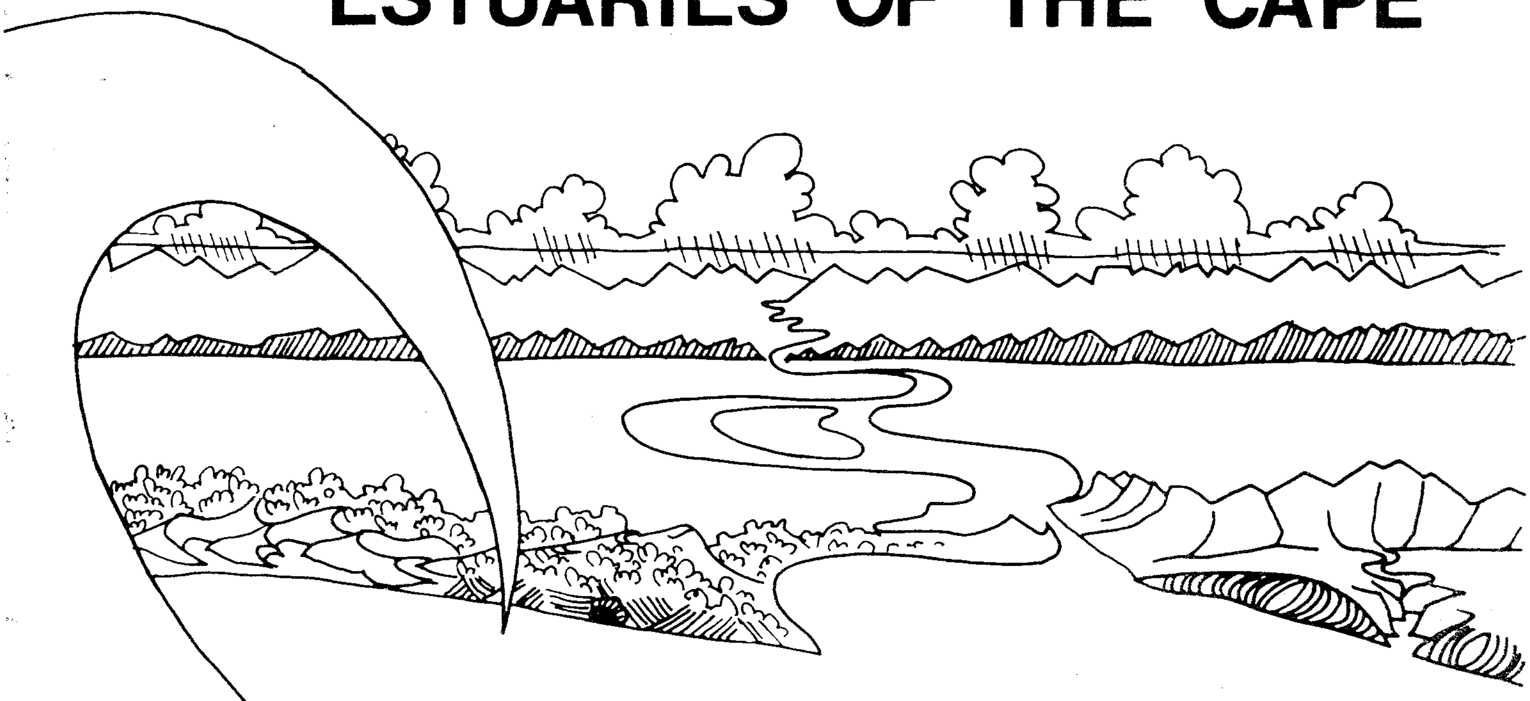
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II

SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 24

ONRUS (CSW 14)

CSIR RESEARCH REPORT 423

Stellenbosch, South Africa
July 1983

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
A E F HEYDORN, National Research Institute for Oceanology, CSIR, Stellenbosch
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FRONTISPIECE: ONRUS ESTUARY – ALT. 460 m, ECRU 79-10-16

REPORT NO. 24: ONRUS (CSW 14)

(CSW 14 – CSIR Estuary Index Number)

BY: T J E HEINECKEN and K St J DAMSTRA

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

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SURVEY TEAMS

The initial ecological surveys were undertaken by the University of Cape Town, Habitat Working Group in November 1979 and in July 1980. The Working Group consisted of the following persons under the supervision of Prof GM Branch.

(1) UCT Habitat Working Group (November 1979 and July 1980)

Mr K St J Damstra
Mr H de Decker
Mr M Cherry
Mr A Rebelo
Ms C Beveridge
Ms M Timm
Ms J Pugh
Ms SJ Milton

This was followed by *ad hoc* visits to the site by the following members of ECRU in December 1979 and May 1983

(2) ECRU (December 1979 and May 1983)

Dr AEF Heydorn (Dec 1979)
Mr TJE Heinecken (Dec 1979 and May 1983)
Prof JR Grindley (Dec 1979)
Dr GAW Fromme (May 1983)
Mr S Quirke (Dec 1979)

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PREFACE

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

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

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

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

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

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

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

FP Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

[+]CSIR Research Report 380

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ONRUS

1. HISTORICAL BACKGROUND

The lower reach of the Onrus River or Onrust River as it is also known, has a small fresh water lagoon at its mouth. The area was originally part of a farm owned by a certain Mr Geldenhuys (Mr J Franken, Town Clerk Onrus Municipality, pers. comm.). According to Bulpin (1980) the first Europeans to visit the area called it "Onrus (restless) because of the everlasting droning of the sea".

During the early 1920s the land on the Western banks of the lagoon was acquired by the "Onrus River Syndicate" who then proceded with the development of a seaside holiday resort.

The Company published a small booklet describing the area with its various attributes in "glowing" terms. The description of the lagoon was as follows "The Fresh Water Lagoon, fed by the Onrust River and overflowing into the Sea, is a beautiful asset to the Town, and the only one of its kind on the whole Coast. The water is so fresh and clear that the bed can be continually seen from the surface, and is nowhere more than about 5 feet deep, affording Boating and Bathing extraordinary", (see Figure 1).

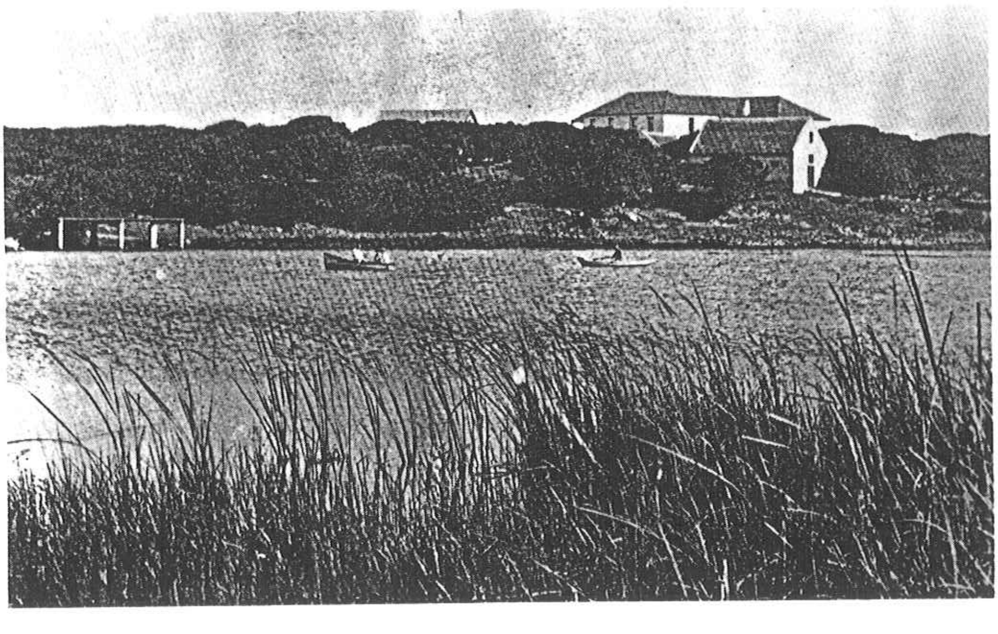


FIG. 1: The Onrus Lagoon in the early 1900s with the hotel on the Western banks (by courtesy of the Onrus Municipality).

Even before the advent of European colonists the estuary was used by the indigenous hunter-gatherers of the Cape. Evidence of this is the presence of three middens containing Cape coastal pottery in the immediate vicinity of the river mouth. Unfortunately a number of other sites have been destroyed by development (Mr WJ van Ryssen, S.A. Museum, *in litt.*).

An elderly resident of Onrus, Mr W Newmark, who has lived in the village since 1916, recollects how the township developed, at first slowly from a small seaside village to the popular resort it is today. Improved roads and communications speeded up the development. According to Mr Newmark the lagoon was always one of the main attractions of the resort but after abnormally heavy rains in May 1948, when the river came down in flood bringing a large amount of silt with it, encroachment by reeds and shallowing of the lagoon became serious problems (Mr W Newmark, *in litt.*).

A map drawn by Mr GF van Wyk on 10 February 1958 describes the lagoon as being "deep" and approximately "100 yards" wide opposite the "Peninsula" area (see Figure 2). His diagram also shows a relatively narrow strip of "Fluitjiesriet" *(Phragmites* sp.) along the upper north-western banks of the main body of the lagoon and a dense patch on the northern banks east of where the Onrus River flows into the lagoon.

In August 1972 discussions were held at Onrus by representatives of the Hermanus Town Council, the Onrus Village Management Board, the Caledon Divisional Council and riparian owners on the effects a dam would have on the Onrus Estuary. It was accepted that the physical appearance and recreational value of the Onrus Lagoon had already changed and deteriorated drastically within the past decade due to siltation and rapid reed growth. It was recommended (a) that a comprehensive hydro-biological survey be undertaken; (b) that engineers provide flow figures in order to calculate the amount of compensation water required from the proposed dam to maintain or preferably improve the system; and (c) that soundly planned measures be taken to halt the deterioration already taking place i.e. siltation, encroachment by reeds and possible nutrient enrichment (Mr WO Morsbach, *in litt.*, NO/2/21 dated 3rd August 1972). A further meeting was held on 11 September 1979 by officials of the Onrus Municipality, local residents and an *ad hoc* committee of the Prime Minister's Advisory Committee for the Coastal Zone. This meeting was held to discuss the problems at the Onrus Estuary and suggest possible steps to be taken to solve these.

As a result of this meeting it was agreed that:

(1) The local authority would compile a dossier containing information on dates that the mouth of the lagoon was open, heights reached by the water, rainfall figures, incidence of floods, etc.

(2) The Estuarine and Coastal Research Unit (ECRU) of NRIO would carry out a survey of the system.

(3) The Steering Committee on Estuaries would decide at its meeting on 7 November 1979 what type of investigation should be carried out and when this would be done.

