road to the waterslide on the sandspit, immediately to the west of the caravan park, has been artificially banked up to act as a barrier to flood or stormwater (Plate V and Figure 26). Spring high-tides push up against this bank and it blocks surface drainage from the camp-site to the estuary.

(iii) Much of Still Bay East was probably laid out on marshland or silt beds. It is interesting to note that many of the Still Bay East roads are situated within the area occupied by river channels in 1855 (Zwamborn and Rossouw, 1967). The row of houses to the west of the main road at 'Die Braak' was probably built on existing marshland on banked-up sand reinforced with stone walls (Figure 9).



Centrespread : Map of Kafferkuils and Duiwenhoks rivers

(iv) On the west bank of the estuary a number of houses have been erected on the flood plain immediately south of the road bridge. These are regularly threatened by high water levels in the estuary (De la Bat, 1986).

(v) The sandspit, since its artificial stabilization (Section 3.2.2), may be considered an additional obstruction. (Plate I).

Neither the Still Bay Municipality nor the Southern Cape Regional Services Council has data on flood lines for the estuary. Consequently, possible flood levels do not appear to be a consideration in the evaluation of development proposals. This perpetuates encroachment of structures into, and disturbance of the estuarine system.

Duiwenhoks

There do not seem to be any obstructions in the Duiwenhoks Estuary.

3.2.5 Physico-chemical Characteristics, Pollution and Public Health Aspects

Kafferkuils

Similar to most Cape south coast estuaries, data on the physical and chemical characteristics are extremely sparse. The discussion below is based on measurements made during the ECRU surveys of March (summer) and August (winter) 1985, the data for which are summarised in Table 3.

The temperature and salinity data for both surveys indicate that the classical salt water lens found in estuaries does not exist in the Kafferkuils. The slight temperature inversion plus salinity gradient found 1,7 km upstream in the winter survey cannot be interpreted as being indicative of such a lens because of the depressed (relative to seawater levels) salinities. The absence of a lens can be attributed to the lack of a sill at the mouth to retain dense water, the low flow rates of the river in general and the tidal domination of the flow in the estuary.

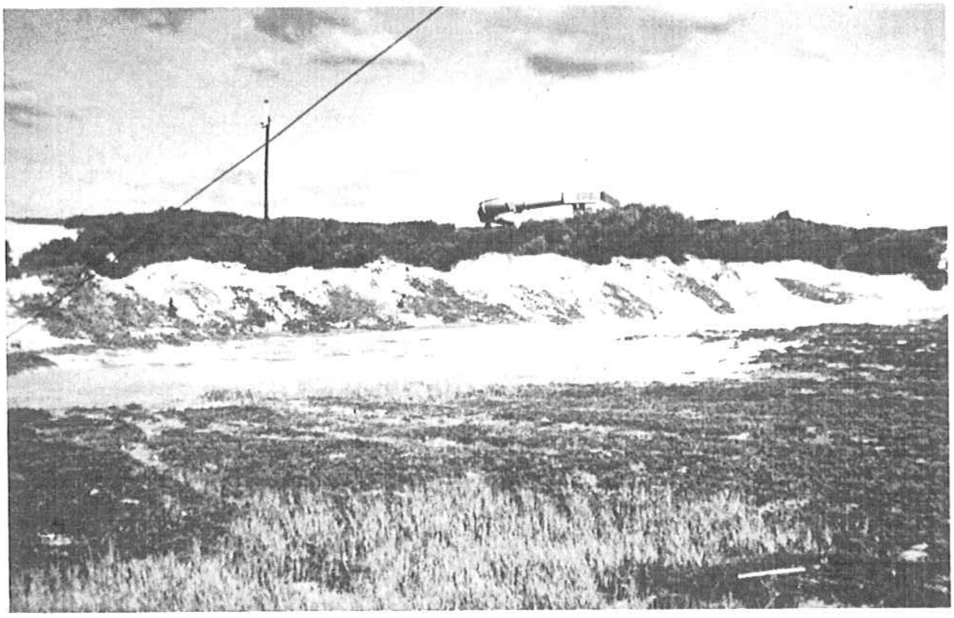


FIG. 26: Embankment protecting the road to the waterslide on the Kafferkuils east bank sand spit (June 1986).

TABLE 3: Kafferkuils Estuary physico-chemical data, ECRU survey March (summer) and August (winter), 1985

Stn No	Distance from mouth (Km)	Sample	Temp (°C)	Sal. (°/₀₀)	pH	Secchi vis. (m)	O_2 (mg/l)	NO_3-N (µM/l)	PO_4-P (µM/l)	chl$_a$ (µg/l)	POM (mg/l)	DOC (mg/l)
Summer												
1	0,5	S	20,5	34.0	7,53	1.5	7,39	2,53	0,58	0,64	4,6	2,76
		B	20,4	34,0	7,58		7,46	1,52	0,38	0,68	4,6	3,25
2	1,7	S	20,7	28,0	7,49	1,3	6,68	3,79	0,13	0,51	3,6	3,94
		B	20,6	28,0	7,49		6,77	2,28	0,39	0,68	4,0	5,66
3	9,5	S	22,6	4,0	7,23	1,2	6,99	3,67	0,81	0,40	2,4	15,37
		B	20,8	6,0	7,26		6,42	3,98	0,41	0,35	2,6	7,36
4	15,0	S	22,9	0,0	7,20	1,0	7,76	3,16	0,37	2,16	1,8	20,18
		B	21,0	0,0	7,80		4,49	3,73	0,24	0,59	1,8	18,25
Winter												
1	0,5	S	14,8	28,0	7,62	-	6,28	4,49	0,26	0,56	-	2,57
		B	14,9	28,0	7,55		6,67	3,86	0,26	0,76		2,89
2	1,7	S	14,5	21,0	7,47	-	6,65	7,59	0,30	0,30	-	3,87
		B	14,7	25,0	7,50		6,68	3,86	0,23	0,80		3,06
3	9,5	S	13,5	0,00	7,32	-	7,15	14,86	0,38	1,08	-	11,32

Note
1) Bottom (B) sample taken 0,5m above substrate
2) Nitrate-nitrogen excludes nitrite
3) River flow rates were similar for both sampling periods

The distribution of pH values, oxygen and phosphates are as to be expected for a southern Cape estuary (Taljaard, 1987). Nitrate-nitrogen concentrations, however, show an inverse relationship with salinity, indicating that the river is the major nitrogen supplier to the estuary. The elevated nitrate-nitrogen concentrations upstream are probably related to agriculture.

The particulate organic matter concentrations found in the water column are moderate whilst the total chlorophyll concentrations are low. Therefore most of the particulate organic matter is probably derived from fringing macrophytes and/or imported marine seaweed. From this it can be inferred that phytoplankton production *per se* plays a small role in the estuarine food chain (see Section 4.1.1 below).

Dissolved organic carbon levels varied from low at the estuary mouth to high upstream. Day (1981) interprets concentrations in the 1-5 mg/l range as being normal for southern Cape estuaries and 20 mg/l as being extreme. Taljaard (1987) found uniformly low dissolved organic carbon concentration in the Palmiet Estuary, west of the Kafferkuils and Duiwenhoks. The high concentrations found upstream may thus be indicative of an organic pollution source. However, it must be noted that land use in this upper region is mainly devoted to agriculture and any pollution source is liable to be diffuse and/or sporadic.

Data on the distribution of organic matter in the estuarine sediments are sparse, being limited to measurements made during the March, 1985 ECRU survey (Table 4). Concentrations are low, with the highest of the low values being found associated with fine sediments. This is essentially in agreement with results from the Breë River estuary (Carter, 1983).

Table 5 compares water quality parameters for the fresh water Olienhoutfontein and Palinggat springs in 1973 and 1977. The table shows that the 1977 levels of free and saline ammonia, as well as absorbed oxygen, are higher than in 1973. From these data it is apparent that there is contamination of the aquifer underlying Still Bay; Scott and De Waal Inc. (1985) attributed this to sewage effluent seeping from septic tank or French drain systems.

A number of Still Bay residents have complained of a proliferation of green algae and bad odours along the beach from the estuary mouth to the harbour after the peak holiday season. This has been ascribed to seepage from septic tanks. If this is the case pathogenic organisms may be associated with the seepages which will thus represent an episodic health hazard to swimmers *etc.* This potential problem has been addressed by the installation of a water-borne sewerage system in Still Bay West (J H Veldsman, pers. comm.).

Duiwenhoks

The only chemical data existing for the Duiwenhoks Estuary are those of the 1985 ECRU surveys. These data are presented in Table 6.

The ranges for all the parameters measured agree fairly closely with those presented for the Kafferkuils in Table 3. Nitrate-nitrogen and DOC concentrations, however, do not reach the same elevations; this will be discussed further below.

In contrast to the Kafferkuils, the data from Duiwenhoks station 3 indicate the presence of a salt water lens overlying the mud reach. This is particularly evident in the winter survey data where, although the bottom

TABLE 4: Organic matter distribution (% Dry weight) in the Kafferkuils Estuary sediment samples obtained in March, 1985

Distance from mouth (km)	Site description	% Organic matter
0,5	Mid-channel reworked marine sediment	2,03
1,7	Mid-channel reworked marine sediment	1,82
1,7	Tidally exposed fine sediment in *Spartina* marsh	5,03

TABLE 5: Water quality in two freshwater springs at the Kafferkuils mouth. (from Scott and De Waal Inc., 1985).

Parameter	Oliehoutfontein		Palinggat		S A B S Limits	
	1973 mg/l	1977 mg/l	1973 mg/l	1977 mg/l	Recommended mg/l	Maximum mg/l
TDS	1942	1732	1474	1652	500	2000
Total Hardness*	488	336	404	336	200	1000
Calcium Hardness*	324	325	282	325		
Magnesium Hardness*	164	146	122	133	210	310
Alkalinity*	240	250	260	300		
Chlorides	784	690	580	600	250	600
Sulphates	103	79	92	86	250	400
Sodium	460	400	357	430		
Ammonia	>0,05	3,0	>0,05	0,6		
Nitrate Nitrogen	3,75	3,4	3,75	4,0	10	
Oxygen Absorbed	0,2	2,4	0,6	2,4		
pH	7,4	7,8	7,4	7,8	6-9	

*These parameters measured as $CaCO_3$

water is nearly a degree Centrigrade warmer than the surface, the density stratification is maintained by the very much higher salinity. Water depths in this region reach 4-5 m, which allows the formation of such a lens.

Similar to the Kafferkuils, nitrate-nitrogen shows an inverse relationship with salinity, this being best illustrated in the winter data for station 3. This reinforces the conclusions reached regarding nitrogen sources for the estuary in the Kafferkuils.

Chlorophyll and particulate organic carbon ratios again point to macrophytes being the dominant driving force in the estuarine food chain. Dissolved organic carbon levels show no regular gradients in the Duiwenhoks Estuary; all values measured being close to Day's (1981) range for Southern Cape estuaries.

Similar to the Kafferkuils, organic matter loading in the Duiwenhoks Estuary sediments (Table 7) is low; highest values being found in fine sediments (mud reach). Vigorous flow in the system does not allow the existence of organic matter deposition areas.

