# AN ENVIRONMENTAL STUDY

# OF THE LOURENS RIVER ESTUARY

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# ABSTRACT

An environmental study of the Lourens River estuary was completed, whereby field surveys were undertaken and all available knowledge was collated. The Lourens estuary is a small system opening into False Bay, Southwestern Cape; it is almost entirely enclosed within AECI security fences and access to the public is restricted. Physico-chemical parameters exhibit seasonal variations and the estuary may be marine dominated in summer and river dominated during the wet season. Terrestrial and aquatic biota are generally depauperate. The poor ecological quality of the estuary may be attributed primarily to periodic pollution inputs from the AECI main drain discharge, but also to the complex arrangements of land ownership and administrative controls and the influences of urban, industrial and agricultural developments in the river basin. It is recommended that attention be paid to the management and conservation of the Lourens River system.

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# CHAPTER ONE

# INTRODUCTION

## 1.1 INTRODUCTION TO STUDY

It has been estimated that the total area of South African estuaries is between 500 and 600 km², estuaries of the Cape Province constituting only a small proportion of this total (Heydorn, 1979). Not only are such areas limited in extent, but there is a paucity of information pertaining to the physical and biological components of estuarine systems as well as the sociological factors which pertain to their management and development.

In recent years more attention has been focused on estuaries, particularly since their economic potential and recreational value has been realised and the sensitivity of the coast to development has been more fully appreciated.

The value of essential ecological functions, such as providing nursery areas for coastal marine fish and crustaceans, has been acknowledged. Moreover, human activities such as recreation and urban and agricultural development, are causing widespread disruption of the natural functioning of estuarine ecosystems. It has only recently been appreciated that estuaries cannot be studied or managed as separate entities, since they form a continuum with both the river system and the marine environment. Furthermore, many conservation efforts are stultified by the multiplicity of responsibility in the control of Cape estuaries (Hey, 1981).

Grindley and Heydorn (1979) expressed the need to compile all existing knowledge on South African estuaries, so that it can be immediately integrated into management policies. Such a task has been undertaken in Natal (Begg, 1978), while Day (1981) gathered and reviewed information on South African estuaries, so as to assess the present-day state of knowledge of these systems.

In February 1979 the Estuarine and Coastal Research Unit (ECRU) of the National Research Institute for Oceanology (NRIO), Stellenbosch, was established at the request, and with the financial support of, the Department of Environmental Planning and Energy (now the Department of Environment Affairs). An interdisciplinary baseline document describing the environmental conditions along the Cape coastline, was compiled (Heydorn & Tinley, 1980).

The Unit was also commissioned to synthesise all available information on each of the estuaries of the Cape between the Kei and Orange Rivers, including that relating to the influence of catchments on estuaries and their interaction with the marine and coastal environment. Additionally, the Unit serves to stimulate research activities within research organisations.

This environmental study of the Lourens River estuary, Southwestern Cape, is a contribution towards the information required by ECRU.

## 1.2 AIMS AND OBJECTIVES

The aim of this study was to record the environmental information pertaining to the estuary; all the available knowledge on the estuarine system was synthesised and field surveys were conducted.

The objectives of this are twofold: firstly, this work serves as a framework on which detailed studies can be based; secondly, it is a general text to which decision-makers may refer if a management policy for the system be formulated; it is not, however, intended as a management recommendation document.

The strategies by which the above aim was realised were as follows:

1. The ecological characteristics of the estuary were described. This included:

    i) a physical description of the estuarine system and associated components of the catchment, river and near-shore marine processes;

    ii) a description of the estuarine biota;

    iii) the characterisation of seasonal changes in physico-chemical parameters of the estuary.

2. Human activities and influences, such as administrative control structures and industrial and urban developments and activities were identified and the significance of these with respect to the estuary was assessed.

## 1.3 LOCATION AND ACCESSIBILITY

The Lourens River mouth is located at 34°06'S and 18°49'E in the north-east corner of False Bay, approximately 40 km southeast of Cape Town. It rises in the Hottentots Holland Mountains, flows through the town of Somerset West and enters False Bay to the northwest of Strand (Fig. 1).

The study area within which field surveys were conducted, extends from the pipe bridge in Strand to the low-water mark on the beach; this area is between 50 and 120 m wide.

The mouth region between the sea and the Beach Road bridge is enclosed within an AECI security fence. Public access to this area is prohibited and permits are required for entry. In August 1982, subsequent to the completion of field surveys, the entire northern bank from Beach Road to the pipe bridge was enclosed within an AECI security fence. At present, access to the estuary is via the southern bank above Beach Road (Fig. 5).