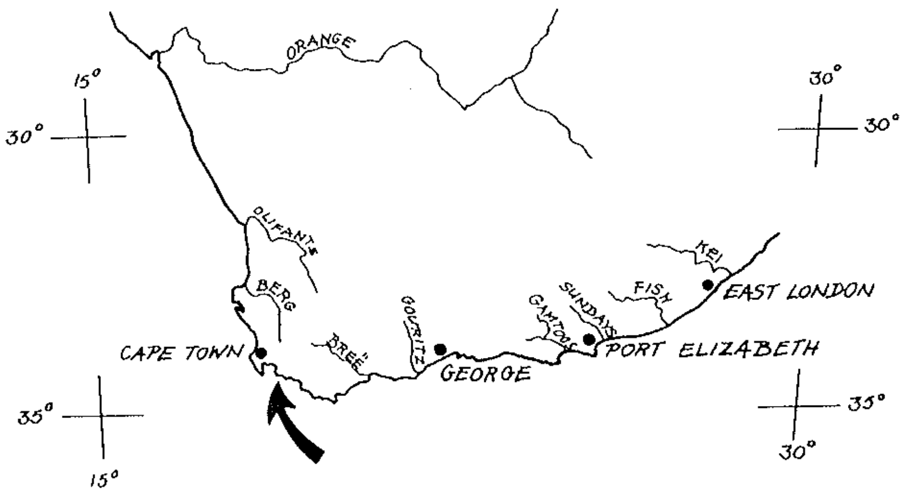
(4) The investigation would be carried out and reported upon within one year after which the Steering Committee and the local authorities would decide upon remedial measures and their financial implications.

Subsequent to this meeting the Habitat Working Group of the Zoology Department of the University of Cape Town was asked to do an ecological survey of the Onrus Lagoon. This was done under the leadership of Mr K St J Damstra and the supervision of Prof GM Branch of the Zoology Dept of the University of Cape Town.

The present ECRU Part 2 report is based largely upon the Habitat Working Group's report together with information which has subsequently become available.

2. LOCATION

The Onrus Lagoon is located at 34°25'S, 19°11'E.



2.1 Accessibility

The lagoon is situated between Hawston and Hermanus, just south of the coastal road about 87 km south-east of Cape Town.

2.2 Local Authorities

From a township plan compiled in November 1977 by Mr FJ Pope, a land surveyor of Hermanus, it appears that the entire Onrus Lagoon falls within the boundaries of the Onrus Municipality. The land to the north and east of the municipal boundary is privately owned, but falls within the jurisdiction of the Caledon Divisional Council (see Figure 3).

FIG. 2: Morphometry and vegetation of the Onrus Lagoon in 1979.
(Drawn from aerial photograph 337/3 of Job 326 (1979)).

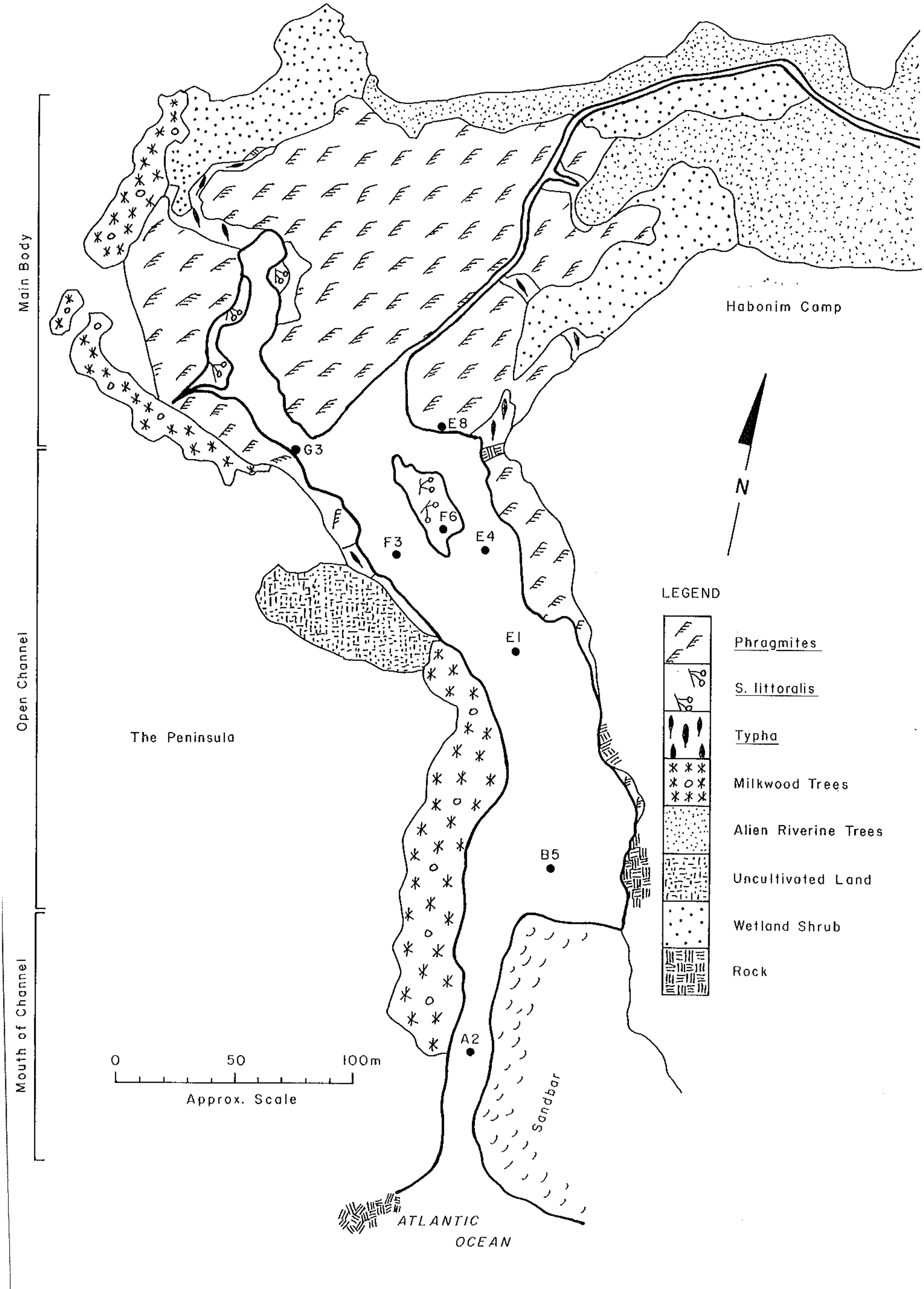
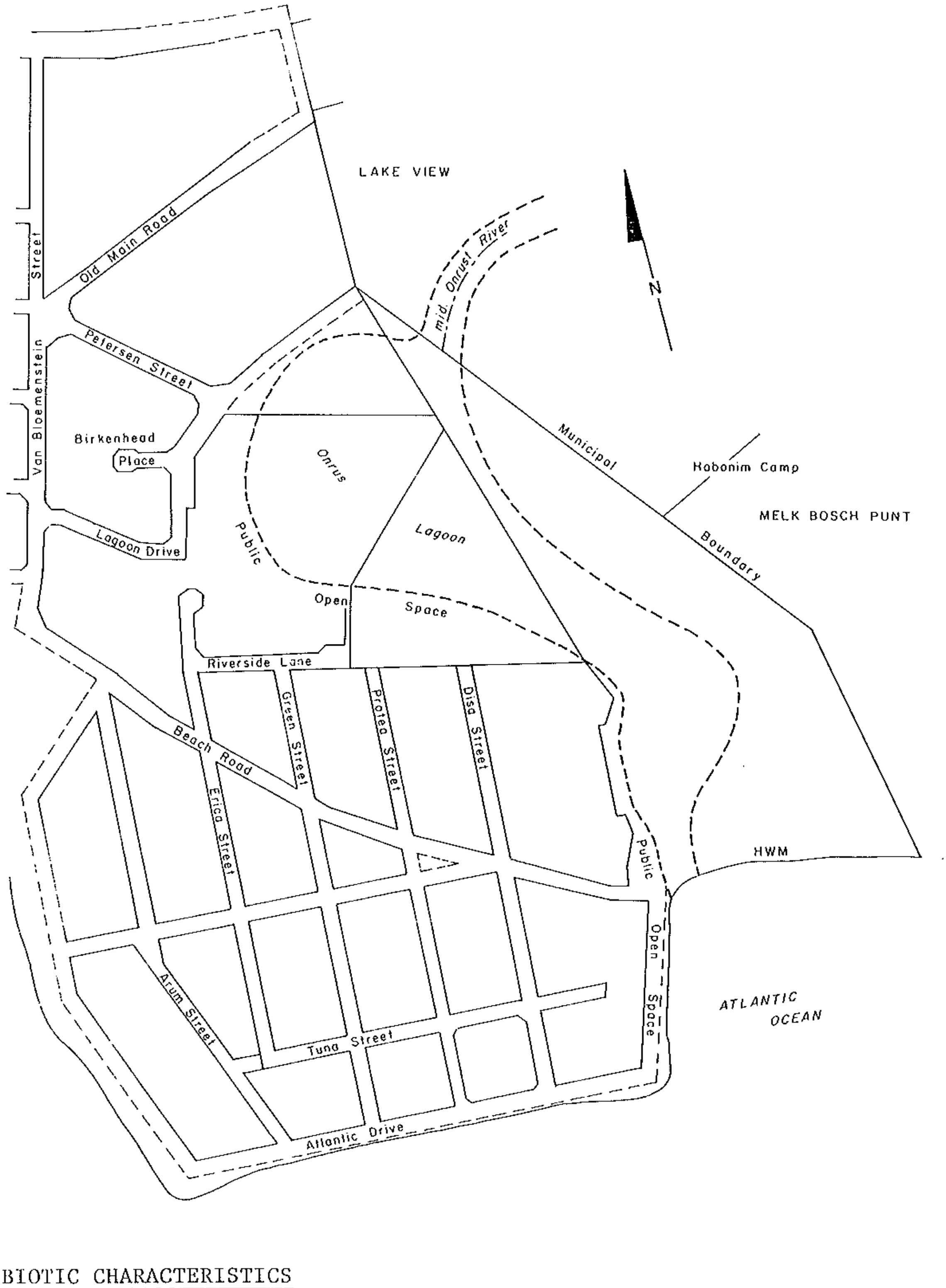


FIG. 3: Township plan of Onrus Village adjacent to the Lagoon.
(F.J. Pope, Land Surveyor, Hermanus Nov 1977).



3. ABIOTIC CHARACTERISTICS

3.1 River Catchment (see Figure 4)

3.1.1 Catchment Characteristics

The steep southern slopes of the Babilonstoringberge as well as the northern slopes of the Kleinrivierberge north of Hermanus, form the main part of the upper catchment area of the Onrus River, which covers a total area of approximately 55 km^2 (1:50 000 Sheets 3419 AC and 3419 AD). The mountains are composed of quartzitic Table Mountain Sandstone and bands of hard Bokkeveld shales, both belonging to the Cape System (Super Group) of palaeozoic age. These hard rocks erode slowly resulting in a relatively low rate of sediment production.

The river, which is 16,5 km long from its source to its mouth, flows through two valleys, the upper Attacquas valley (alt. 600-1000m) being separated from the lower, Hemel en Aarde valley (alt. 200-400m) by the narrow Attacquas Kloof (see Figure 4). The Attacquas valley consists of a local intrusion of Cape Granite (Lambrechts, 1979). The only tributary of the Onrus River, the Antjiesrivier, rises at the upper end of the Hemel en Aarde valley (1:50 000 Sheets 3419 AC and 3419 AD), (see Plate I).

The gentle gradient in each valley results in the braiding of the river, forming large vlei areas. The De Bos Dam which was constructed in 1976, is situated in the narrow Attacquas Kloof. The river flows out of the Hemel en Aarde valley between the Onrusberge and the Olifantsberg and enters the narrow coastal plain (1 000 - 2 000 m wide) where it is crossed by the coastal road between Onrus and Hermanus (see Frontispiece). Although much of the surrounding coastal plain consists of Tertiary to Recent sediment, the bed of the Onrus consists of Table Mountain Sandstone; this also forms the backbone of a dune ridge running parallel to the coast. The river flows into the Onrus Lagoon which opens into the Atlantic Ocean to the east of Onrus village.