There have been no reports of green scums/bad odours, *etc.* in the Duiwenhoks but this may be more the result of fewer observers than reduced or non-existent occurrence.

4. BIOTIC CHARACTERISTICS

4.1 Flora

Previous botanical surveys in the region were by Acocks (1953), who mapped the Puntjie and Still Bay areas as coastal macchia (veld type No. 47) and Moll *et al.* (1984) who mapped dune fynbos and inland limestone fynbos. The description below was contributed by M O'Callaghan (National Botanical Institute) and is based on a survey by M O'Callaghan during 1984, as well as an ECRU survey during 1985 and a co-operative botanical survey for macrophytes and terrestrial vegetation during late 1987 (Rebelo *et al.*, 1990). Physical features and species composition of the vegetation mapping units identified are given in Appendix I.

4.1.1 Phytoplankton

The only records of phytoplankton occurrence in both estuaries are the chlorophyll data obtained during the ECRU surveys listed in Tables 3 and 6 and J Grindley's (University of Cape Town, *in litt.*) 1969 records of diatoms (Appendix II). These data indicate generally low phytoplankton biomasses, which are in agreement with the generally high turbidity caused by high inorganic particle loads. No gradients are evident in the data.

4.1.2 Algae

Marine algae are washed into the lower part of the estuaries and deposited at the drift line on the estuary banks. The POM data (Tables 3 and 6) suggest that some of this material is reworked in the estuaries.

4.1.3. Submerged Aquatic Vegetation

Beds of *Zostera capensis* are present on sand banks and lower tidal flats in both estuaries.

TABLE 6: Duiwenhoks Estuary physico-chemical data, ECRU survey March (summer) and August (winter), 1985

Stn No	Distance from mouth (Km)	Sample	Temp (°C)	Sal. (°/₀₀)	pH	Secchi vis. (m)	O_2 (mg/l)	NO_3-N (µM/l)	PO_4-P (µM/l)	chl$_a$ (µg/l)	POM (mg/l)	DOC (mg/l)
Summer												
1	0,3	S	19,4	20,0	8,05	0,8	7,75	2,53	0,50	0,67	2,2	3,24
		B	19,4	-	-		-	2,47	0,44	0,50	-	6,31
2	1,0	S	19,7	34,0	8,12	0,5	8,19	3,54	0,42	1,18	5,6	4,87
		B	19,8	32,5	-		8,45	1,96	0,32	0,38	3,4	4,55
3	3,5	S	20,4	30,0	8,20	1,0	8,10	3,60	0,73	0,42	4,0	5,67
		B	20,1	34,0	-		8,11	1,96	0,59	1,02	3,0	5,67
4	10,0	S	21,9	6,5	7,17	0,3	6,76	4,24	0,37	0,79	3,6	4,09
		B	21,9	6,0	-		6,24	4,43	0,26	0,75	4,6	6,01
Winter												
1	0,3	S	14,1	22,0	8,18	-	6,91	6,70	0,36	0,12	6,7	5,81
		B	14,0	-	-		6,96	6,32	0,40	1,56	5,0	3,70
2	1,0	S	14,2	20,0	7,84	-	7,02	7,84	0,33	0,68	4,1	4,84
		B	14,2	20,0	7,85		6,73	7,59	0,36	1,16	3,7	5,16
3	3,5	S	14,0	12,0	6,95	-	6,93	11,46	0,32	0,50	3,7	7,75
		B	14,9	30,0	7,95		6,71	3,79	0,40	0,50	0,9	2,74
Mouth			14,2	-	-	-	-	3,29	0,35	0,70	-	1,44

Note
1) Bottom (B) sample taken 0,5m above substrate
2) Nitrate-nitrogen excludes nitrite
3) River flow rates were similar for both sampling periods

4.1.4 Wetland Vegetation

Kafferkuils

Saltmarshes are found along both banks of this estuary and cover large areas along the eastern bank below the road bridge (Figures 27 and 28). *Spartina maritima* (strandkweek) dominates the lower areas, followed by *Sarcocornia perennis, Limonium scabrum* and *Cotula coronopifolia*. Within this middle zone, the annual glasswort *Salicornia meyerana* often occurs in disturbed areas. Higher up the shore, *Juncus kraussii* is found.

Further up the river, where salinities drop to below 15 parts per thousand, patches of *Phragmites australis* fringe the river. Even higher up the river, occasional stands of *Typha capensis* are found where there is a fairly constant fresh water supply.

Aerial photography over the period 1942 to 1987 indicates that the area and distribution of salt marshes and reed beds are relatively stable.

Duiwenhoks

Saltmarshes are found along much of this river course (Figure 29). They are well-developed and show distinct zonation patterns, similar to those described above. *Spartina maritima* dominates the lower zone, with *Sarcocornia perennis*, *Chenolea diffusa* and *Sporobolus virginicus* in the middle zones. *Sarcocornia pillansii* and *Chenolea diffusa* are found in the upper zones of the marshes.

FIG. 27: Saltmarsh area behind the east bank sand spit at the Kafferkuils Estuary mouth (85-03-08).

TABLE 7: Organic matter distribution (% dry weight) in the Duiwenhoks Estuary sediments. Samples obtained in March, 1985.

Distance from mouth km	Site description	% Organic matter
0	Beach opposite mouth	1,16
0,3	Mid-channel reworked marine sediment	1,45
0,3	Tidally exposed sand flat on eastern bank	3,58
1,0	Mid-channel reworked marine sediment	2,40
1,0	Tidally exposed sand flat on eastern bank	3,92
3,5	Mid-channel seaward end of mud reach	5,59

Parts of these marshes have been disturbed by grazing and trampling. These vegetation types are highly sensitive to this type of disturbance and it is recommended that stricter control be maintained over these activities.

4.1.5 Terrestrial Vegetation

The vegetation of the Riversdale Plain, in which the catchments of the Kafferkuils and Duiwenhoks rivers fall, can be divided into three non-fynbos types (forests and thickets, karroid and renoster shrublands and grasslands, and grassy shrublands) and five fynbos types (grassy, asteraceous, restioid, proteoid and ericaceous). The distribution of these types is strongly related to the geology and soil characteristics of the area.

The Riversdale Plain is an important floristic region as relatively large areas of rare plant communities occur. Further, in terms of fynbos, the plain has been identified as a centre of endemism (Rebelo *et al.*, 1990) because of the occurrence of three distinct vegetation communities, each characterised by endemic Proteaceae taxa. The region also supports a unique dune scrub forest which represents the western most distribution of many kaffrarian thicket species. It thus has a high conservation value (Jarman, 1986).

For simplicity of presentation the terrestrial vegetation is divided into Dune vegetation, Riparian thicket, Upland fynbos and alien vegetation. For more detail see Rebelo *et al.* (1990).

Kafferkuils

i) Dune vegetation

The dune vegetation consists of three types : dune pioneers, dune scrub and dune fynbos. Dune pioneers are found on the foredunes and reach their greatest abundance to the east of the estuary. Species such as *Arctotheca populifolia, Agropyron distichum* and *Tetragonia decumbens* are common and *Scaevola plumieri* occurs but is reaching its westernmost distribution point. Dune scrub appears as small patches of southern coast strandveld on the deep alkaline sands of the dunes on both sides of the estuary. This vegetation type hardly grows taller than two metres and is comprised of fleshy-leaved shrubs but no proteoids nor aloes. Numerous *Rhus* species (particularly *R. lucida*), *Chrysanthemoides monolifera, Metalasia muricata, Euclea racemosa, Sideroxylon inerme* and other shrubs are present. Dune fynbos occurs behind the primary dunes, generally on deep calcareous sands and forms a mosaic of asteraceous and restioid types. Numerous restioids, such as the tall *Thamnochortus erectus* and the short *Ischyrolepsis eleocharis* and numerous *Ficinia* species are found here, together with shrubs such as *Metalasia muricata, Helichrysum* species and *Rhus* species. Cowling *et al.* (1988) differentiated Dune asteraceous fynbos from the more general asteraceous fynbos type on the basis of the high cover of non-ericaceous ericoids and absence of proteoids. This vegetation type occurs on young calcareous sands and is extremely limited in distribution. There is a small patch on the Stilbaai Wes peninsula (behind Morris Point, Figure 27) (R M Cowling, 1987 *in litt*).

ii) Riparian thicket

This vegetation is mainly found along the eastern bank of the river on Bokkeveld shales. It contains numerous succulent species such as *Aloe arborescens, Euphorbia mauritanica* and other species such as *Azima tetrachantha, Rhus longispina, Lycium afrum, Euclea racemosa* and *Sideroxylon inerme*.

iii) Upland fynbos

This consists of two types. The *Leucadendron meridianum/ Protea obtusifolia* community is a mesic proteoid fynbos vegetation type which is found on soils up to 0,5 m deep on the crests and midslopes of limestone outcrops and ridges to the east and west of the river. The oligotrophic asteraceous fynbos community is found on shallower limestones soils, primarily on the slopes bordering the river valley.

iv) Alien vegetation

Alien shrubs, mainly in the form of the highly invasive *Acacia cyclops* (rooikrans) dominate large areas, particularly on the dunes. Other alien plants including *Solanum nigrum* (Black nightshade) and *Opuntia ficus-indica* (Prickly pear) were also noted in the area.

A large proportion of the Kafferkuils Estuary is either used for agriculture or recreational and residential purposes. This, coupled with the large encroachment of alien vegetation is placing some of the plant communities at risk. The efforts of the local community in the removal of aliens from the proclaimed nature reserves deserve commendation. These efforts should be