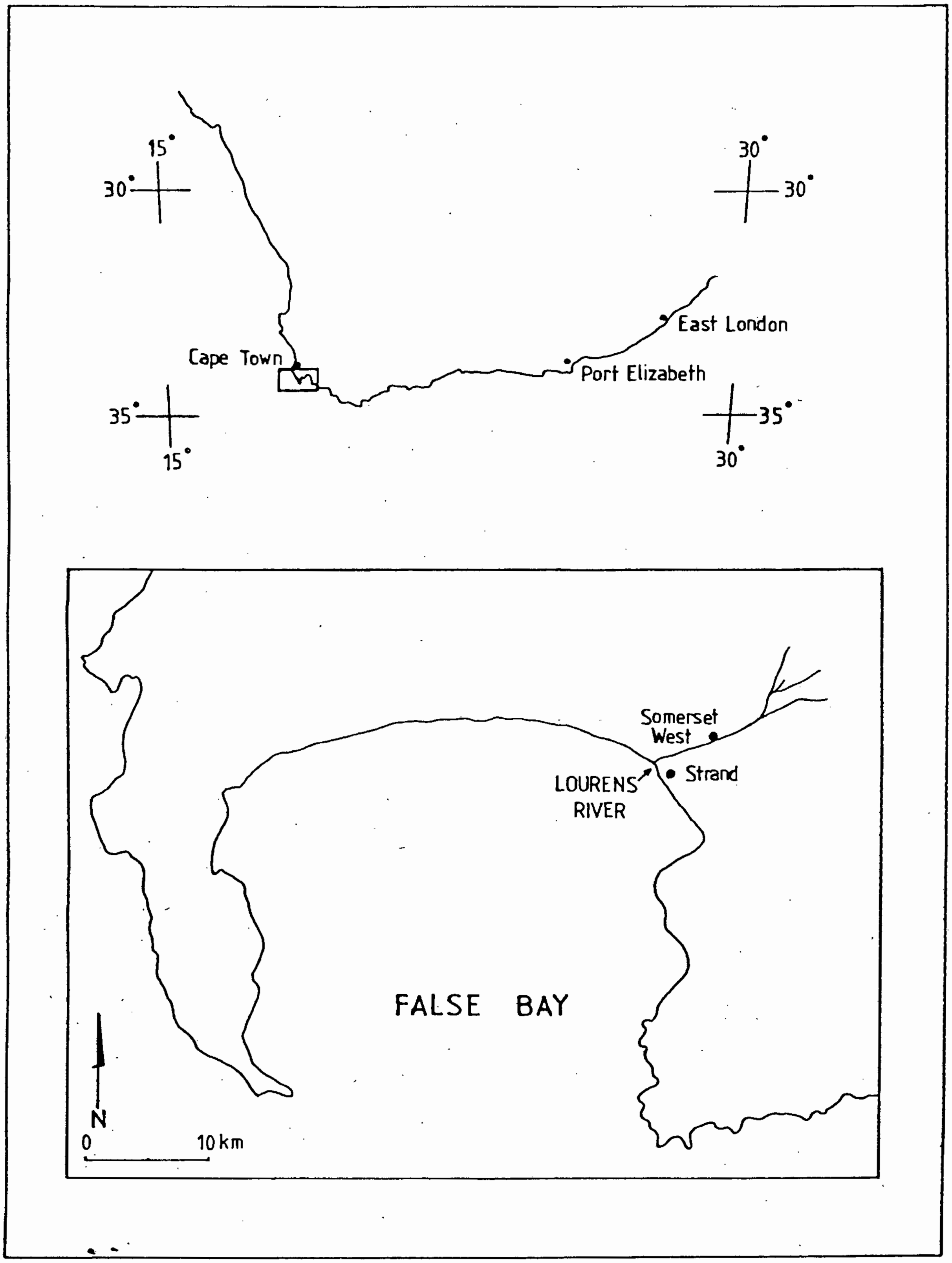



Figure 1: Location of the Lourens River.

## 1.4 HISTORICAL BACKGROUND

The river was known in the 17th century as the Tweederivier, as it was the second river crossed after the "Eersterivier" on the journey from the Cape Peninsula to the Hottentots Holland Mountains. In 1671 it was called the Breitenbach River after a Lieutenant Breitenbach who led an expedition to the Hottentots Holland. This title did not endure since early maps usually referred to it as the Tweederivier. According to Heap (1970) it became the Laurens River, after someone of that name was drowned in it; the spelling being subsequently changed to Lourens. Hoge (1970) considers that it was named after Johann Lorenz Fischer, who established a Dutch East India Company post in the Hottentots Holland in 1673.

Historically, the Lourens River has been used as a source of domestic and agricultural water since the late seventeenth century, when the first white settlers established a camp on the banks of the river. Through the ages the farmlands of the upper catchment have been subdivided and consolidated and at present the river rises almost entirely within the vast estates of Lourensford and Vergelegen.

Strand was proclaimed a municipality in 1897 and water used for domestic purposes was obtained from a small stream leading off the river. After the proclamation of the Somerset West Municipality in 1903, a piped water system, which led from a reservoir at the present Helderberg Nature Reserve and fed by the river, was introduced. With the expansion of these towns a variety of measures have been utilised to obtain greater supplies from the river.

Subsequent to the establishment of De Beers Explosive Works (now known as AECI) in 1903, the furrow which leads off the river below the Provincial Main Road into Paardevlei, as well as the vlei itself, were enlarged, resulting in an increase in the volume of water removed from the Lourens River (Heap, 1970).