Rainfall is brought by cyclonic low-pressure cells moving in an easterly direction south of the continent in winter. During summer, south-easterly winds prevail, often resulting in seasonal drought conditions. The river flow is thus decidedly seasonal; occasionally there is no flow at all during summer. Orographic rain caused by the mountain ranges close to the coast would also tend to cause local concentrations of rainfall. The mean annual rainfall at Hermanus is 662 mm and varies from 447 mm (1969) to 1 038 mm (1941) (Damstra, 1980).

3.1.2 Landownership/Uses

The catchment area consists mostly of privately owned farms, with much of the higher lying mountain slopes being covered with low mountain "fynbos" (Macchia, Veld type 69 in Acocks, 1975). The flatter land in the valleys and some of the slopes have been cleared for cultivation of grain crops, pastures and a few small vineyards (ECRU Survey 19 May 1983) (See Plate I). The river course is heavily overgrown with exotic vegetation such as pines, gums and acacias.

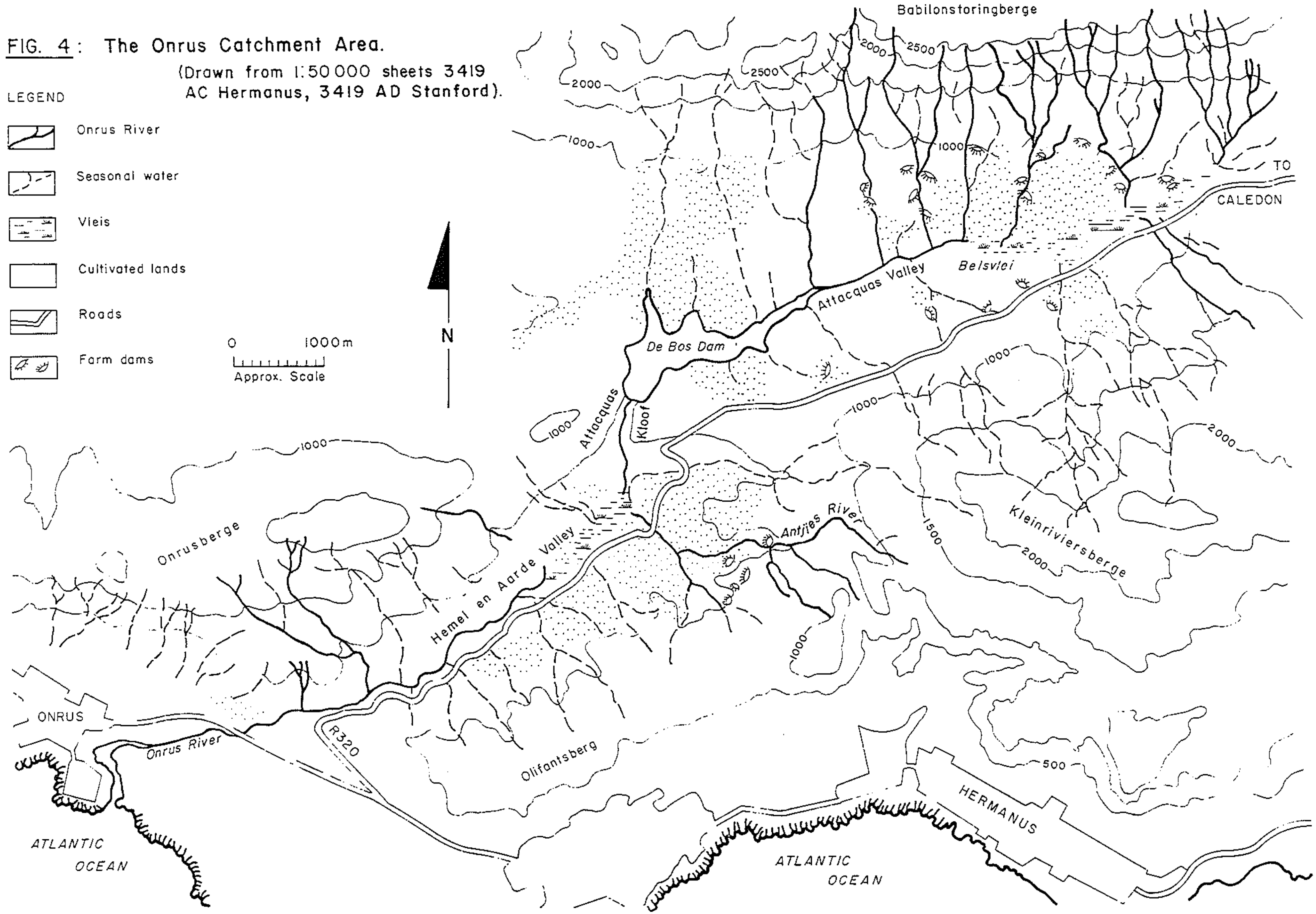


FIG. 4: The Onrus Catchment Area.
(Drawn from 1:50 000 sheets 3419 AC Hermanus, 3419 AD Stanford).

Where the river forms vleis in the valleys, extensive marshlands occur and these vleis form excellent sediment traps in the upper catchment. A more detailed description of the plant communities of this area has been given by Damstra (1980).

3.1.3 Obstructions (dams, bridges, weirs, etc.)

Numerous small farm dams have been constructed on the smaller tributaries in the catchment area. The De Bos Dam with a capacity of 6,303 x 10^6 m^3 is the only large dam on the Onrus River. The dam releases water during the dry summer months, as compensation water for landowners along the river (Mr van Rooyen, Town Engineer, Hermanus Municipality, pers. comm.). The De Bos Dam was built to supply domestic water to the towns of Hermanus, Vermont, Onrus, Hawston, Sonesta and Sandbaai as well as to other private residences and undertakings situated within the local area. The water is filtered and purified at a treatment plant managed by the Hermanus Municipality.

A few low bridges connect farms on the western river bank with the Onrus/Caledon road (R320). The main Onrus/Hermanus road crosses the river on the coastal plain. Three bridges have been constructed at this point. The original bridge was washed away by floodwaters in the late 1940s, a second bridge was then constructed just north of the old main road and subsequently the new Onrus/Hermanus highway bridge was built north of the previous main road. During construction of this bridge, three pipes were placed in the riverbed and covered with gravel (see Figure 5). The construction of bridges by this method can have serious ecological consequences unless clearing-up operations are

FIG. 5: The new Onrus/Hermanus highway bridge under construction. Temporary gravel fill threatens to add further sediment to the Onrus Lagoon unless there is thorough rehabilitation after completion of the bridge (ECRU 79-12-06).

conducted before heavy rains wash the temporary fill sediment downstream, further aggravating the problem of siltation in the estuary. As can be seen from the following figures the new bridge offers far less obstruction to flow than the previous bridge did, and clearing-up operations after construction have been more than adequately carried out.

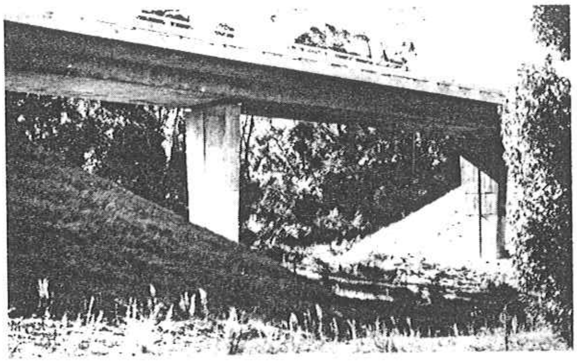


FIG. 6: The new Onrus/Hermanus highway bridge after construction and rehabilitation (ECRU, 83-05-19).

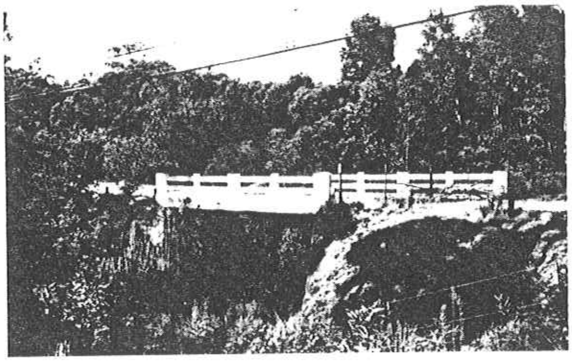


FIG. 7: The old Onrus/Hermanus main road bridge which may cause more obstruction to the flood flow of the river than the new bridge (ECRU, 83-05-19).

3.1.4 Siltation

The nature of the soils and topography in the Onrus catchment result in a river which has high erosive properties and a relatively low silt load. The braided configuration of the river and the densely vegetated vlei areas in the Attacquaskloof and Hemel en Aarde valleys tend to trap any sediment carried by the river. The De Bos Dam also acts as a sediment trap at times of high river flow. The water in the Onrus River and the De Bos Dam was clear and typically peat-stained at the time of the ECRU Survey on 19 May 1983 which indicates that in normal circumstances the river carries a small load of suspended sediment.

Before the building of the De Bos Dam and at times when the mountain slopes are cleared for agriculture, and lie fallow or are ploughed and prepared for planting, the winter rains could cause erosion which would carry sediment downstream.

Another important source of sediment is the run-off from the gravelled Onrus/Caledon road. At the time of the ECRU Survey this road was being widened and the road embankment had encroached onto the streambed in places (see Figure 8). The erosion of this embankment will also result in sediment being carried downstream.

FIG. 8: Encroachment of the embankment of the Onrus to Caledon gravel road onto the Onrus riverbed. Run-off from this road could be a source of sediment to the lagoon during storm conditions. (ECRU, 83-05-19).

3.1.5 Abnormal Flow Patterns

Little information is available on the flow patterns of the river. The Hermanus Municipality, however, has records of the flow into the De Bos Dam. According to Mr W Newmark *(in litt.)*, abnormally heavy rains in May 1948 brought down a large amount of silt which was deposited in the Onrus Lagoon. This is not reflected in the rainfall figures collected at the Hermanus Weather Station, which show that the total rainfall at Hermanus for May 1948 was only 42,9 mm. The highest rainfall recorded by this Weather Station for the period July 1935 to December 1975 was 260,0 mm in September 1951 (Damstra, 1980).

3.2 Estuary

Data for Sections 3.2.1 and 3.2.2 was extracted from a contribution made by Dr GAW Fromme of the Sediment Dynamics Division of NRIO.

3.2.1 Estuary Characteristics

Geomorphology

Geomorphologically, the Onrus Lagoon consists of three sections (see Figure 2):

(a) The Main Body
This part of the original lagoon lies landwards of a coastal ridge. It is approximately 300 m long and 150 m wide, but encroachment by reeds and trees has reduced the area of this part considerably so that only about 30 percent of the open water remains (Damstra, 1980).

(b) The Open Channel (see Figure 2)
This channel connects the main body of the lagoon with the mouth of the lagoon. It is approximately 200 m long and 50 to 80 m wide and is situated between fairly steep banks with the Habonim Camp on the east side and the Onrus township on the west side.