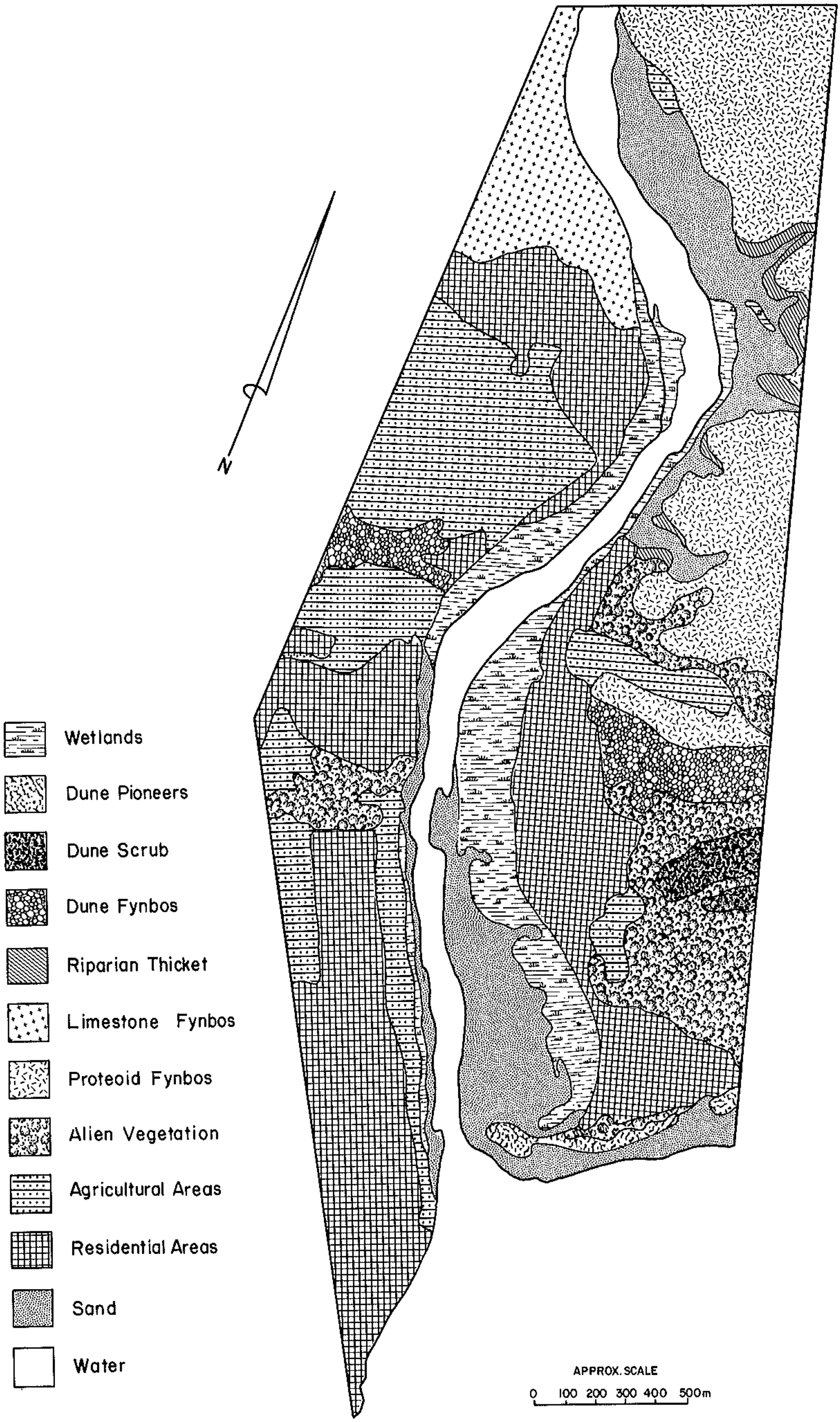


FIG.28: Vegetation units recognized at the Kafferkuils Estuary.

extended to protect and re-establish areas of natural vegetation. Of particular importance here are the salt marshes, as they are sensitive to both trampling, grazing and wave damage from passing speedboat wakes, and the more restricted fynbos types. A clear case in point here is the dune asteraceous fynbos vegetation type that occurs behind Morris Point.

Duiwenhoks

The vegetation around this river (Figure 29) is similar to that at the Kafferkuils River, although much less disturbed.

Dune pioneers occur on the foredunes west of the estuary mouth with dune scrub on the primary dunes and fynbos on the secondary dunes. The riparian thicket is more extensive than at the Kafferkuils River and extends into some of the protected valleys away from the river. There is also a relatively large patch of eastern forest remnant along the western bank of the river with *Sideroxylon inerme, Cassine peragua, Carissa bispinosa, Canthium mundianum* and *Rhus glauca* dominating.

Numerous plants endemic to this area occur in and around Still Bay as well as near the Duiwenhoks River. Some of these include *Apodolirium lanceolatum, Euryops muirii, Stoebe muirii,* and *Agathosma muirii* (Bohnen, 1986; Steyn, 1983).

An oligotrophic asteraceous fynbos is present on shallow soils on the limestone hills to the east of the river. Further away from the river, a proteoid fynbos grows on mesic soils. This is dominated by *Leucadendron meridianum* and *Protea obtusifolia*. Other species found here include numerous ericoids (*Erica arenaria, E. coccinia*), restioids (*Restio leptocladus, Willdenowia teres*) and other proteoids (*Leucadendron muirii*) in varying relative abundance.

The lowland fynbos vegetation around the Duiwenhoks River has a high species diversity and is relatively undisturbed. Numerous fynbos types occur in close proximity and outliers of a number of other veld types (eg valley bushveld) are found in the area, although species depauperate.

According to Jarman (1986), this area has a high conservation value. However, the limestone hills to the east of the river have been grazed excessively (as have the marshes) and some erosion has taken place along disused tracks to the south of the river.

4.2 Fauna

4.2.1 Zooplankton

Grindley (*in litt.*) sampled the Kafferkuils and Duiwenhoks estuaries in May 1969 and recorded 19 and 12 taxa respectively (Appendix IIa, IIb). Mean zooplankton biomass for this period in the Kafferkuils Estuary was 51,88 mg DW/m^3 (N=5) and that for the Duiwenhoks was 9,98 mg DW/m^3 (N=5). The high values observed at the Kafferkuils were due to an extremely high biomass recorded at the estuary mouth (135,3 mg DW/m^3). However, because of the small coverage obtained in time and space it is difficult to draw conclusions on the significance of this value or make comparisons between the two systems and with other South African estuaries.

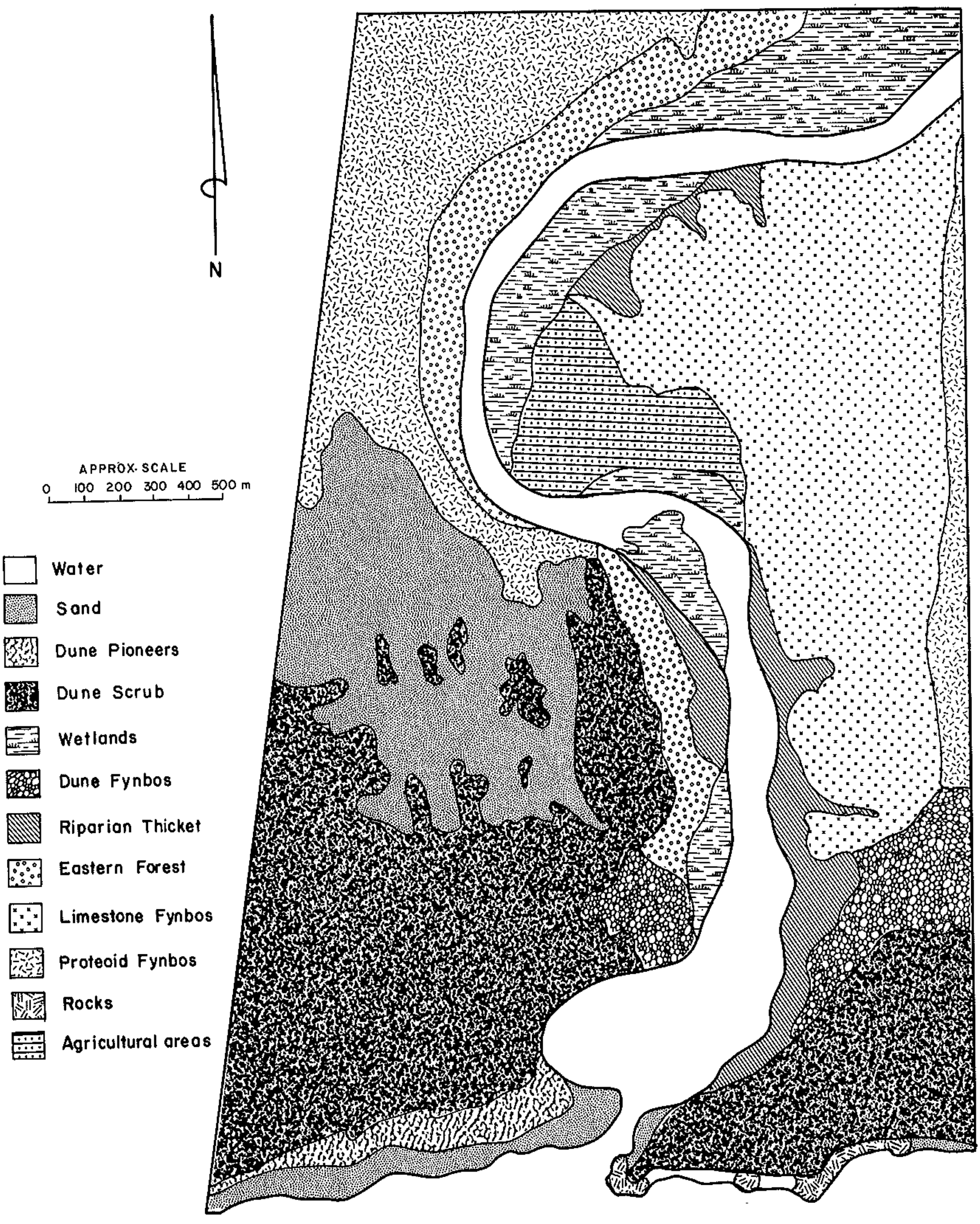


FIG.29: Vegetation units recognized at the Duiwennoks Estuary

4.2.2 Invertebrates

Despite their unique characteristics, compared to adjacent estuarine systems, neither the Kafferkuils nor the Duiwenhoks estuaries have been subjected to any intensive biological surveys (cf Breë Estuary, Carter, 1983). There is thus a severe lack of information on invertebrate distribution patterns which bedevils attempts to use biological indicators as indices of change in the systems.

Appendix III lists the macro-invertebrate taxa recorded in the systems, with some remarks on distributions and abundance. The surveys on which the appendix is based were not exhaustive and thus absence from the species/taxa list does not necessarily indicate absence from the estuaries. All the species/taxa recorded have been found in adjacent systems.

There are four burrowing bait organisms in the two estuaries that are subject to exploitation pressure. These organisms are the blood worm, razor clam, sand and mud prawn. Still Bay residents have expressed concern that the numbers of these organisms in the Kafferkuils have declined over the years, but C Gaigher (CDNEC, *in litt.*) could not substantiate this. With more people exploiting the bait beds, however, overall availability in terms of numbers per person may have declined.

Of the four bait organisms, blood worms and razor clams are the most sensitive to exploitation. The former species spreads to the more inaccessible subtidal regions of estuaries and therefore the population may be buffered against over exploitation to some extent (Gaigher, 1978). However, other factors also affect this population, eg B de la Bat (pers. comm.) has observed that blood worms suffered a marked decline in the Kafferkuils after the 1981 Laingsburg floods. Recovery has apparently been poor. Razor clams, although widely distributed, are generally very sparse ($<1/m^2$, Gaigher, *in litt.*) but as individuals also inhabit subtidal areas, the population is probably buffered against over exploitation.

Notwithstanding small scale patchiness in distribution patterns, the Kafferkuils Estuary, despite its apparently greater exploitation level, appears to have supported higher densities of mud prawns than the Duiwenhoks Estuary in 1979 (Gaigher, *in litt.*). For example, mean densities in the Kafferkuils Estuary were $192/m^2$ whilst mean densities in the Duiwenhoks were $20/m^2$. Gaigher (*in litt.*) postulates that this may be due to terrestrial silt starvation in the Duiwenhoks caused by impeded flood-flow, as the mud prawn beds near the mouth showed signs of sensitivity (compacted mud and reduced prawns per hole). This cannot be substantiated with the data at hand but deserves investigation as all of our estuarine systems are becoming 'flood damped'.

Sand prawns, although too sparse to warrant exploitation, are far commoner in the Kafferkuils than the Duiwenhok Estuary (Gaigher, *in litt.*). This trend continues to the Breë Estuary (Carter, 1983; Gaigher, *in litt.*) and does not appear to be due to exploitation.