(c) Mouth of the Channel (see Figure 2)
This joins the channel to the sea. The mouth is closed by a massive sandbar, but during the winter season, after heavy rains, a narrow channel is formed in the western edge of the sandbar. At the time of the ECRU survey on 27 May 1983 this channel was about 5 to 10 m wide and about 0,5 m deep. The channel serves only as an overflow from the lagoon to the sea and is not a tidal inlet (see Plate III).

According to Mr Franken, Town Clerk of Onrus, the lagoon usually breaks open for short periods after heavy rain. This can happen several times during the year. At such times sea water penetrates into the lagoon during spring tides and is flushed out again by the river flow. Although wave penetration can be seen, it is unlikely that much seawater enters the lagoon in this way against the outflow of the river water. Local residents also report that during storm conditions waves have on some occasions washed over the sandbar to about halfway up the Open Channel. On 27 May 1983 during HWOST it was observed that the waves only reached halfway up the outlet channel and no waves washed over the sandbar. It can therefore be assumed that a major influx of sea water occurs only during very high storm spring tides and that the lagoon can be regarded as being mainly *supratidal* (the sandbar is higher than the tidal reach). During extreme storm events there would however, be an influx of marine sediments into the lower part of the lagoon.

Siltation

Sediment is transported in the rivers during heavy rains from the catchment area and deposited in the slower-flowing lagoon area. According to information provided by local residents the silting-up of the lagoon resulted from the erosion which took place after a mountain fire which was followed by torrential rains in the period from the late 1940s to the early 1950s. Greater farming activity since 1948 could also have led to a greater sediment load in the river after heavy rains. According to calculations by Rooseboom (1980) about 3 500 m^3 of sediment could be expected to enter the lagoon annually. This would represent an average rise in bottom level of about 5 cm/year over the whole lagoon area. These figures need to be substantiated with actual measurements.

The shape of the lagoon and the relatively small inflow of river water result in very little scouring of the high sandbar at the mouth. This tends to cause retention of sediment in the lagoon. It is improbable therefore that the lagoon will be flushed of its sediment load by natural means.

Bottom Material
Soil profiles by Damstra (1980) indicate that the influx of marine sediment (coarse sand) extends to only about 100 m upstream of the mouth, where the coarse sand wedges out at the bottom of the profile and is overlain discordantly by medium to fine terrestrial-lagoonal sand (Stn B5, see Figure 1). As distances from the mouth increase this sediment becomes finer and contains higher percentages of organic mud.

In the main section of the lagoon these sediments are unconformably intercalated by medium to coarse sand which indicates various past flood depositions. It is, however, significant that the layer of fine, chiefly organic sediment in the main lagoon which is associated with the reed beds is not much thicker than 0,3 m, with fine to medium sand below.

3.2.2 Mouth Dynamics

As already described, the sandbar is breached only partially during floods by the formation of an overflow channel. Quick closing of this channel after a flood is due to the natural rebuilding process by which waves deposit sand on the shore during calm periods. Since Onrus is situated in a small cove on a rocky coastline, there is no large-scale longshore movement of sediment. Any sand removed from the mouth during erosional conditions is usually deposited in an off-shore bar from where it is moved back to the beach during conditions favouring accretion. Data from Voluntary Observing Ships, (VOS), (Swart and Serdyn, 1982) and data from the Slangkop Waverider (Rossouw and Coetzee, 1982) for the area of the south-western Cape Coast were used to determine the factors which affect this coastline. The predominant wave direction is from the south-westerly sector (SSW, SW and WSW): 43 percent. The average significant wave height is 2,2 m and the extreme significant wave height 7 m. The Slangkop Waverider data show an average significant wave height of 2,4 m and a maximum significant wave height of 9 m which agrees with the VOS data.

The average energy wave height along this coast was calculated as 2,0 m, which classifies it as a high energy coastline. Comparison with the False Bay coastline shows that the coast between Kleinmond and Hermanus receives twice as much wave energy.

3.2.3 Landownership/Uses

According to the township plan for Onrus, a strip of land around the Onrus Lagoon is owned by the Onrus Municipality and is designated as a public place. At the upper end of the lagoon two privately owned portions of land (Ptn. 581/341 Lake View and Ptn. 581/360) have the middle of the "Onrust River" as their common boundary. (Township Plan Compiled by FP Pope, Land Surveyor, Hermanus, November 1977.) The township of Onrus is situated to the west of the lagoon and the Habonim holiday camp to the east.

3.2.4 Obstructions

There are no man-made obstructions within the lagoon or at its mouth. The natural obstructions in the lagoon are the extensive reed beds which have developed since approximately 1938 and the progressively increasing shallowness of the lagoon (see Plate II). These factors have seriously affected the recreational potential of the system and represent the major management problems facing the authorities controlling the lagoon. According to Damstra (1980), the reed beds covered an area of 15 400 m^2 in 1938 and the lagoon had a total water area of 84 400 m^2, whereas by 1979 the reed beds covered an area of 51 500 m^2 with only 25 900 m^2 of open water. The progressive growth of these reed beds is illustrated in Figures 9 to 12. A fuller description of the reed encroachment, the bathymetry and the bottom sediments of the lagoon is given by Damstra (1980).

3.2.5 Physico-chemical Characteristics

At times such as during the UCT Survey in November 1979, the entire lagoon contained fresh water. This situation changes when waves break over the sand-bar and sea water enters the lagoon. The brown colour and low pH (Appendix I) are characteristic of most short rivers of the south-western Cape fed by mountain run-off. The colour is assumed to be caused by "humic acids" (secondary plant compounds) in the water (King *et al.*, 1979).

As the surface water of the lagoon is warmed by the sun a noticeable thermocline developes and the surface water was recorded to be 5,5 $^{\circ}$C warmer than that on the bottom. Colder river water seeps through the *Phragmites* beds and flows along the bottom of the lagoon.

Dissolved oxygen concentrations ranged from 5,8 to 13,4 parts per million. In unvegetated areas, the oxygen content decreases with increasing depth. It was found that the aquatic plants *Chara* and *Potomogeton* increased the content of dissolved oxygen in local areas by 25 percent by photosynthesis.

Nutrient values are summarized in Appendix II. Nitrate values ranged from 0,59 to 5,7 μg ats N/ℓ, ammonia from 0,77 to 2,63 μg ats N/ℓ, silicates from 1,39 to 36,3 μg ats Si/ℓ and reactive phosphate from 0,21 to 3,3 μg ats P/ℓ. Reactive phosphate and nitrate values were highest and silicate values lowest in the blind channel (Stn G3, see Figure 2). This apparently reflects a local release of nutrients as well as a lack of mixing. The effectiveness of reed-beds in the uptake of nutrients has led to the use of these beds in the tertiary treatment of domestic sewage (De La Cruz, 1978). The overall nutrient status of the lagoon is low, but comparable with that of other water bodies fed by run-off from the nutrient-poor soils of the south-western Cape (Harrison, 1962; Gardiner, 1980). Nitrate levels are orders of magnitude lower than, and phosphate levels half, of those found in the Natal estuaries (Begg, 1978).

3.2.6 Pollution and Public Health Aspects

During the UCT survey of the lagoon in November 1979, no evidence was found of eutrophication, of nutrient input from local sewage or of excessive fertilization. This situation should be monitored regularly as development increases, particularly because the entire sewerage system for Onrus township consists of septic tanks with soakaways.

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton/Diatoms

No data could be traced.

4.1.2 Algae, Aquatic and Semi-aquatic Vegetation

The two dominant submerged aquatic plants in the lagoon are *Potamogeton pectinatus* and the algae *Chara.* Both grow together in the bottom mud of the shallower water in the upper northern part of the lagoon. These plants cause a local increase in dissolved oxygen and they form valuable sites for the attachment of aquatic fauna.

Neither plant grows among the Fluitjiesriet (*Phragmites* spp.) but both survive in amongst the more open *Scirpus littoralis*. This appears to be the result of greater availability of light and space. In contrast to other areas where *Potamogeton* appears to be decidedly seasonal, with maximum biomass between November and February, in Onrus Lagoon both *Chara* and *Potamogeton* had grown extensively by July 1980, forming a thick web of stems. Numerous red-knobbed coot were seen feeding amongst these plants.

Reeds have overgrown more than half of Onrus Lagoon. Fluitjiesriet or *Phragmites australis* is the most abundant reed and forms dense, almost pure, stands (see Figure 13). It grows to a height of 2 to 4m. The stem is hollow but divided into compartments at the nodes from which broad belt-like leaves grow. The stem is unbranched and new growth arises from the rhizomes shallowly buried in the silt. The aerial stems die back in winter and may fall over but often remain upright, supported by the surrounding growth. *Phragmites* flowers from January to March, although dead flower stalks stick out above the reed-bed and can be seen throughout the year. In the past cattle have grazed around the lagoon, feeding partly on young *Phragmites* shoots. It is common practice to burn *Phragmites* reed-beds in order to provide grazing of the young plants.

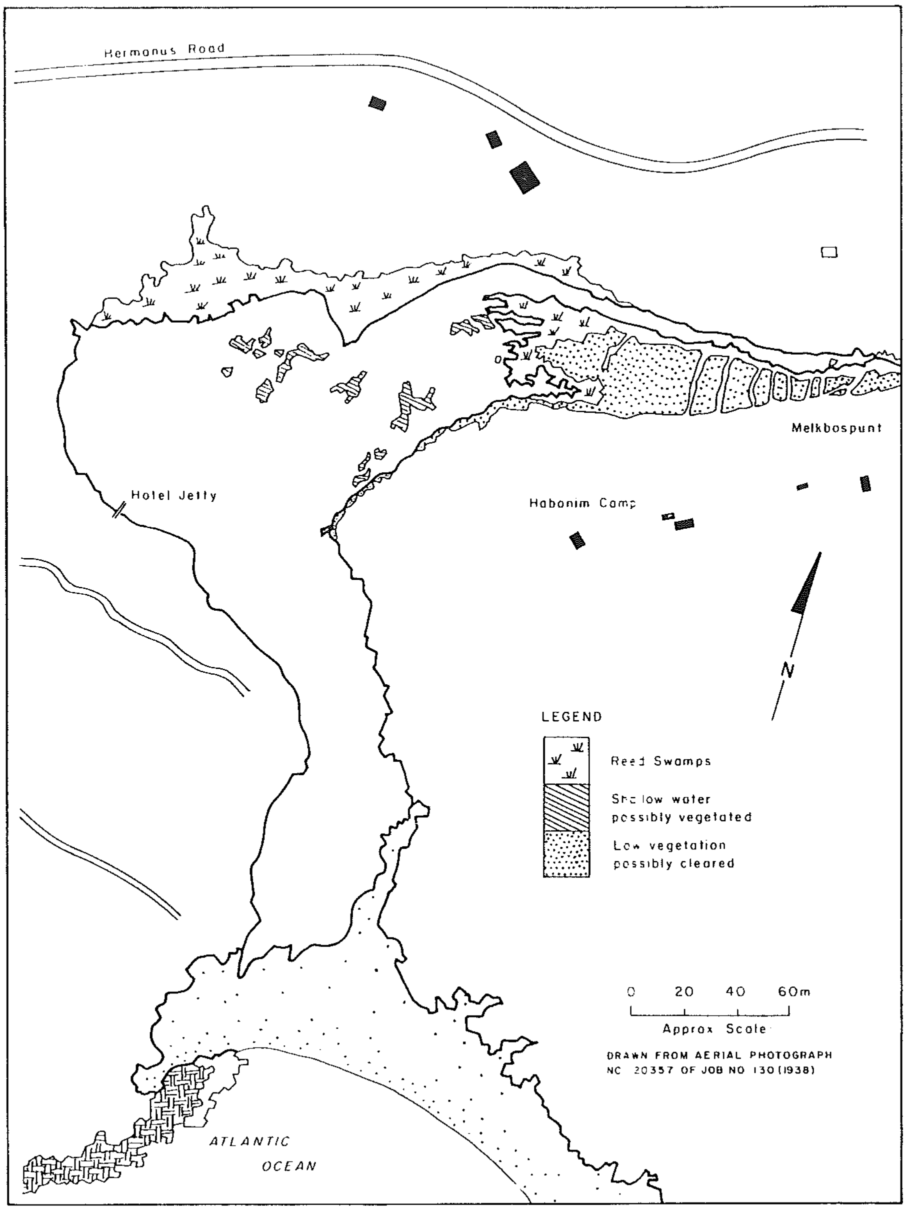


FIG. 9: Onrus Lagoon in 1938.

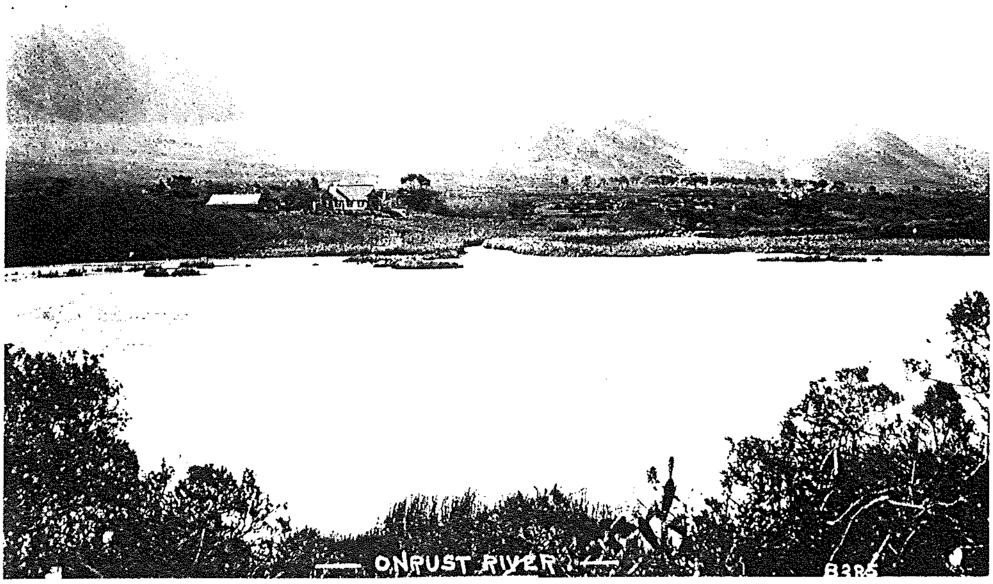


FIG. 10: Onrus Lagoon 1921, photographed from "Sleepy Lagoon", Protea Street. The wide lagoon is fringed with a narrow *Phragmites* bed. Islands in the lagoon are vegetated with a *Scirpus* species. (Photograph by courtesy of Mr Swingler.)

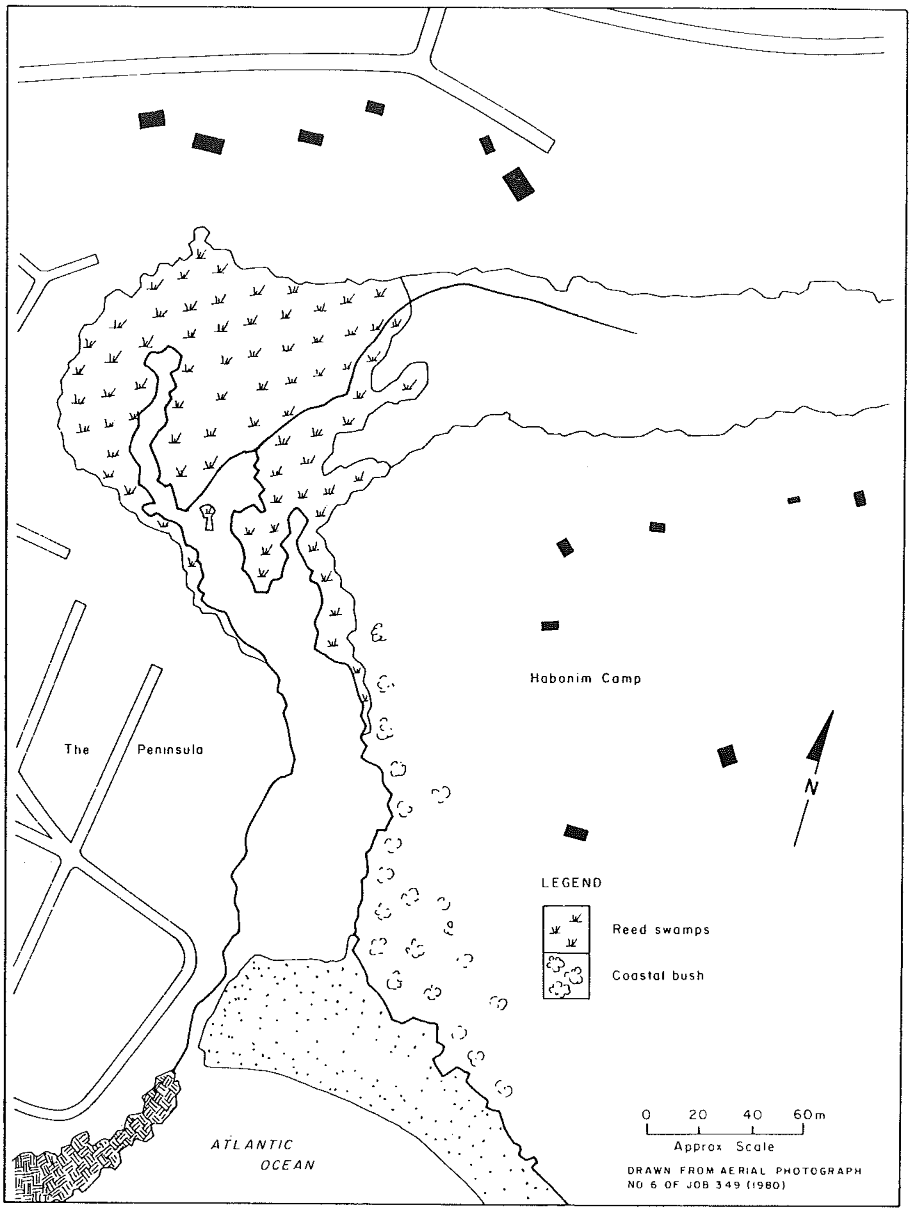


FIG. 11: Onrus Lagoon, 1980

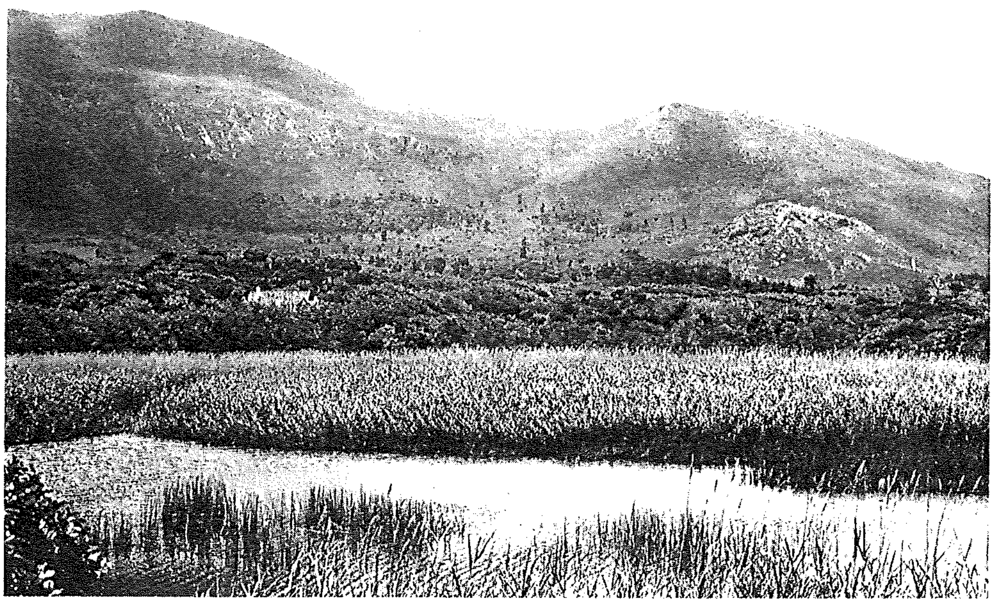


FIG. 12: Photograph illustrating the extensive reed growth that has taken place since 1921 (ECRU, 79-12-06)

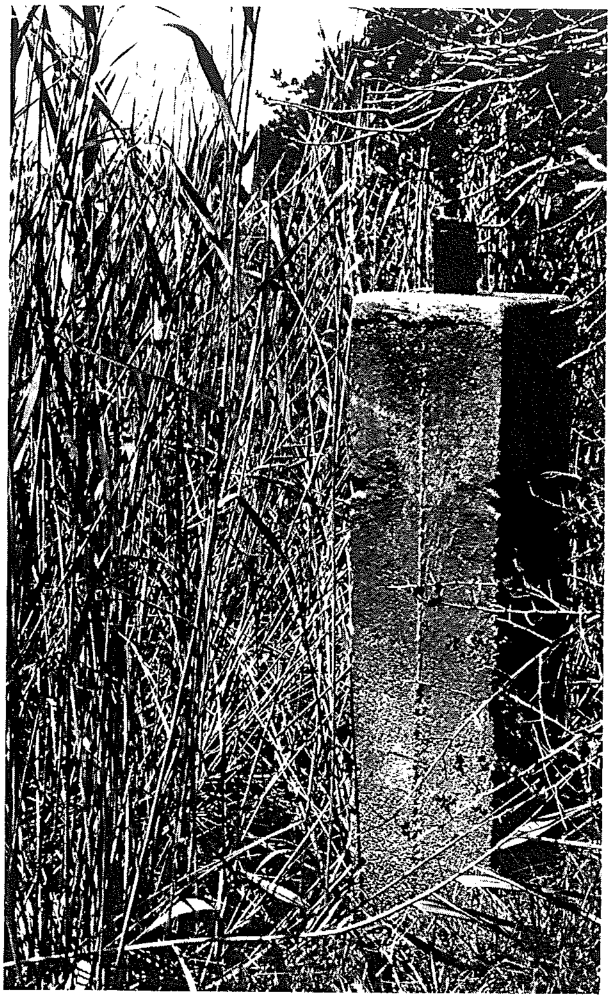


FIG. 13: Fluitjiesriet or *Phragmites australis* at the old hotel jetty. The concrete pillar on this photograph appears as part of the structure shown in Figure 1 (Damstra, November 1979).

An old lagoon margin on the eastern edge of the lagoon is revealed by the sudden decrease in water depth as well as the presence of a senescent population of *Scirpus triqueter*. The old bank shows evidence of having been burned.

On the landward edge the *Phragmites* community is less dense and the plants shorter. Here *Juncus, Stenotaphrum secundatum* and *Scirpus nodosus* grow among the *Phragmites*.

The triangular-stemmed member of the Cyperaceae, *Scirpus triqueter*, seldom forms pure stands, but grows among the *Phragmites*, particularly in shallower water.