The regulations pertinent to the exploitation of bait organisms in these estuaries are listed in Appendix IX.

4.2.3 Fish

The fresh water fish species recorded in the lower river and upper estuary regions of the Kafferkuils and Duiwenhoks systems are listed in Appendix IVa.

The eels *Anguilla (Muraena ?) mossambicus* have reached the stage of being 'community' pets in the 'Palinggat' of Still Bay. Steyn (1983) states that at least five generations have been 'vertroetel' (pampered) and they are now so tame that they will eat out of a person's hand. These eels suffer other than human predation pressures, however. The two largest eels were caught by an otter which was subsequently shot (De la Bat, pers. comm.). These eels have also been recorded in the Breë River (Carter, 1983).

Despite the Kafferkuils and Duiwenhoks being renowned as excellent angling estuaries no detailed surveys of the fish occurring in these systems have been carried out. Species records are thus limited to the largely anecdotal recollections of anglers and gill and 'D' net catches obtained during the 1985 ECRU surveys. Appendix IVb lists the marine/estuarine species recorded in the two systems.

Both estuaries support winter migrations of the southern mullet, *Liza richardsoni*. De la Bat (pers. comm.) states that these migrations can be large. He further states that the mullet form large shoals in the estuaries and whilst migrating upstream 'make a noise like a 10 ton truck'. The mullet apparently remain in the systems for three to twenty days whereafter they migrate out to sea again. During the periods they are in the estuaries large numbers are allegedly caught by trek-net operators (De la Bat, pers. comm.; E Dicey, *in litt.*). Surprisingly these immigrations have not received any research attention.

The coastal regions adjacent to the two estuaries provide good, varied rock angling and limited sandy beach angling. Galjoen (*Coracinus capensis*) and elf (*Pomatomus saltatrix*) are seasonally plentiful whilst large kob (*Argyrosomus hololepidotus*) and musselcracker (*Cymatoceps nasutus*) are occasionally landed. Angling success is allegedly diminishing and some previously commonly caught species (eg dageraad, *Chrysoblephus cristiceps*) have virtually disappeared (Steyn, 1983). This phenomenon is unfortunately not limited to this area and is apparently a result of fishing pressure.

Still Bay harbour itself has supported a commercial fishery based on line fishing boats with a major commercial company erecting a coldstore for catches in the early 1960s, and another currently proposing to do so. Over the years the larger species caught have changed from dageraad (*Chrysoblephus cristiceps*), roman (*Chrysoblephus laticeps*), *etc.* to kabeljou (*Argyrosomus hololepidotus*). This change has apparently been dictated by availability.

4.2.4 Amphibians and Reptiles

A list of amphibian and reptile species which have been recorded, or are likely to occur, in the grid squares 3421 AC Vermaaklikheid and 3421 AD Stilbaai, has been compiled by M E and A L de Villiers (CDNEC, *in litt.*) (Appendix V). None of the 52 species listed appear in the revised edition of the reptile and amphibian Red Data Book (Branch, 1988). The region previously supported a large snake population and Steyn (1983) reports that the first 'industry' of the area was snake catching.

4.2.5 Birds

The Western Cape Wader Study Group (Summers *et al.*, 1976) recorded six migrant and three resident wader species at the Kafferkuils Estuary, and five migrant and two resident wader species at the Duiwenhoks Estuary. Ryan *et al.* (1988) listed eight migrant and four resident wader species at the Kafferkuils Estuary and four migrant and two resident wader species at the Duiwenhoks

Estuary in summer 1981. In addition, they counted 11 and 9 non-wader species associated with the Kafferkuils and Duiwenhoks estuaries respectively. These are presented in Appendix VI.

Of the 26 species listed, only the Caspian Tern appears in the Red Data Book (Brooke, 1984). This species appears to be declining in numbers.

Locals at Still Bay are concerned that the recent rapid expansion of the feral cat population at Still Bay will lead to a reduction in bird numbers.

4.2.6 Mammals

Kafferkuils

The following mammals have been recorded for the area covered by the 1:50 000 Topocadastral Sheet 3421 AD (P H Lloyd, CDNEC, *in litt.*).

Schreiber's longfingered bat	*(Miniopterus schreibersii)*
Temminck's hairy bat	*(Myotis tricolor)*
Cape horseshoe bat	*(Rhinolophus capensis)*
Striped mouse	*(Bathyergus suillus)*
Cape dune molerat	*(Rhabdomys pumilio)*
Cape fox	*(Vulpes chama)*
Striped pole cat	*(Ictonyx striatus)*
Honey badger	*(Mellirova capensis)*
Cape grysbok	*(Raphicerus melanotis)* (pers. obs.).

Further to this Bosbok (*Tragelaphus scriptus*), Dassie (*Procavia capensis*), Creeping Mole (*Amblysomus hottentotus*) and Marsh Mongoose (Kommetjiegatmuishond, *Atilax paludinosis*) have been observed in the area (Rudd, pers. comm.).

Duiwenhoks

Mammals known to occur in the area covered by 1:50 000 Topocadastral Sheet 3421 AC are Schreiber's longfingered bat *(Miniopterus schreibersii)*, the Cape gerbil *(Tatera afra)* and the Cape grysbok *(Raphicerus melanotis)*.

A list of species likely to occur, although not recorded, in the 3421 AC/AD areas is given as Appendix VII.

5. SYNTHESIS AND RECOMMENDATIONS

Present State of the Systems

The Kafferkuils and Duiwenhoks systems originate in the Langeberg Mountains and have similar catchment sizes (1 550 vs 1 340 km^2 respectively). Both systems have medium-sized dams and numerous farm dams in their upper catchments which affect run-off to, and flow patterns in the rivers. Both estuaries are perennially open to the sea and have large tidal exchanges which provide the hydraulic force to keep the mouths open. Each of the estuaries provides important wetland habitats for water associated birds and supports floristically important plant communities.

In terms of human impact, however, there are considerable differences between the systems. The Kafferkuils catchment is in a fair condition whilst that of the Duiwenhoks is heavily farmed. The town of Still Bay on the Kafferkuils Estuary has been a popular seaside retreat for residents of the Little Karoo for the past 100 years and is presently considered to be the fastest growing resort on the southern Cape coast. In contrast, the land bordering the Duiwenhoks Estuary has remained in private hands, with the historic settlement of Puntjie on the east bank and San Sebastian on the west bank being the only developments at present. Largely because of this, the Duiwenhoks Estuary is currently considered to be the least spoilt system between Cape Point and Knysna (Heydorn, 1986).

Present State of Knowledge

Little information exists on the Kafferkuils and Duiwenhoks estuaries. The sediment and hydraulic dynamics of both the systems have been investigated in some detail, but data on the biota and physico-chemical characteristics are sparse. In recent years, increasing development pressures on Still Bay have resulted in the establishment of conservation bodies in the area (Still Bay Conservation Trust and the Kafferkuils River Protection Society) which has led to a greater focus on the Kafferkuils Estuary and environs. The aims of the Still Bay Trust are summarised in Appendix VIII.

Problems: Present and Foreseeable

There are a number of problems evident in the estuarine systems. These can be classified into four general types, namely :

* Disturbance of natural processes;
* Biological modification;
* Population effects; and
* Inappropriate developments.

i) <u>Disturbance of Natural Processes</u>: Problems grouped here are those emanating from alterations in sediment distribution patterns due to interference with, or the actual disruption of sediment transport processes and/or reductions in river flow.

In the Kafferkuils the sediment dynamics of the estuary mouth region have been altered by the breaking of the sediment pathway into the historic sediment sink east of the mouth (Figure 16). This was done by the initial fixing of the drift sand region by planting programmes and the subsequent building of roads and houses across the sand transport route (Figure 19). This resulted in a net westward transport of sediment to the estuary mouth region and the development (grow-out) of the dune on the eastern sandspit. This has forced the estuary mouth westward and it is now effectively pinned against the western bank. The breadth of the mouth has also been reduced (compare Figure 16 with Plate I).

There are two consequences of this. The first is that in periods of high flow very high water levels can occur in the estuary due to backflooding as the east bank sand spit will retard the widening of the mouth. The campsite, water slide and ablution facilities as well as houses and roads on the east and west bank of the lower flood plain will be prone to flooding during such events (Figure 15). The second consequence is that the sand and saltmarsh areas behind the eastern sandspit (Plate I and Figure 27) will increase in height due to sand trapping. This will initially restrict and eventually terminate water flow through the upper saltmarsh areas and these will die. This will reduce both the biological carrying capacity of the system and its overall biological diversity.

Freshwater supply to both the Kafferkuils and Duiwenhoks estuaries is being progressively curtailed by the proliferation of farm dams, direct pumping and increased agricultural take-off in the catchment areas. This affects the volume flowing in the rivers but, more importantly, small flood events which play an important role in the sediment balance in the estuaries are damped. Evidence of reduced flow rates is most noticeable at Kleinefontein Farm on the Duiwenhoks where considerable bank erosion is occurring owing to the river becoming more sinuous. In fact Mr E Dicey (*in litt.*), present owner of the Kleinefontein Farm, has observed that periods of low or even no flow occur in this river. The progressive closure of the western 'ox-bow' channel adjacent to San Sebastian (Plate II) may also be an effect of reduced flow although the blasting open of the ski boat transit channel through the intertidal rock ledge below Puntjie (Figure 17 and 24) may play a role here. Unchecked development of small farm dams plus increased agricultural take-off in general will lead to increased marine sediment influx in both of the estuarine systems. A potential consequence of this is episodic closure of the estuary mouths; the Kafferkuils is probably more vulnerable here because of its already restricted mouth. If this occurs the character of the estuaries will be completely changed.

The Still Bay small boat harbour and its approaches suffer episodic siltation problems. These are due to movements of the sediment reserves in the Bay itself under the varying current regimes that operate. The sediment that does invade the harbour, under south-easterly wind and swell conditions, is subsequently removed by residual wave energy derived from south-westerly swells refracted around Morris Point. The situation presents a severe problem to boat operators. Due to the configuration of Still Bay itself it is unlikely that anything but an extremely expensive harbour design coupled with dredging or sand pumping operations will solve this problem. It is doubtful if this is warranted by the scale of boating and/or fishing activity that occurs year round from this harbour. Shifting sand banks in the harbour approaches make the region unsafe for the operation of larger boats.

ii) Biological modification: Saltmarsh areas in the Kafferkuils Estuary have been effectively reduced by developments on the lower flood plain and especially some of the east bank roads that actually follow old river channels (Zwamborn and Rossouw, 1967). Such reductions in areas are not evident in the Duiwenhoks Estuary but here considerable damage is done to saltmarshes through trampling by cattle. As pointed out above, saltmarshes play important roles in estuarine systems.

There is considerable angling pressure and harvesting of bait organism in both estuaries. The opinion of local residents is that availability of both fish and bait has declined over the recent past but, as no formal records have been kept nor surveys carried out, this is difficult to substantiate (cf Breë; Carter, 1983). However, it is apparent that with greater angling pressure on the systems, populations will come under increased threat. The depletion of bait organisms specifically has implications for both the quantity and type of fish that the estuaries support.

Alien vegetation, primarily rooikrans, has extensively invaded both estuarine systems and their catchments. The spread of exotic plants seems to be unchecked outside proclaimed nature areas and is encouraged in the catchments by veld burning. This appears to be a serious problem in the vicinity of Vermaaklikheid where recent uncontrolled fires have seriously damaged the vegetation (Figure 30). The Riversdale plain supports floristically important plant communities and these are being threatened by exotics.

iii) Population Effects: Corresponding with differences in development, the Kafferkuils Estuary appears to have more problems associated with population pressure than does the Duiwenhoks Estuary.

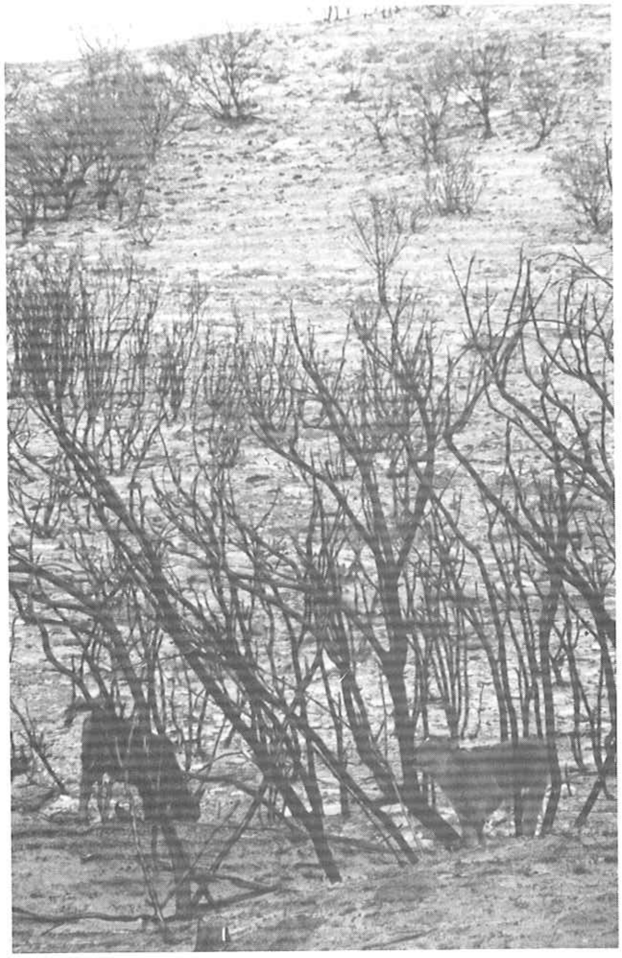


FIG. 30: Severe fire damage to vegetation east of Vermaaklikheid.

During peak holiday season at the Kafferkuils Estuary supplies of electricity and water, sewage disposal systems and parking facilities are under severe strain. Traffic congestion is also a problem at these periods. The municipality is taking steps to ameliorate these problems through installing a water-borne sewage system in Still Bay West and ensuring sufficient supplies of electricity and water (J H Veldsman, Still Bay Town Clerk, *in litt*).

Still Bay offers a wide variety of recreational opportunities and these are generally fully exploited during peak holiday periods. Some of the activities pursued, however, can exclude others and/or can damage the environment. Of particular concern here are boating and other water sport activities carried out in the estuary and lower river reaches. For example, speedboating and waterskiing require large water areas if they are not to limit or prohibit other water activities such as swimming, windsurfing, *etc* (Van Riet, 1990). Further, wakes from speed boats cause bank erosion, a problem specifically pertinent to the upper estuary and lower river reaches.

It is clear that in peak season the number of boats on the estuary, coupled with the specific activities pursued, exceed both environment and physical safety limits.

iv) Inappropriate Development: There are a number of inappropriate developments in the Still Bay municipal area. These are :

* The sea front-houses immediately east of Lappiesbaai beach as well as the parking area are situated in the dynamic fore dune region of the beach. Consequently, these structures are frequently inundated by sand as shown in Figure 21. The houses further east of these are in danger of having similar problems due to apparently indiscriminate removal of primary dune vegetation to improve their view of the beaches and the sea.

* The water-slide and putt-putt course as well as the access road and parking area on and adjacent to the east bank sand spit are in the dynamic zone of the estuary mouth. As such they are in danger of being damaged in large floods and they hinder the natural dynamics of this area.

* Houses on both banks of the estuary have been built upon saltmarsh areas (eg Die Braak, Figure 9 and the area immediately downstream of the road bridge and road on the west bank).

* The visually obtrusive Stille Heuwels development in Still Bay west (Figure 5).

Sowman (1988), states that apart from being inappropriately situated some of these developments have caused dissention amongst the Still Bay property owners and between some of the property owners and the town council. These problems can be attributed to a lack of holistic planning and inadequate consultation between the town council and developers on the one hand and ratepayers and interest groups on the other.

Recommendations

1) Carry out a comprehensive hydrodynamic study on the Kafferkuils Estuary to establish the required mouth dimensions for effective flood release to prevent backflooding during large floods.

2) As a precautionary measure prior to the above study, provide latitude for the lateral movement of the Kafferkuils Estuary mouth as well as flow induced increases in mouth cross sectional area by removing some of the western extremity of the sand dune on the eastern sand spit and bulldoze channels through it to allow high flood flows to escape before disastrous backflooding occurs.

3) Determine the ecologically acceptable upper limit of fresh water removal from both river systems and regulate take-off so as not to exceed this. If possible, devise a system to allow small scale flood events to flow through the estuaries.

4) Vigorously conserve and protect the remaining saltmarsh areas in the estuaries. Implementation of recommendation (2) should reduce sand inundation and consequent dry-out of the Kafferkuils lower eastbank salt marsh.

5) Determine sustainable fish and bait organism yields for both systems and regulate exploitation so as not to exceed this level. This will require the instigation of a permit system and regular inspection to enforce individual quotas. Renewal of permits should be predicated on submission of catch returns to provide a data base for management. Strict control of illegal fishing activities, eg harder netting, is implicit here.

6) Preserve and protect the unique vegetation communities and archaeological sites of the area. This particularly applies to the dune asteraceous fynbos vegetation community behind Morris Point and the 'visvywers' at Noordkapper Point and between the Still Bay harbour and the estuary mouth. Protection of the former two entities can be achieved by having the Morris Point to Noordkapper Point stretch of coastline incorporated into the Limited Development Area proclaimed for the Plattebosch to Diuwenhoks river mouth area in July, 1990 (Government Gazette, 6 July, 1990). The latter entity will require the special attention of the local conservation officers.

7) Explore incentive systems to encourage landowners in the estuary and catchment areas to remove alien vegetation. Such vegetation on State-owned land in the region must be concurrently removed to limit reseeding. This, coupled with the conservation of unique vegetation areas (point 6 above) will improve the aesthetic appeal of the environment and thereby broaden public commitment to a saner land use philosophy than followed heretofore.

8) Institute a boat operating permit system to control the number of boats that have access to both the Kafferkuils and Duiwenhoks estuaries. Subdivide the estuaries into zones and define and enforce permissible boating activities and boat speeds for each of the zones.

9) Construct a development application approval system that considers:

   (i) the position of the 1:50 year flood line to prevent further development in the flood plains and

   (ii) the sediment dynamics of the coast and estuaries to prevent interference in natural sediment cycles.

   The above should be incorporated into clear structured procedures implementable at local authority level to ensure that the relevant coastal and estuarine management and planning experts, as well as public interest groups, are consulted before a decision is made.

10) Compile structure plans for both estuarine systems which set limits on the extent and type of development permissible. These plans must consider natural limiting factors (eg water supplies), recreational carrying capacity, areas which are unique or worthy of protection, and ratepayers' and interest groups' opinion. These structure plans must be compatible with, and complimentary to, structure and/or management plans for the respective riverine areas and river catchment. Without such measures the quality of the estuarine environment and the recreational attraction of the areas are likely to deteriorate.

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Kafferkuils

Date	Job no.	Photo no.	Scale 1:	Type	Source
1942	8/42	6815	34 000	B/W	Trig. Survey
Mar/Apr 1954	344	176	30 000	B/W	Trig. Survey
1963	492	2018	30 000	B/W	Trig. Survey
08.05.67	564	229	38 000	B/W	Trig. Survey
22.09.72	295/8	6960	8 000	B/W	Dept Transport
10.05.74	735	9729	50 000	B/W	Trig. Survey
04.04.76	243	016	10 000	Col.	Univ. of Natal
08.04.77	228	589	7 600	Col.	Univ. of Natal
21.04.79	326	303/3	10 000	Col.	Univ. of Natal
09.04.80	349	20	20 000	B/W	Dept Transport

Kafferkuils (cont.)

Date	Job no.	Photo no.	Scale 1:	Type	Source
Dec 1980	374	218	20 000	B/W	Dept Transport
Dec 1980	391	312/3	20 000	Col.	Univ. of Natal
08.06.83	498/180	489	30 000	B/W	Trig. Survey
Feb 1987		534-540	10 000	Col.	ECRU/EMATEK
May 1990		-	10 000	Col.	ECRU/EMATEK

Duiwenhoks

Date	Job no.	Photo no.	Scale 1:	Type	Source
1942	170/42	3863	43 000	B/W	Trig. Survey
Mar/Apr 1954	334	203	30 000	B/W	Trig. Survey
08.05.67	564	241	38 000	B/W	Trig. Survey
18.05.74	735	0125	50 000	B/W	Trig. Survey
04.04.76	243	013	10 000	Col.	Univ. of Natal
08.04.77	282	584	6 000	Col.	Univ. of Natal
21.04.79	326	307/3	1 000	Col.	Univ. of Natal
Dec 1980	374	221	20 000	B/W	Trig. Survey
Dec 1981	391	316/3	20 000	Col.	Univ. of Natal
Feb 1987		509-515	10 000	Col.	ECRU/EMATEK
May 1990		-	10 000	Col.	ECRU/EMATEK

8. GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

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

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

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

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

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

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

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

BIMODAL: having two peaks.

BIOGENIC: orginating from living organisms.

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

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

BIOTIC: living (characteristics).

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

CALCAREOUS: containing an appreciable proportion of calcium carbonate.

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

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

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

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

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

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

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

DETRITUS: organic debris from decomposing plants and animals.

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

DYNAMIC: relating to ongoing and natural change.

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

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

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

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

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

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

EPISODIC: sporadic and tending to be extreme.

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

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

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

FLUVIAL (deposits): originating from rivers.

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

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

GEOMORPHOLOGY: the study of land form or topography.

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

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

HALOPHYTES: plants which can tolerate saline conditions.

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

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

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

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

INDIGENOUS: belonging to the locality; not imported.

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

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

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

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

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

LIMPID: clear or transparent.