The bulrush or papkuil, *Typha capensis*, grows in dense single-species stands in localized areas around the lagoon (see Figure 14). The long strap-like leaves fan out from a central point under water. New leaves are constantly being produced from the centre. The dense cylindrical spikes containing the male and female flowers are produced in December and January.

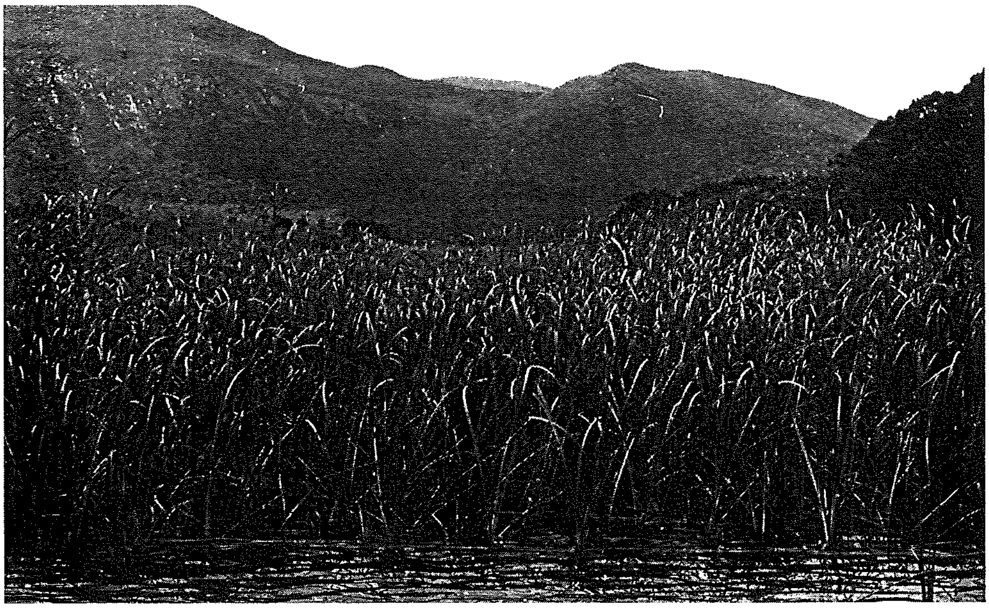


FIG. 14: Papkuil or the bulrush *Typha capensis* growing in an old river channel (Damstra, November 1979).

Typha was found in an old channel in the eastern part of the lagoon as well as in a belt north of the blind channel. A sharp division often occurs between *Phragmites* and *Typha* beds. In contrast to *Phragmites*, *Typha* seldom occurs along with *S. triqueter*.

A later successional stage in the development of the reed-beds involves the colonization by terrestrial plants that grow in wet areas. This shrub community north of the lagoon consists of the exotic plants *Albizzia lophantha*, *Datura stromonium*, the willow *Salix babylonica* and the tomato *Solanum* as well as the indigenous *Pennisetum macrourum*, *Cliffortia strobilifera*, the bulrush *Typha capensis*, the sour fig *Carpobrotus*, *Pelargonium capitatum*, *Conyza pinnatifida*, the arum lily *Zantedeschia aethiopica*, *Rhus glauca*, *Psoralea pinnata*, *Rhus* spp., *Passerina vulgaris*, *Helichrysum orbiculare*, buffalo grass *Stenotaphrum secundatum* and *Tetragonia fruticosa*. North of Habonim camp a similar community is dominated by *Cliffortia strobilifera* and the restio *Chondropetalum*.

The recently-developed island in the centre of the lagoon is colonized by *Scirpus littoralis* (see Figure 15). This is an erect reed with narrow cylindrical stems which grow from underground rhizomes. The growth of this island has been remarkably rapid. By July 1980 rhizomes of *Scirpus littoralis* had extended northwards, completely closing the eastern channel.

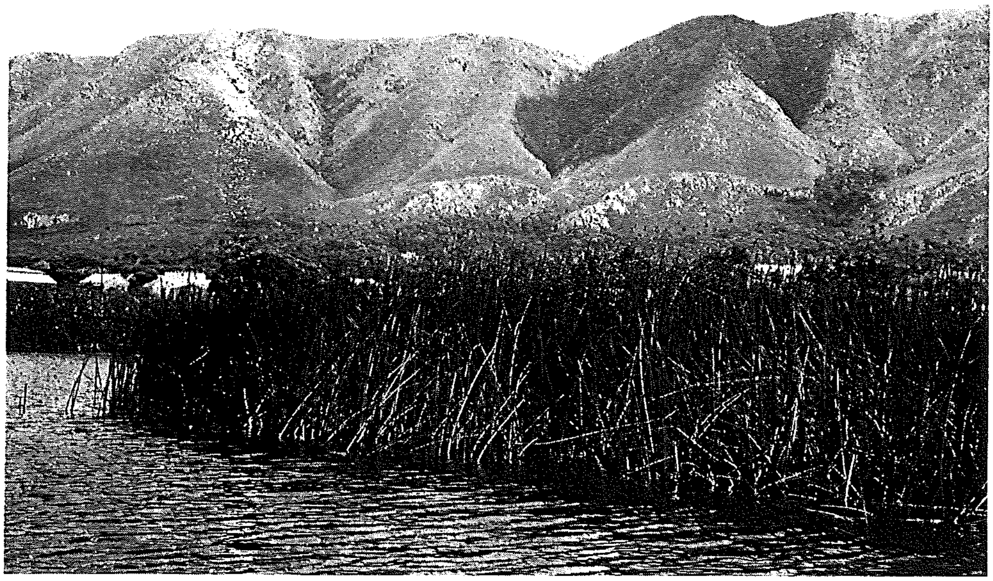


FIG. 15: The recently developed *Scirpus littoralis* island in the centre of the lagoon. (Photograph by courtesy of Mike Cherry, November 1979).

4.1.3 Terrestrial Vegetation

The narrow south-eastern bank of the lagoon is colonized by *Chrysanthemoides monilifera, Plantago carnosa,* the reed *Juncus, Sporobolus virginicus,* buffalo grass *Stenotaphrum secundatum, Centella* sp., the arum lily *Zantedeschia aethiopica, Albuca* sp., *Orphium frutescens, Helichrysum orbiculare, Samolus porosus, Cotula coronopifolia, Falkia repens, Carex clavata* and *Cyperus difformis*.

Beyond this, the Habonim camp is thickly vegetated with bushes and trees, chiefly *Acacia cyclops, Sideroxylon inerme, Euclea racemosa, Cussonia thyrsiflora, Asparagus* sp, *Pterocelastrus tricuspidatus, Mystroxylon maritimum* and *Rhus lucida*.

The western bank rises steeply to a height of 15 m. This hill forms part of Onrus residential area and is called the Peninsula (see Figure 1). White milkwoods *(Sideroxylon inerme)* line the estuary. A patch of low natural vegetation exists on the north-facing slopes of the Peninsula and contains *Sideroxylon inerme, Podalyria* sp., *Metalasia muricata, Rhus glauca, Olea africana, Cotyledon orbiculare, Diosma hirsita, Asparagus* sp., *Tetragonia fruticosa, Carpobrotus* sp., *Pelargonium capitatum, Chrysanthemoides monilifera, Olea capensis, Cyanella capensis, Nylandia spinosa* and *Polygala* sp. and the alien *Acacia cyclops*.

To the north and north-west the land rises gently to the foot of the Onrusberge and the natural vegetation has made way for residential plots, with exotics being planted along the boundaries of the properties.

The sea Pumpkin, *(Arctotheca populifolia)*, Klappiesbrak *(Tetragonia decumbens)* and Sea wheat *(Agropyron distichum)* grow along the edge of the beach and the sand-bar.

4.2 Fauna

4.2.1 Zooplankton

No data could be traced.

4.2.2 Aquatic Invertebrates, Insects and Other Invertebrates

The seaward end of the lagoon has an estuarine fauna. Holes of the sandprawn *Callianassa kraussi* are scattered in the sandy floor of the shallower water and the crab *Hymenosoma orbiculare* was caught in the seine net (Appendix III). Maximal numbers of the estuarine amphipod *Corophium triaenonyx* were found in this area. The estuarine polychaete *Ceratonereis keiskamma*, the tanaid *Tanais philetaerus* and various species of chironomid larvae were also present.

The muddy substrate in the upper part of the lagoon is inhabited by *Ceratonereis keiskamma*, *Corophium trianonyx* and chironomid larvae. The low numbers reflect an unsuitable substrate as the few rocks and waterlogged branches that are found on the bottom of the lagoon, are densely populated. Numerous mussels, *Musculus virgiliae*, are attached to these substrates by their byssus threads. *Corophium triaenonyx* and *Tanais philetaerus* are more abundant than in the surrounding muds and *Ceratonereis keiskamma*, *Melita zeylanica*, *Pseudosphaeroma barnardi*, *Cirolana africana*, corixids and chironomid larvae were also found. Most of the kelp deposited onto the beach is collected before it is washed into the lagoon, but that which reaches the lagoon has few animals attached to it.

The underwater plants provide an attachment area for small invertebrates. Seven species were found living on *Chara* and four on *Potamogeton*. Two ephemeropteran nymphs as well as 67 individuals of *Tanais philetaerus* were collected from 100 g of *Chara*.

The anoxic mud of the blind channel is inhabited by chironomid larvae as well as a few individuals of *Ceratonereis* and *Corophium*.

The reed-beds support fewer estuarine fauna than does the rest of the lagoon. Numerous chironomid larvae, *Corophium*, the detritus eating *Melita zeylanica* and *Pseudosphaeroma barnardi* inhabit the rich detritus in the *Phragmites* and *Scirpus* beds. Aquatic insects, especially the whirligigs (Gyrinidae) were living among the submerged, decaying leaves and spiders were found amongst the stalks.

4.2.3 Fish and Amphibians

Two species of frog, *Rana fasciqulata* and *Bufo pardalis*, were collected in the seine net along with six species of small fish (Appendix IV). The estuarine fish caught were the southern mullet *Liza richardsoni*, the sand goby *Psammogobius knysnaensis*, the Cape stumpnose *Rhabdosargus tricuspidens* and the estuarine round-herring *Gilchristella aestuaria*. Two fresh water species, the Cape galaxias *Galaxias zebratus* and the Cape kurper *Sandelia capensis* were also present. When the Onrus Lagoon was very much deeper with a more defined channel seasonally open to the sea, it would probably have formed a more suitable area for juvenile estuarine fish.

A total of seven species of amphibians are recorded from the area covered by the 1:50 000 Sheet 3419 AC within which the Onrus Lagoon is situated and a further 11 species are likely to occur within the area. These are listed in Appendix V (A de Villiers, Cape Dept. of Nat. and Envir. Conservation, *in litt.*).

The Cape platanna *(Xenopus gilli)* and the Micro frog *(Microbatrachella capensis)* are listed by McLachlan (1978) in the S.A. Red Data Book for Reptiles and Amphibians.

4.2.4 Reptiles

A list of reptiles occurring in the area covered by the 1:50 000 Sheet 3419 AC is given in Appendix V (A de Villiers, *in litt.*).

4.2.5 Birds

Twenty-eight species of birds were seen at the lagoon in November 1979; these are listed in Appendix VI together with the counts carried out by Underhill and Cooper in 1983. The reed-beds are used for breeding with numerous nests amongst the stalks. Coot were very common, especially feeding on the *Potamogeton* and *Chara* beds.