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

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

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

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

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

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

MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23°, 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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APPENDIX I: Physical features and species composition of the vegetation mapping units identified at the Kafferkuils and Duiwenhoks estuaries. (M O'Callaghan, NBI *in litt.*)

	Duiwenhoks		Kafferkuils		Duiwenhoks and Kafferkuils			
	Area (ha)	%Area studied	Area (ha)	%Area studied	Total area studied (ha)	%total area studied	Cover (%)	Height (m)
Wetlands	50,78	7,48	44,20	8,43	94,98	7,89	80	0,4
Dune Pioneers	9,82	1,45	3,52	0,67	13,34	1,11	20	0,2
Dune Scrub	159,34	23,48	5,96	1,15	165,30	13,74	90	1,5
Dune Fynbos	19,99	2,94	17,16	3,27	37,15	3,09	50	0,5
Limestone Fynbos	120,66	17,78	23,47	4,47	144,13	11,98	80	1,5
Proteoid Fynbos	83,83	12,35	65,78	12,54	149,61	12,43	80	1,5
Riparian Thicket	20,83	3,07	4,65	0,89	25,48	2,12	80	2,5
Eastern Forest	37,70	5,55			37,70	3,13	80	2,5
Alien Vegetation			45,17	8,61	45,17	3,75	100	2,0
Agricultural Areas	20,68	3,05	77,06	14,69	97,70	8,12		
Residential Areas			126,93	24,20	126,93	10,55		
Water	72,91	10,74	47,78	9,11	120,69	10,03		
Sand	79,38	11,70	62,78	11,97	142,16	11,82		
Rocks	2,78	0,41			2,78	0,24		
Total	678,69	100	524,43	100	1203,12	100		

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

r - 1/few individuals, cover less than 0,1 percent of area
+ - occasional plants, cover less than 1 percent of area
1 - abundant, cover 1 - 5 percent of area
2 - any number, cover 6 - 25 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.

Wetlands

Chenolea diffusa (1); *Cotula coronopifolia* (+); *Disphyma crassifolium* (2); *Sarcocornia perennis* (5); *S. pillansii* (5); *Spartina maritima* (4); *Sporobolus virginicus* (1).

Dune Pioneers

Arctotheca populifolia (4); *Chrysanthemoides monilifera* (+); *Heteroptilis suffruticosa* (4); *Myrica cordifolia* (+); *Passerina rigida* (+); *Scaevola plumieri*(+); *Silene bellidioides* (+); *Senecio elegans* (+); *Tetragonia decumbens* (+); *Trachyandra divaricata*(+); *Zygophyllum morgsana*(+).

Dune Scrub

Carissa bispinosa (1); *Carpobrotus edulis* (1); *Cassine aethiopica* (1); *Chasmanthe aethiopica* (1); *Chironia baccifera* (+); *Chrysanthemoides monilifera* (1); *Cussonia thyrsiflora* (1); *Cynanchum* sp. (+); *Diospyros lycoides* (1); *Euclea racemosa* (2); *E. undulata* (1); *Pterocelastrus tricuspidatus* (+); *Putterlickia pyracantha* (2); *Rhoicissus digitata* (1); *Rhus longispina* (1); *Sideroxylon inerme* (2); *Tarchonanthus camphoratus* (1); *Zygophyllum* sp. (1).

Dune Fynbos

Aridaria brevifolia (1); *Aspalathus* sp. (2); *Carpobrotus edulis* (+); *Cassine aethiopica* (+); *Cassytha ciliolaris* (1); *Chasmanthe aethiopica* (+); *Chironia baccifera* (+); *Chrysanthemoides monilifera* (+); *Colpoon compressum* (+); *Cynanchum obtusifolium* (+); *Erharta villosa* (+); *Erica* spp. (1); *Eriocephalus africanus* (+); *Euclea racemosa* (1); *Ficinia lateralis* (+); *Ficinia praemorsa* (1); *Helichrysum teretifolium* (+); *Hellmuthia membranacea* (+); *Heteroptilis suffruticosa* (+); *Lampranthus explanatus* (1); *Lachanalea bulbifera* (+); *Maytenus oleoides* (+); *Metalasia muricata* (2); *Nyalandtia spinosa* (2); *Protasparagus aethiopicus* (+); *Pteracelostrus tricuspidatus* (+); *Protea* spp. (1); *Ischyrolepis eleocharis* (1); *Rhus crenata* (2); *R. glauca* (+); *R. laevigatus* (+); *Tetragonia fruticosa* (+).

Limestone Fynbos

Chondropetalum microcarpum (2); *Colpoon compressum* (+); *Erica regerminans* (+); *Eriocephalus africanus*(+) *Euclea racemosa* (+); *Euphorbia mauritanica* (+); *Ficinia truncata* (+); *Leucadendron muirii* (1); *Metalasia muricata* (1); *Protasparagus suaveolens* (+); *Rhus glauca* (+) *Ruschia geminiflora* (+); *Sideroxylon inerme* (+); *Thamnochortus erectus* (2).

Proteoid Fynbos

Chrysanthemoides monilifera (+); *Carpobrotus edulis* (+); *Erica coccinnia* (+); *E. arenaria* (+); *Ficinia bergiana* (+); *Leucadendron meridianum* (+); *Metalasia muricata* (+); *Protea obtusifolia* (2); *Restio leptocladus* (+); *Rhus glauca* (+); *Tetraria cuspidata* (+); *Struthiola argentea* (+); *Willdenowia teres* (+).

Riparian Scrub

Acacia karroo (1); *Aloe arborescens* (1); *Azima tetracantha* (2); *Euclea racemosa* (+); *Euphorbia mauritanica* (+); *Lycium afrum* (1); *Opuntia ficus-indica* (1); *Polygala myrtifolia* (+); *Rhus longispina* (1); *Sideroxylon inerme* (+); *Solanum nicotianum* (+); *Zygophyllum morgsana* (1).

APPENDIX IIa: Plankton data for the Kafferkuils River estuary. Sampling date: 25 May 1969. Five stations sampled from mouth to approximately 13 km upstream (J R Grindley, *in litt.*)

Dry biomass at the mouth 135,3 mg/m^3. Mean biomass at 5 stations 51,88 mg/m^3

Taxa/species recorded

ALGAE	Diatoms
PROTOZOA	Foraminifera
NEMATODA	Nematode sp.
ANNELIDA	Polychaete larvae
OSTRACODA	Ostracod sp.
COPEPODA	*Acartia natalensis*
	Harpacticoids
	Hemicyclops sp.
	Pseudodiaoptomus hessei
	Nauplius larvae
MYSIDACEA	*Mesopodopsis africana*
ISOPODA	*Cirolana* sp.
	Leptanthura laevigata
AMPHIPODA	*Austrochiltonia subtenuis*
	Zoea larvae
MOLLUSCA	Lamellibranch larvae

APPENDIX IIb: Plankton data for the Duiwenhoks River estuary. Sampling date: May 1969. Five stations sampled (J R Grindley, *in litt.*).

Dry biomass at the mouth 31,0 mg/m^3. Mean biomass at 5 stations 9,98 mg/m^3.

Taxa/species recorded

ALGAE	Diatoms
PROTOZOA	Foraminifera
NEMATODA	Nematode sp.
ANNELIDA	Polychaete larvae
OSTREACODA	Ostracod sp.
COPEPODA	Harpacticoids
	Pseudodiaoptomus hessei
	Nauplius larvae
INSECTA	Chironomid larvae
MOLLUSCA	Gastropod larvae
	Lamellibranch larvae
PISCES	Fish larvae

APPENDIX III: Macro-invertebrates Taxa recorded in the Kafferkuils and Duiwenhoks estuaries

* = recorded from Kafferkuils only ** = recorded from Duiwenhoks only

TAXA	COMMON NAME	REMARKS	SOURCE
* Nemertea sp.	Proboscis worm	Sandbank 0,3 km upstream	ECRU
Annelida			
Arenicola loveni	Blood worm	Bait organism. Sparsely distributed but locally abundant in coarse sand areas	Gaigher
Glycera convoluta		Present in lower estuary	ECRU
Lumbrineris tetraura		"	ECRU
Orbinia sp.		"	ECRU
Arthropoda			
Cirripedia			
Balanus elizabethae		Sparsely distributed on rocks in the lower estuary	ECRU
Chthalamus denteatus	Acorn barnacle	"	ECRU
Malacostraca			
Urothoe sp.		Sandbanks in lower estuary	ECRU
***Rhopalophthalmus terranatalis*	Opossum shrimp	Vicinity of *Zostera* bed	ECRU
Alpheus crassimanus	Pistol shrimp	"	ECRU
Penaeus japonicus	Ginger prawn	"	ECRU
Diogenes brevirostris	Common hermit crab	Distributed throughout lower estuary	ECRU
Callianassa kraussi	Sand prawn	Lower sandbanks abundant in Kafferkuils, rare in the Duiwenhoks	Gaigher, ECRU
Upogebia africana	Mud prawn	Abundant on fine and muddy sand banks	Gaigher, ECRU
Cleistostoma edwardsii	Burroughing crab		ECRU
Dotilla fenestrata	Sand crab	Lower sand banks	ECRU
Hymenosoma orbiculare	Brown crab		ECRU
Sesarma catenata	Marsh crab	Abundant in *Spartina* marshes	Gaigher, ECRU
Scylla serrata	Giant mud crab	Sparsely distributed but more common in upper reaches	Dicey, ECRU
Mollusca			
Pelecypoda			
Loripes clausus	Estuarine sand mussel	Abundant on sand bank	ECRU
Solen capensis	Razor clam	Abundant in main channel and drainage gulleys	Gaigher, ECRU
* *Perna perna*	Brown mussel	Sparsely distributed on Road bridge pylons	ECRU
* *Psammotellina capensis*		Present on lower sandbanks	
Gastropoda			
Assiminea ovata		Abundant in lower estuary	ECRU
Nassarius kraussianus	Whelk		

APPENDIX IVa: Fresh water fish species recorded in the Kafferkuils and Duiwenhoks rivers. Data from S C Thorne (1985, CDNEC *in litt.*) and Barnard (1943).

Species	Common Name	Remarks
Barbus anoplus	Chubbyhead barb	Duiwenhoks only
Pseudobarbus burchelli	Burchell's redfin	Both systems
Galaxias zebratus	Cape galaxias	"
Sandelia capensis	Cape kurper	"
Tilapia sparrmanii	Banded tilapia	Duiwenhoks only (introduced)
Micropterus dolomieu	Smallmouth bass	Both systems (alien)
M. salmoides	Largemouth bass	Duiwenhoks only (alien)
Salmo trutta	Brown trout	Duiwenhoks only (in dams)
Salmo myhiss	Rainbow trout	Duiwenhoks only (in dams)
Anguilla mossambicus	Longfin eel	Both systems

APPENDIX IVb: Marine/Estuarine fish species recorded in the Kafferkuils and Duiwenhoks estuaries (assembled from various sources).