Hockey and Underhill (1983, unpublished) list a total of 198 species occurring in the area covered by the 1:50 000 Sheet 3419 AC. Of these the following are marine-or estuarine-associated species which could, at times, possibly occur at the Onrus Lagoon and which are listed in the S.A. Red Data Book-Aves (Siegfried *et al.*, 1976).

Roberts Number	Common name	Roberts Number	Common name
3	Jackass Penguin	96	Greater Flamingo
49	White Pelican	97	Lesser Flamingo
57	Bank Cormorant	148	African Fish eagle
59	Crowned Cormorant	322	Caspian Tern

4.2.6 Mammals

Stuart *et al.* (unpublished) and Stuart (1981) record the following mammals from the area covered by the 1:50 000 Sheet 3419 AC.

Chacma baboon	-	*Papio ursinus*
Caracal (lynx)	-	*Felis caracal*
Small-spotted genet	-	*Genetta genetta*
Egyptian mongoose	-	*Herpestes ichneumon*
Southern elephant	-	*Mirounga leonina*

5. SYNTHESIS

All rivers erode material from their catchment and carry it downstream where it is deposited as sediment when the flow rate decreases. Human activity in the catchment has unfortunately resulted in a rapid increase in deposition in the Onrus Lagoon, which has changed from a seasonally-closed estuary with a relatively large open water lagoon to a shallow reed-choked lagoon. Seasonal ploughing of farmland and clearing of indigenous vegetation, subsequent afforestation with trees which discourage the growth of stabilizing ground cover, and the building of bridges, dams and roads, have all increased the quantity of sediment borne by the river. In addition, the effectiveness of the river in washing this increased silt-load out to sea was reduced by construction of a dam which buffers the winter spates which would normally have scoured out the river bed. Because the water-flow is reduced, trees and vegetation encroach beyond the river bank causing silt-laden flood-waters to deposit sediment before they reach the sea. Once the sand in the estuary is stabilized by reed-beds it is unlikely to be flushed out either by tidal action or by river flow. The build up of sediment in the lagoon has also reduced the twice-daily inflow of sea water which because of the salinity curbs the growth of reeds.

The nett effect on sediment export by tidal exchange between an estuary and the sea is complex, and depends on the speed as well as the duration of the incoming and outgoing tides (Branch and Day, 1980). The sediment in an estuary is usually finer than marine sand. Tidal flow assisted by river outflow can export sediment but it often brings in more sand than it removes. However, the sediment cores taken during the UCT survey show that more of Onrus Lagoon has been filled in with alluvial deposits of riverine origin than with sand originating from the sea or with beach-sand blown into the lagoon.

As mentioned in Section 4.1.2, Onrus Lagoon is dominated by extensive reed-beds. Reed-swamps have been shown to be the most productive plant community in temperate regions (Westlake, 1963), supporting a large number of invertebrates and birds. The bird density at Onrus is high; this can be ascribed in part to the shelter and food provided by the reed-beds. Although the reed-beds are extensive and *Phragmites* produces its standing stock afresh each year, growth is probably limited by the low nutrient content of the river water.

The low nutrient-status is also reflected in the lack of filamentous and free-living green algae which colonise the waters of similar but eutrophic lagoons (Harrison, 1962).

The reed-beds at Onrus overlie thick layers of coarse white alluvial sand brought downstream by erosion. Any increase in the nutrient status of the lagoon caused by excessive application of fertilizers in the catchment area or from sewage, should be avoided as it could further increase the growth of the reeds. These factors do not however, appear to have been responsible for the present situation.

Sedimentation is a natural process which has been accelerated in Onrus Lagoon by human activities causing changed habitats. Previously the lagoon may have provided shelter for juvenile estuarine fish, whereas now the reed-beds which have developed have increased the habitat available to a number of birds. The present motivation for removal of the reeds is to reinstate the recreational potential of the lagoon and a deep lagoon suitable for swimming, boating and diving is therefore required.

In the absence of a good management policy, sedimentation will continue and the reed-beds will extend towards the mouth, halted only by the increase in salinity which results from the breaking of waves over the sandbar. Strong floodwaters may be able to flatten areas of the reeds but there will be rapid regrowth from the rhizomes.

Various proposals have been made with regard to the removal of the reed-beds. Cutting of the stalks will only encourage growth. Burning stimulates shoot-growth from the rhizomes. Morton (1975) has shown that *Typha angustifolia* can be destroyed by regular cutting, is drowned in 1,2 m of water, and increasing salinity discourages growth but vigourous chemical treatments are the principal means of elimination. These methods might work with *T. capensis* but are not recommended for Onrus. Even if the rhizomes were destroyed the water would remain less than a metre deep and knee-deep water has limited recreational value. In any case, the reeds would recolonize the shallow areas and constant removal of the rhizomes would not be a practical solution.

Damming of the lagoon by raising the level of the sandbar or constructing a dyke across the river mouth have also been suggested but dams are effective silt-traps and if this were done, then no silt would be washed out to sea. Present estimates are that the lagoon floor may have risen over 1 m. in 30 years; at this rate a dam created by constructing a dyke would require periodic dredging. If the water level is once again lowered, the lagoon bed would be recolonized by reeds, or worse still, by Port Jackson and Rooikrans, whose seeds are present in the mud.

Ecological management should strive to maintain a diversity of habitats. Onrus Estuary could act as a shelter for estuarine fish and support a marine invertebrate population near the mouth. It could have an area of reeds in the shallow water at the lagoon head with associated freshwater invertebrates, birds and small mammals and also provide a large expanse of deep water for recreational activities. Damming would only reduce the habitat diversity of the estuary, and is therefore not recommended.

The problem at Onrus Lagoon lies not in the reeds themselves but rather in the sediment. Attention should therefore centre on removal of this sediment. This can be achieved by mechanical excavation or dredging. However, as mentioned by Heydorn and Tinley (1980) "it is of particular importance that mechanical sediment removal techniques (by dredger, front-loaders or other machines) should not be applied right up to river banks but that the transitional or 'ecotone' zone of the river or estuary banks should be protected". It seems likely that disposal of the sediment out to sea would be the most practical method. Once cleared of sediment the estuary would need to be maintained, primarily by the control of water-flow from De Bos Dam to simulate normal winter spates. The flow in the river itself would also have to be improved by removal of the dense alien vegetation growing along the river course. Any action will temporarily upset the system, but Onrus Lagoon should recover rapidly. It is strongly recommended that before any dredging is undertaken an *ad hoc* investigation by competent sedimentologists and ecologists be carried out in collaboration with the authorities involved so as to determine the best *modus operandi* for such an operation.

6. ACKNOWLEDGEMENTS

Sincere thanks are due to the members of the Habitat Working Group of UCT who helped so energetically with the original survey.

The residents of Onrus, especially Mr J Cope, Mr W Newmark, Mr Swingler and the Town Clerk, Mr Franken are thanked for the valuable data and information they provided. Dr JA Day and Prof GM Branch are also thanked for their encouragement and constructive criticism.

The production of this report was carried out at the request of the Department of Environment Affairs and Fisheries. The encouragement of this Department, the NRIO Steering Committee for Estuarine and Coastal Research and of the S.A. National Committee for Oceanographic Research is gratefully acknowledged.

7. GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

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

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

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

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

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

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

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

BIMODAL: having two peaks.

BIOGENIC: orginating from living organisms.

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

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

BIOTIC: living (characteristics).

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

CALCAREOUS: containing an appreciable proportion of calcium carbonate.

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

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

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

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

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

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

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

DETRITUS: organic debris from decomposing plants and animals.

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

DYNAMIC: relating to ongoing and natural change.

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

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

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

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

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

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

EPISODIC: sporadic and tending to be extreme.

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

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

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

FLUVIAL (deposits): originating from rivers.

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

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

GEOMORPHOLOGY: the study of land form or topography.

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

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

HALOPHYTES: plants which can tolerate saline conditions.

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

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

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

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

INDIGENOUS: belonging to the locality; not imported.

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

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

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

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

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

LIMPID: clear or transparent.

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

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

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

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

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

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

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

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

OLIGOTROPHIC: poor in nutrients and hence having a paucity of living organisms.

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

PATHOGENIC: disease producing.

PERIPHYTON: plants and animals adhering to parts of rooted aquatic plants.

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

PHYTOPLANKTON: plant component of plankton.

PISCIVOROUS: fish eating.

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

QUARTZITE: rock composed almost entirely of quartz recemented by silica. Quartzite is hard, resistant and impermeable.

RIPARIAN: adjacent to or living on the banks of rivers, streams or lakes.

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

SALINITY: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand.

SECCHI DISC: a simple instrument used to measure the transparency of water.

SHEET FLOW: water flowing in thin continuous sheets rather than concentrated into individual channels.

SLIPFACE: the sheltered leeward side of a sand-dune, steeper than the windward side.

TELEOST: modern day bony fishes (as distinct from cartilaginous fishes).

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

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

WAVE HEIGHT (average energy wave height): an index which reflects the distribution of average incident wave energy at inshore sites along the coast presented as a wave height.

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

ZOOPLANKTON: animal component of plankton.

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{ONRUS LAGOON}. Colour. Job No. 326. Photo No. 337/3. Dept. Land Surveying, University of Natal, 1:10 000, 1979.

APPENDIX I: Physico-chemical conditions in Onrus Lagoon, November 1979 (Damstra 1980).

Station (see Fig. 2)	Description		Water Temp. °C	Dissolved Oxygen ppm	pH	Salinity parts per thousand
	Onrus River		18	13,2	5,2	0
E8	*Phragmites* bed	Surface	24	11,6	5,5	0
		Bottom	22	8,2	5,5	0
F6	*Scirpus* bed	Surface	26	11,2	5,5	0
		Bottom	25	12,0	5,5	0
E4	Submerged plants	Surface	24,2	11,6	5,5	0
		Bottom	23,5	14,3	5,5	0
	Between patches of submerged plants	Surface	24,2	11,8	5,5	0
		Bottom	23,5	11,4	5,5	0
G3	Blind channel	Surface	23,0	10,0	5,5	0
		Bottom	22,0	9,3	5,5	0
		In mud	21,0	5,8	5,5	0
F3	River channel	Surface	24,5	12,0	5,5	0
		Bottom	19,0	9,6	5,5	0
E1	Trough with detritus between E1 and E2	Surface	24,5	10,4	5,5	0
		Middle	24,0	10,3	5,5	0
		Bottom	21,0	10,2	5,5	0
B5	Sea-end of lagoon	Surface	24,0	13,4	5,5	0
		Middle	23,5	11,6	5,5	0
		Bottom	23,0	11,4	5,5	0
A2	River mouth	Surface	23,0	10,2	5,5	0
		In sand	22,0		5,5	1

APPENDIX II: Nutrient values in Onrus Lagoon, November 1979 (Damstra, 1980).