Species	Common Name	Remarks
Gilchristella aestuaria	Estuarine round herring	
Galeicthys feliceps	White seacatfish	
Heteromycteric capensis	Cape sole	
Solea bleekeri	Blackhand sole	
Syngnathus acus	Longnose pipefish	
Lichia amia	Garrick/Leervis	Not abundant
Pomatomus saltatrix	Elf	Seasonal
Argyrosomas hololepidotus	Kabeljou (Kob)	Max. size >45 kg
Monodactylus falciformis	Cape moony	
Pomadasys commersonnii	Spotted grunter	Seasonal
P. olivaceum	Piggy	
Diplodus sargus capensis	Blacktail (dassie)	
Lithognathus lithognathus	White steenbras	Seasonal
Rhabdosargus globiceps	White stumpnose	
Sarpa salpa	Strepie	
Liza dumerilii	Groovey mullet	
L. macrolepis	Large-scale mullet	
L. richardsonii	Southern mullet (Sea harder)	
L. tricuspidens	Striped mullet	
Mugil cephalus	Flathead mullet (Springer)	
Myxus capensis	Freshwater mullet	
Caffrogobius multifasciatus	Prison goby	
Psammogobius knysnaensis	Knysna sandgoby	
Amblyrhynchotes honchenii	Evil-eyed blaasop	

APPENDIX V: Amphibians and reptiles which have been recorded or can be expected to occur in the Kafferkuils, Duiwenhoks and adjacent environs (A L de Villiers CDNEC *in litt.*).

L = Likely to occur
XC = CDNEC herpetological specimen collection (1972-1985)
XB = Broadley (1983)
XG = Greig and Burdett (1976)
XP = Poynton (1964)
XV = Visser (1984)

Species	Common Name	3421AC Vermaaklik-heid	3421AD Stilbaai
AMPHIBIANS			
Xenopus l. laevis	Common platanna	L	L
Bufo angusticeps	Sand toad	L	L
Bufo rangeri	Raucous toad	L	XP
Breviceps rosei	Sand rain frog	L	XP
Tomopterna delalandii	Cape sand frog	L	XP
Rana fuscigula	Cape river frog	L	L
Strongylopus grayii	Spotted rana	L	XP
Strongylopus fasciata	Striped grass frog	L	XP
Cacosternum boetetgeri	Common caco	L	L
Semnodactylus wealii	Rattling kassina	L	L
Hyperolius horstockii	Arum lily frog	L	L
REPTILES			
TORTOISES			
Geochelone pardalis	Mountain tortoise	L	L
Chersina angulata	Angulate tortoise	L	XG
Homopus areolatus	Common padloper	L	L
Pelomedusa subrufa	Cape terrapin	L	L
SNAKES			
Typhlops lalandei	Pink earth snake	L	L
Lycodonomorphus rufulus	Brown water snake	L	L
Lamprophis aurora	Aurora house snake	L	L
Lamprophis inornatus	Olive house snake	L	L
Lamprophis fuliginosus	Brown house snake	L	L
Duberria l. lutrix	Southern slug eater	L	L
Pseudaspis cana	Mole snake	L	L
Amplorhinus multimaculatus	Many-spotted reed snake	L	L
Psammophylax r. rhombeatus	Spotted skaapsteker	L	L
Psammophis crucifer	Cross-marked sand snake		XB
Homoroselaps lacteus	Spotted harlequin snake	L	?
Prosymna s. sundevallii	Southern shovel-snout	L	?
Philothamnus natalensis occidentalis	Western Natal green snake	L	
Crotaphopeltis hotamboeia	Herald snake	L	L
Dispholidus t. typus	Boomslang	L	L
Dasypeltis scabra	Common egg eater	L	L
Hemachatus haemachatus	Rinkhals	L	L
Aspidelaps l. lubricus	Coral snake	L	L
Naja nivea	Cape cobra	L	L
Causus rhombeatus	Rhombic night adder	L	L
Bitis atropos	Cape mountain adder	L	L
Bitis a. arietans	Puff adder	L	L

Species	Common Name	3421AC Vermaaklikheid	3421AD Stilbaai
LIZARDS			
Pachydactylus geitje	Ocellated gecko	L	XV
Phyllodactylus porphyreus	Marbled gecko	L	L
Bradypodion pumilum	Cape dwarf chameleon	L	L
Agama a. atra	Rock agama	L	L
Acontias m. meleagris	Golden sand skink	L	L
Mabuya capensis	Cape three-striped skink	L	L
Mabuya h. homalocephala	Cape speckled skink	L	L
Gerrhosaurus f. flavigularis	Yellow-throated plated lizard	L	XV
Tetradactylus s. seps	Short-legged skink	L	L
Tropidosaura gularis	Yellow-striped mountain lizard	L	L
Tropidosaura m. montana	Green-striped mountain lizard	L	L
Pedioplanus lineoocellata pulchella	Ocellated sand lizard	L	XV
Pedioplanus burchelli	Burchell's sand lizard	L	L
Cordylus c. cordylus	Common Cape girdled lizard	L	XV
Chamaesaura a. anguina	Cape snake lizard	L	L

<u>APPENDIX VI</u>: Bird species observed in the vicinity of the Kafferkuils and Duiwenhoks rivers.

R = Ryan *et al.* (1988)
S = Summers *et al.* (1976)
* = Listed in Red Data Book (Brooke, 1984)

New Roberts Number (Maclean, 1985)	Common Name	Generic Name	Source
KAFFERKUILS			
<u>Migrant Waders</u>			
245	Ringed Plover	*Charadrius hiagicula*	R & S
254	Grey Plover	*Pluvialis squatarola*	R & S
272	Curlew Sandpiper	*Calidris ferruginea*	R & S
264	Common sandpiper	*Tringa hypoleucos*	R & S
270	Greenshank	*Tringa nebularia*	R & S
290	Whimbrel	*Numenius phaeopus*	R & S
262	Turnstone	*Arenaria interpres*	R
289	Curlew	*Numenius arquata*	R

New Roberts Number (Maclean, 1985)	Common Name	Generic Name	Source
Resident Waders			
246	Whitefronted Plover	*Charadrius marginatus*	R & S
258	Blacksmith Plover	*Vanellus armatus*	R & S
249	Threebanded Plover	*Charadrius tricollaris*	R & S
255	Crowned Plover	*Vanellus coronatus*	R
Water associated Non-waders			
55	Whitebreasted Cormorant	*Phalacrocorax carbo*	R
58	Reed Cormorant	*Phalacrocorax africanus*	R
63	Black-headed Heron	*Ardea melanocephala*	R
67	Little Egret	*Egretta garzetta*	R
104	Yellowbilled Duck	*Anas undulata*	R
228	Red-knobbed Coot	*Fulica cristata*	R
312	Kelp Gull	*Larus dominicanus*	R
*322	Caspian Tern	*Hydroprogne caspia*	R
326	Sandwich Tern	*Sterna sandvicensis*	R
428	Pied Kingfisher	*Ceryle rudis*	R
713	Cape Wagtail	*Motacilla capensis*	R

DUIWENHOKS

Migrant Waders			
254	Grey Plover	*Pluvialis squatarola*	R & S
264	Common Sandpiper	*Tringa hypoleucos*	R & S
270	Greenshank	*Tringa nebularia*	R & S
290	Whimbrel	*Numenius phaeopus*	R & S
272	Curlew Sandpiper	*Calidris ferruginea*	S
Resident Waders			
246	Whitefronted Plover	*Charadrius marginatus*	R & S
258	Blacksmith Plover	*Vanellus armatus*	R & S
Water associated Non-waders			
58	Reed Cormorant	*Phalacrocorax africanus*	R
62	Grey Heron	*Ardea cinerea*	R
67	Little Egret	*Egretta garzetta*	R
170	Osprey	*Pandion haliaetus*	R
312	Kelp Gull	*Larus dominicanus*	R
327/8	Common/Arctic Tern	*Sterna hirundo*	R
326	Sandwich Tern	*Sterna sandvicensis*	R
428	Pied Kingfisher	*Ceryle rudis*	R
713	Cape Wagtail	*Motacilla capensis*	R

<u>APPENDIX VII</u>: Mammals probably occurring in areas covered by 1:50 000 topocadastral sheets 3421 AC Vermaaklikheid (Duiwenhoks) and 3421 AD Stilbaai (Kafferkuils) (after P H Lloyd, CDNEC *(in litt.)*). Those recorded and/or observed in the area are given in section 4.2.6.

Species	Common name
Myosorex varius	Forest shrew
Suncus varilla	Lesser dwarf shrew
Crocidura flavaescens	Red musk shrew
Crocidura cyanea	Reddish-grey musk shrew
Raphicerus campestris	Steenbok
Pelea capreolus	Grey rhebuck
Lepus saxatilis	Scrub hare
Lepus capensis	Cape hare
Pronolagus rupestris	Smith's red rock rabbit
Otomys irroratus	Vlei rat
Aethomys namaquensis	Namaqua rock rat
Mus minutoides	Pygmy mouse
Mus musculus (exotic)	House mouse
Rattus norvegicus (exotic)	Brown rat
Rattus rattus (exotic)	Black rat
Hystrix africaeaustralis	Cape porcupine
Cryptomys hottentotus	Common mole rat
Canis mesomelas	Black-backed jackal
Georychus capensis	Cape mole rat
Aonyx capensis	Cape clawless otter
Genetta genetta	Small-spotted genet
Genetta tigrina	Large-spotted genet
Atilax paludinosus	Water mongoose
Felis lybica	African wild cat
Felis caracal	African lynx
Arctocephalus pusillus	Cape fur seal

<u>APPENDIX VIII</u>: The Still Bay Trust (Rudd, 1985)

AIMS: To further the conservation of the cultural-historical heritage of Still Bay and environs, as well as of its natural environment, and promote the harmonious development of the area, taking into account ecological, socio-economic and aesthetic factors.

To achieve these ends by the dissemination of information and the undertaking of educational projects, by interaction with residents and tourists, and through co-operation with official bodies at local, provincial and Government level.

AREA: The coast and adjacent waters from the mouth of the Duiwenhoks River to the mouth of the Gourits River, the town of Still Bay and its environs and the estuary and catchment area of the Kafferkuils River.

APPENDIX IX: Restrictions on use of the Kafferkuils and Duiwenhoks estuaries and their resources

All activities at these estuaries must comply with the Nature Conservation Ordinance No. 19 of 1974, and with any Proclamations, Regulations or Provincial Notices made in terms thereof.

In terms of the Ordinance, both the Kafferkuils and Duiwenhoks estuaries are 'tidal waters' defined as 'that part of any inland waters which, owing to the influence of the sea, become saline at any time or the level of which rises at any time owing to the influence of the sea'.

Fishing

The use of all nets, except landing nets, in tidal waters requires a permit.

An angling licence is required from the Receiver of Revenue, Riversdale, to fish in the Kafferkuils Estuary (Rudd, 1985). Fishing in inland waters which are not tidal also requires an angling licence in both the Kafferkuils and Duiwenhoks rivers.

Angling from the road bridge in the Kafferkuils Estuary is not permitted. Netting in the estuary is not allowed.

Certain methods of catching fish in inland waters are prohibited in terms of Section 56 of Ordinance 19 of 1974.

Regulations pertaining to fish species liable to be caught in the Kafferkuils and Duiwenhoks estuaries and adjacent seas areas (from South Africa Dept. Environment Affairs and CDNEC, 1988 and Rudd, 1985. This guide is presently being revised in view of the latest legislation).