Station (see Figure 2)	Description	T.P.M. mg/ℓ	P.O.M. µg/ℓ	Nitrate µg ats/ℓ	Silicate µg ats/ℓ	Ammonia µg ats/ℓ	Reactive Phosphate µg ats/ℓ
	Onrus river	11,82	4,14	0,68	11,76	0,77	0,21
E8	*Phragmites* bed	13,46	7,30	0,59	8,93	2,63	1,79
F6	*Scirpus* bed			1,00	16,67	2,59	1,81
G3	Blind channel			5,70	1,39	1,34	3,33
F3	River channel			2,78	21,43	0,81	1,80
E1	Detritus trough						
	surface	7,18	4,22	1,50	36,30	1,05	1,78
	bottom	11,00	2,54	1,23	33,33	0,53	1,83
A2	River mouth	6,66	2,08	3,10	18,45	1,78	1,91

APPENDIX III: Faunal list of invertebrates found at Onrus Lagoon (Relative abundance: Rare = 1; Present = 2-10; Common = 11-50; Abundant = 50 specimens collected) (Damstra, 1980).

	Sandy sub-strate	Muddy sub-strate	Rock in muddy sub-strate	Log in muddy sub-strate	*Chara*	*Potamo-geton*	Blind channel	Decom-posing kelp	*Phragmites* beds	*Scirpus* Island
POLYCHAETA										
Ceratonereis keiskamma	P	C		P			P			R
CRUSTACEAE										
Amphipoda										
Corophium triaenonyx	C	C	C	A	P	P	P		R	R
Melita zeylanica			R	R					P	P
Isopoda										
Pseudosphaeroma barnardi			P	A					C	P
Cirolana africana				P						
Tanaidacea										
Tanais philetaerus	P		P	C	A			R		
Anomura										
Callianassa kraussi	P									
Brachura										
Hymenosoma orbiculare	P									
INSECTA										
Crocothemus erythraea					R					
Zygopteran nymph					P					
Cloeon lacunosum									R	
Coleopteran										R
Gyrinidae adult		R							C	P
Hydrophilide larvae										P
Corixidae			C						C	
Chironomus sp. larvae								P	C	C
Chironomus sp. larvae	R	R			R		P	P	C	C
Chironomid larvae	P	C		R	C	C	C	P		P
Chironomid larvae	R	R		R	C	P	P			R
ARACHNIDA										
Araneae									R	
Araneae									R	
MOLLUSCA										
Helcion juveniles	P									
Musculus virgiliae		P	A	A		P				C

APPENDIX IV: Amphibia and fish caught in seine net. Relative abundance given as P (1-10); C (10-50); A (> 50) specimens collected (Damstra, 1980).

Common name		Status	Mean length (cm)
	AMPHIBIA		
Cape river frog	*Rana fuscigulata*	P	
Leopard toad	*Bufo pardalis*	C	
	PISCES		
Southern mullet	*Liza richardsoni*	C	4,6
Knysna sandgoby	*Psammogobius knysnaensis*	A	3,9
Stumpnose	*Rhabdosargus tricuspidens*	P	5,9
Cape galaxias	*Galaxias zebratus*	P	3,8
Cape kurper	*Sandelia capensis*	P	
Estuarine round-herring	*Gilchristella aestuarus*	P	

APPENDIX V: Reptile and Amphibian Checklist for the area recorded by the 1:50 000 Sheet 3419 AC Hermanus (A de Villiers, *in litt.*) (L = likely to occur, X = recorded species).

Frogs			
Common name		Scientific name	
Common platanna	-	*Xenopus laevis*	L
Cape platanna+	-	*Xenopus gilli*	X
Cape ghost frog	-	*Heleophryne purcelli*	L
Sand toad	-	*Bufo angusticeps*	L
Cape mountain toad	-	*Capensibufo rosei*	L
Raucous toad	-	*Bufo rangeri*	X
Leopard toad	-	*Bufo pardalis*	X
Sand rain frog	-	*Breviceps rosei*	L
Cape mountain rain frog	-	*Breviceps montanus*	L
Cape sand frog	-	*Tomopterna delalandii*	L
Cape rana	-	*Rana fuscigula*	L
Spotted rana	-	*Rana grayii*	X
Cape grass frog	-	*Rana montana*	X
Micro frog+	-	*Microbatrachella capensis*	X
Common caco	-	*Cacosternum boettgeri*	L
Cape chirping frog	-	*Arthroleptella lightfooti*	L
Rattling kassina	-	*Kassina weallii*	L
Arum frog	-	*Hyperolius horstockii*	X

Tortoises			
Common name		Scientific name	
Angulate tortoise	-	*Chersina angulata*	X
Padloper tortoise	-	*Homopus areolatus*	X
Water tortoise	-	*Pelomedusa subrufa*	L

APPENDIX V: (Cont.)

Snakes			
Common name		Scientific name	
Pink earth snake	-	*Typhlops lalandei*	L
Black worm snake	-	*Leptotyphlops nigricans*	L
Brown water snake	-	*Lycodonomorphus rufulus*	L
Aurora house snake	-	*Lamprophis aurora*	L
Olive house snake	-	*Lamprophis inornatus*	L
Southern shovel-snout	-	*Prosymna sundevallii*	L
Mole snake	-	*Pseudaspis cana*	L
Southern slug-eater	-	*Duberria lutrix*	X
Common egg-eating snake	-	*Dasypeltis scabra*	L
Herald snake	-	*Crotaphopeltis hotamboeia*	L
Cape many-spotted snake	-	*Amplorhinus multimaculatus*	L
Boomslang	-	*Dispholidus typus*	L
Spotted skaapsteker	-	*Psammophylax rhombeatus*	X
Whip snake	-	*Psammophis notostictus*	L
Cross-marked sand snake	-	*Psammophis crucifer*	L
Coral snake	-	*Aspidelaps lubricus*	L
Spotted dwarf garter snake	-	*Elaps lacteus*	L
Rinkals	-	*Hemachatus haemachatus*	L
Cape cobra	-	*Naja nivea*	L
Puff adder	-	*Bitis arietans*	L
Cape mountain adder	-	*Bitis atropos*	L
Lizards			
Common name		Scientific name	
Ocellated gecko	-	*Pachydactylus*	L
Marbled gecko	-	*Phyllodactylus prophyreus*	L
Cape dwarf chameleon	-	*Bradyopdion pumilum*	L
Rock agama	-	*Agama atra*	L
Yellow-striped mountain lizard	-	*Tropidosaura gularis*	L
Green-striped mountain lizard	-	*Tropidosaura montana*	L
Golden sand lizard	-	*Acontias meleagris*	L
Silver sand lizard	-	*Scelotes bipes*	L
Common skink	-	*Mabuya capensis*	L
Cape speckled skink	-	*Mabuya homalocephala*	L
Cape snake lizard	-	*Chamaesaura anguina*	L
Small-scaled girdled lizard	-	*Pseudocordylus microlepidotus*	L
Cape small-scaled girdled lizard	-	*Pseudocordylus capensis*	L
Cape girdled lizard	-	*Cordylus cordylus*	L
Yellow-throated plated lizard	-	*Gerrhosaurus flavigularis*	L
Short-legged seps	-	*Tetradactylus tetradactylus*	L

+Although *X. gilli* and *M. capensis* (both rare and endangered species endemic to the south-west Cape) have been recorded from locus 3419 AC, they have not been recorded from the vicinity of the Onrusrivier Lagoon.

APPENDIX VI: Bird-list of Onrus Lagoon, November 1979 (Damstra, 1980) (Relative abundance: R = Rare; P = Present; C = Common; A = Abundant)

Roberts Number	Common name	Status	Notes
298	Swift Tern	R	
296	Sandwich Tern	C	Roost on sandbank
289	Hartlaub's Gull	A	Roost on sandbank
287	Southern Black-backed Gull	C	Roost on sandbank
495	White-throated Swallow	C	Breeding - feed off water
502	Greater Striped Swallow	C	Breeding - feed off water
509	African Sand Martin	C	Breeding - feed off water
604	Cape Reed Warbler	C	Breeding - utilize reed-beds
646	Le Vaillant's Cisticola	P	Breeding - utilize reed-beds
67	Little Bittern	P	Breeding - utilize reed-beds
394	Pied Kingfisher	P	
274	Water Dikkop	R	
212	Red-knobbed Coot	C	Feed off *Potamogeton*
258	Common Sandpiper	C	
269	Avocet	R	
357	Burchell's Coucal	P	Heard
96	Yellow-billed Duck	P	
97	Red-billed Teal	R	
686	Cape Wagtail	P	Using edges for drinking and bathing
316	Cape Turtle Dove	P	Using edges for drinking and bathing
317	Laughing Dove	P	Using edges for drinking and bathing
857	Cape Canary	P	Using edges for drinking and bathing
383	White-rumped Swift	P	Flying overhead only
?	Mousebird	P	Flying overhead only
524	White-necked Raven	P	Flying overhead only
799	Cape Weaver	A	Breeding, roost in reed-beds
810	Cape Widow	R	Seen in reed-beds
397	Malachite Kingfisher	P	Breeding

Counts of waders (Charadrii) and other birds at Onrus rivermouth on 6 January 1981 at 16h45 (Underhill and Cooper 1983, unpublished)

Roberts Number	Common name	Number seen
212	Red-knobbed Coot	5
274	Water Dikkop	1
289	Hartlaub's Gull	3
686	Cape Wagtail	1

APPENDIX VII: Summary of available information

Guide to available information

Group	Subgroup	Topic	Acocks	Begg	Branch and Day	Bulpin	Damstra	De La Cruz	Gardiner	Harrison	Heydorn and Tinley	Hockey and Underhill	King *et al*	Lambrechts	McLachlan	Morton	Rooseboom	Roussouw and Coetzee	Siegfried *et al*	Stuart *et al*
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)			1975	1978	1980	1980	1980	1978	1980	1962	1980	1983	1979	1979	1978	1975	1980	1982	1976	1980

ESTUARY / RIVERMOUTH / LAGOON: ONRUS (Lagoon)

Sources of information: Acocks; Begg; Branch and Day; Bulpin; Damstra; De La Cruz; Gardiner; Harrison; Heydorn and Tinley; Hockey and Underhill; King *et al*; Lambrechts; McLachlan; Morton; Rooseboom; Roussouw and Coetzee; Siegfried *et al*; Stuart *et al*

APPENDIX VII: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: ONRUS (Lagoon)

		Sources of information	Stuart	Swart and Serdyn	Underhill and Cooper	Van Wyk	Westlake		MAPS	S.A. 1:50 000 3419 AC	S.A. 1:50 000 3419 AD	Pope (surveyor) 1:20 000		AERIAL PHOTOGRAPHY	Trig Survey	Job No. 130		Univ. of Natal, Dept. Land Surveying	Job No. 326	Job No. 349
		YEAR (DATE OF INFORMATION)	1981	1982	1983	1958	1963			1975	1976	1977				1938			1979	1980
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								*	*									

Guide to available information

APPENDIX VII: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: ONRUS (Lagoon)

Category	Sub-group	Topic	A de Villiers (*in litt.*)	J Francken (*pers. comm.*)	WO Morsbach (*in litt.*)	W Newmark (*in litt.*)	Town Engineer, Hermanus	WJ van Ryssen
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)			1983	1983	1983	1979	1983	1983

Guide to available information

Sources of information

PLATE I:

The catchment area of the Onrus River called "Hemel en Aarde". Mountain fynbos in the foreground with cleared agricultural lands and the tree lined river course in the valley. (ECRU, 83-05-19).

PLATE II:

Extensive beds of "Fluitjiesriet", *(Phragmites australis)* now occupy the once open lagoon which was used for boating and swimming.
(ECRU, 79-12-06).

PLATE III:

The mouth of the Onrus Lagoon showing the sandbar and the narrow channel on the western edge through which the lagoon drains after heavy rains in the catchment (ECRU, 79-09-11).