1) Estuarine Fish

Estuarine Fish	Daily catch limit*	Minimum length (mm)
Steenbras	unrestricted	400
Spotted Grunter	unrestricted	400
Kabeljou or Kob	unrestricted	400
Leervis	unrestricted	700
Haarder	unrestricted	150

*NB Total daily bag limit is 20 fish per person

2) Marine Fish

Marine Fish	Minimum length (mm)	Status/Catch limit
Kabeljou or Kob	400	A
Geelbek	400	B
Yellowtail	400	A_1
Elf or Shad	300	C^1
Red Steenbras	250	C^1
Musselcracker (Blou stompkop)	400	C
Musselcracker (Wit stompkop)	400	C
Red Roman	250	C
Soldier (Bastermeid*)	250	C
Dageraad	250	C
Magistraat or Bontdageraad (Concertina*)	250	C

Marine fish (cont.)	Minimum length (mm)	Status/Catch limit
Rock Cod (Yellow Belly)	300	C
Speckled Rock Cod	300	C
Blue Hottentot (Bronze Bream) (Pens en derms*)	220	C
Galjoen	350	C^2
Baardman (Belman, Tasselfish)	300	C
Dassie (Blacktail)	200	B
Zebra	200	B
Silverfish (Snapper*)	250	B
Mackerel	-	A
Butterfish (Steenklipvis)	-	B
Strepie (Karanteen, Golden Strepie)	150	A
Steentjie	-	A
Parrot fish (Beaked Galjoen)	250	C

* Names used only at Still Bay

Status

A : Unrestricted

B : Regulated, catch limit 10 per person per day

C : Protected, catch limit 5 fish in total per day (eg 5 elf, or 1 each of 5 other species *etc.*).

C^1: Season closed from 1 September to 30 November

C^2: Season closed from 15 October to 28 February

<u>Note</u>: cleaning of fish in the sea or river mouth is forbidden

<u>Bait Collection</u>

Prawns, pencil bait and blood worms can be dug in the estuary, subject to restrictions on the numbers taken and the method of capture, as laid down from time to time.

Aquatic animals caught in inland waters may not be transferred from one inland water to another, or to the sea, nor may they be bought or sold unless by permit.

Proclamation Numbers 357 of 1972, 326 of 1974 and Provincial Notice 955 of 1975 contain provisions relating to the sizes and numbers of aquatic animals that may be caught.

Present restrictions are:

Bait Organism	Number allowed	Method of capture allowed
Blood worm	5	Pump*
Prawns	70	Pump or tin**
Pencil bait	20	Pump/hooked wire

* Suction or blow pump

** A 'prescribed' tin: minimum diameter: 115 cm (4,5")

<u>Note</u>: SPADES or GARDEN FORKS may NOT be used in the estuary. (Rudd, 1985)

Boating

In terms of Proclamation Number 357 of 1972 no person shall use any boat or other engine-propelled craft, unless he holds a permit, in the area between the mouth of the Kafferkuils Estuary and an imaginary direct line drawn from beacon PA78 (on the right-bank) across and in line with beacon PA79 (on the left-bank) to the HWM on the left bank. In the tidal waters of the Kafferkuils and Duiwenhoks estuaries, no person shall use any boat or craft for speed-boating, aquaplaning, water-skiing or taking part in a regatta between the hours of 20h00 and 08h00, other than for transporting animals, goods or persons by the shortest possible route at a speed of less than 19 km/h.

APPENDIX X: GUIDE TO AVAILABLE INFORMATION

ESTUARY / RIVERMOUTH / LAGOON: KAFFERKUILS/DUIWENHOKS

Group	Subgroup	Guide to available information / Sources of information	ACOCKS	BARNARD	BOHNEN	BRANCH	BRAUNE AND WESSELS	BROADLEY	BROOKE	BULPIN	CAPE OF GOOD HOPE	CAPE OF GOOD HOPE	CAPE OF GOOD HOPE	CAPE OF GOOD HOPE	CAPE PROVINCIAL ADMINISTRATION	CARTER	DAY	DEACON	DEACON	DE LA BAT
		YEAR (DATE OF INFORMATION)	1953	1943	1986	1988	1981	1983	1984	1980	1974	1972	1974	1975	1977	1983	1981	1989	1979	1986
MANAGEMENT		Historical			*					*										
		Conservation/Utilization			*						*	*	*	*		*				*
		Management/Planning					*								*	*				*
		Legislation									*	*	*	*						
		Water					*													
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals																		
		Birds							*											
		Reptiles				*		*												
		Amphibians				*														
		Fish														*				
		Molluscs																		
		Crustaceans														*				
		Other aquatic invertebrates														*				
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation	*	*	*															
		Semi-aquatic vegetation																		
		Aquatic vegetation																		
		Algae																		
		Phytoplankton																		
		Microbiology																		
ABIOTIC	Chemistry	Pollution															*			
		Eutrophication														*	*			
		General Chemistry														*	*			
		Salinity																		
	Physics	Circulation and mixing																		
		Hydrology / Flood regime																		
		Oceanography																		
		Climate																		
	Geology	Sedimentology														*				
		Palaeoenvironment																*	*	
		Geology			*															
	Physiography	Morphology																		
		Dams/Obstructions					*													
		Catchment characteristics					*													

APPENDIX X: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: KAFFERKUILS/DUIWENHOKS

Category	Group	Guide to available information	ELLIS	FROMME	GAIGHER	GAIGHER et al.	GOHL	GOODWIN	GREIG AND BURDETT	HEYDORN	HEYDORN AND TINLEY	JARMAN	JUBB	KLONUS	LAVER	MACLEAN	MOLL et al.	OELOFSON AND VAN GASS	PITMAN et al.	POYNTON
MANAGEMENT		Historical						*										*		
MANAGEMENT		Conservation/Utilization	*							*	*	*						*		
MANAGEMENT		Management/Planning					*			*	*	*			*					
MANAGEMENT		Legislation																		
MANAGEMENT		Water									*									
BIOTIC		Food webs/Ecosystems																		
BIOTIC	Fauna	Mammals																		
BIOTIC	Fauna	Birds														*				
BIOTIC	Fauna	Reptiles							*											
BIOTIC	Fauna	Amphibians																		*
BIOTIC	Fauna	Fish				*							*							
BIOTIC	Fauna	Molluscs												*						
BIOTIC	Fauna	Crustaceans																		
BIOTIC	Fauna	Other aquatic invertebrates			*															
BIOTIC	Fauna	Terrestrial invertebrates					*													
BIOTIC	Fauna	Zooplankton																		
BIOTIC	Flora	Terrestrial vegetation										*					*			
BIOTIC	Flora	Semi-aquatic vegetation																		
BIOTIC	Flora	Aquatic vegetation																		
BIOTIC	Flora	Algae																		
BIOTIC	Flora	Phytoplankton																		
BIOTIC		Microbiology																		
ABIOTIC	Chemistry	Pollution																		
ABIOTIC	Chemistry	Eutrophication																		
ABIOTIC	Chemistry	General Chemistry																		
ABIOTIC		Salinity																		
ABIOTIC	Physics	Circulation and mixing																		
ABIOTIC	Physics	Hydrology / Flood regime		*							*									
ABIOTIC	Physics	Oceanography																	*	
ABIOTIC	Physics	Climate																	*	
ABIOTIC	Geology	Sedimentology	*	*							*				*					
ABIOTIC	Geology	Palaeoenvironment																		
ABIOTIC	Geology	Geology																		
ABIOTIC	Physiography	Morphology																		
ABIOTIC	Physiography	Dams/Obstructions																	*	
ABIOTIC	Physiography	Catchment characteristics									*								*	
YEAR (DATE OF INFORMATION)			1973	1989	1978	1980	1944	1946	1976	1986	1980	1986	1967	1987	1936	1985	1984	1984	1981	1964

APPENDIX X: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: KAFFERKUILS/DUIWENHOKS

Sources of information			RAPER	REBELO, CAMPBELL, COWLING	ROGERS	ROOSEBOOM AND COETZEE	RUDD	RYAN, UNDERHILL, COOPER, WALTNER	SCHOONEES AND SWART	SCHULZE	SCOTT AND DE WAAL INC	SCOTT AND DE WAAL INC	SKELTON	SMITH AND HEEMSTRA	SOUTH AFRICA DEPT. ENV. AFFAIRS	SOUTH AFRICA DEPT. PLANNING	SOUTH AFRICA DEPT. WATER AFFAIRS	SOWMAN	STEYN	SUMMERS, PRINGLE, COOPER
YEAR (DATE OF INFORMATION)			1987	1990	1985	1975	1985	1988	-	1965	1984	1985	1987	1986	1988	1968	1968	1988	1983	1976
MANAGEMENT		Historical	*																*	
		Conservation/Utilization					*					*				*		*		
		Management/Planning									*							*		
		Legislation					*								*	*				
		Water									*	*					*			
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals																		
		Birds						*												*
		Reptiles																		
		Amphibians																		
		Fish											*	*					*	
		Molluscs																		
		Crustaceans																		
		Other aquatic invertebrates																		
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation		*															*	
		Semi-aquatic vegetation																		
		Aquatic vegetation																		
		Algae																		
		Phytoplankton																		
		Microbiology																		
ABIOTIC	Chemistry	Pollution										*								
		Eutrophication																		
		General Chemistry										*								
		Salinity																		
	Physics	Circulation and mixing																		
		Hydrology / Flood regime															*			
		Oceanography																		
		Climate								*										
	Geology	Sedimentology				*			*											
		Palaeoenvironment																		
		Geology			*															
	Physiography	Morphology					*													
		Dams/Obstructions															*			
		Catchment characteristics				*														

Guide to available information

APPENDIX X: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: KAFFERKUILS/DUIWENHOKS

Guide to available information

			TALJAARD	VAN RIET	VISSER	VONK	WALSH	WEIDEMANN	ZWAMBORN AND ROSSOUW
MANAGEMENT		Historical							
		Conservation / Utilization		*					
		Management / Planning		*				*	
		Legislation							
		Water							
BIOTIC		Food webs / Ecosystems							
	Fauna	Mammals							
		Birds							
		Reptiles							
		Amphibians			*				
		Fish							
		Molluscs							
		Crustaceans							
		Other aquatic invertebrates							
		Terrestrial invertebrates							
		Zooplankton							
	Flora	Terrestrial vegetation					*		
		Semi-aquatic vegetation							
		Aquatic vegetation							
		Algae							
		Phytoplankton							
		Microbiology							
ABIOTIC	Chemistry	Pollution							
		Eutrophication							
		General Chemistry	*						
		Salinity							
	Physics	Circulation and mixing							
		Hydrology / Flood regime							
		Oceanography				*			
		Climate							
	Geology	Sedimentology					*	*	*
		Palaeoenvironment							
		Geology							
	Physiography	Morphology						*	*
		Dams/Obstructions							
		Catchment characteristics							
YEAR (DATE OF INFORMATION)			1987	1990	1984	1977	1968	1978	1967

Sources of information: TALJAARD, VAN RIET, VISSER, VONK, WALSH, WEIDEMANN, ZWAMBORN AND ROSSOUW

PLATE III: Small boat harbour, launching facilities and historic 'visvywers', Still Bay West (89-08-06)

PLATE IV: Unobtrusive group of private beach houses at San Sebastian on the west bank of the Duiwenhoks Estuary (89-08-06)

PLATE V: Development on the eastern sandspit of the Kafferkuils Estuary. Note the embankments protecting the access road and parking area (89-08-06)

NOTES