In 1936 a Water Court Order ruled how the water of the river should be apportioned amongst riparian owners, including private landowners, municipalities and AECI (Ninham Shand & Partners, 1974). This ruling still forms the basis for the allocation of river water.

The Strand Municipality Sewage Works which stands, disused, on the northern bank of the Lourens estuary, commenced operation in 1948 and biologically-treated sewage was discharged into the estuary. The works were decommissioned in 1978 as a result of being overloaded (F. Sheffler, Strand Municipality, pers. comm.).

# CHAPTER TWO

# PHYSIOGRAPHIC FEATURES

## 2.1 INTRODUCTION

Since an estuary is formed where the sea and river meet, both these systems affect conditions in the estuary. This interaction between fresh and saline water, therefore, provides a unique environment which is nevertheless an integral part of the coast and forms a continuum with the riverine system. The geomorphology and hydrology of the catchment, as well as inshore current and wave movement and sediment transport, contribute to the characterisation of the physical environment of an estuary.

## 2.2 RIVER

### 2.2.1 Catchment Characteristics

The river rises in Nuwejaarskloof in the Hottentots Holland Mountains at a height of approximately 1500 m. It has a catchment area of 92 $km^2$ and is approximately 20 km long (D. Zietsman, Department of

Environment Affairs, pers. comm.). The catchment area is very small and represents only four percent of the average area of 43 river catchments in the Cape Province (Noble & Hemens, 1978).

The river has no major tributaries but is supplemented by streams arising in Landdroskloof and Sneeukopkloof, at heights of 1300 and 1600 m, respectively.

### 2.2.2 Geomorphology and Geology

Information regarding the geology and geomorphology of the area was obtained from Simpson *et al.* (1968), Glass (1980) and Mountain, Consulting Geologist (1981; Engineering geological map ).

The Lourens River has its origins in the deep kloofs of folded mountains, passes through a shallow valley surrounded by undulating hills and finally cuts across a flat coastal plain before emptying into the sea.

The oldest rocks in the area, belonging to the Malmesbury System, underlie the eastern portion of the Cape Flats and produce a rather flat topography, typical of the lower reaches of the river. These beds were deposited approximately 700 million years ago and lie in a folded state as geosynclinal sediments. About 610 million years ago, granite of the Cape Granite Group was intruded into the aforementioned system, also producing a rather flat topography, but occasionally outcropping as isolated rounded cupolas typical of the hills surrounding the river. Resistant quartz arenites of the Table Mountain Group were deposited in a shallow tidal sea on top of the older Malmesbury System and Cape Granite Group, 450 million years ago. Table Mountain sandstone constitutes a major part of the surrounding mountains and these sediments are folded along a southerly axis.

Shallow sandy soils overlie the mountain bed rock. The hills surrounding the river valley consist of shallow soils overlying granite, shale and greywacke. The river valley is largely overlain by sediments deposited during the Tertiary and Quaternary Periods and in many places these soils have a depth of more than two metres; this soil is alluvial in origin and is composed of boulders and clay. Near the mouth of the river, transported soils of the Tertiary and Quaternary Periods are aeolian in origin and comprise mostly sand, forming a superficial covering over the Cape Flats bed rocks.

### 2.2.3 Rainfall and Annual Run-off

The Lourens River lies within a winter rainfall region (Heydorn & Tinley, 1980). Schulze and McGee (1978) have defined the rainy season as including all months with a precipitation greater than or equal to 50 mm.

Data obtained at the Lourensford Estates office gauging station (unpublished data), between November 1970 and October 1981, indicated a mean rainfall value of approximately 34 mm for the months November to March. A mean value of 110 mm was obtained for the seven months of the rainy season. Thus, 76 percent of the annual rainfall occurs in winter as compared with 24 percent in summer. Mean monthly rainfall data for the period November 1970 to October 1975 are presented in Fig. 2.

Analysis of rainfall data collected for the period January 1917 to December 1981, indicated an average annual rainfall of 915 mm, ranging from 637 mm in 1934 to 1470 mm in 1977 (Lourensford Estates, unpublished data).

Total annual run-off recorded at the gauging station near the National Monument Bridge, Somerset West, for the period November 1970 to October 1981, ranged from 8,08 x $10^6$ $m^3$ to 50,17 x $10^6$ $m^3$ with an average value of 21,0 x $10^6$ $m^3$ (Directorate of Water Affairs, unpublished data). This mean value represents only six percent of the average annual run-off obtained for 43 estuaries in the Cape Province (Noble & Hemens, 1978).

From the data collected by the Directorate of Water Affairs, it was ascertained that 13 percent of the annual run-off occurs between November and March, while 87 percent occurs during the rainy season. Mean monthly run-off data for the period November 1970 to October 1975 are presented in Fig. 3.

The Lourens River, therefore, has a relatively small catchment and run-off, although rainfall and run-off are high during the seven months of the rainy season.

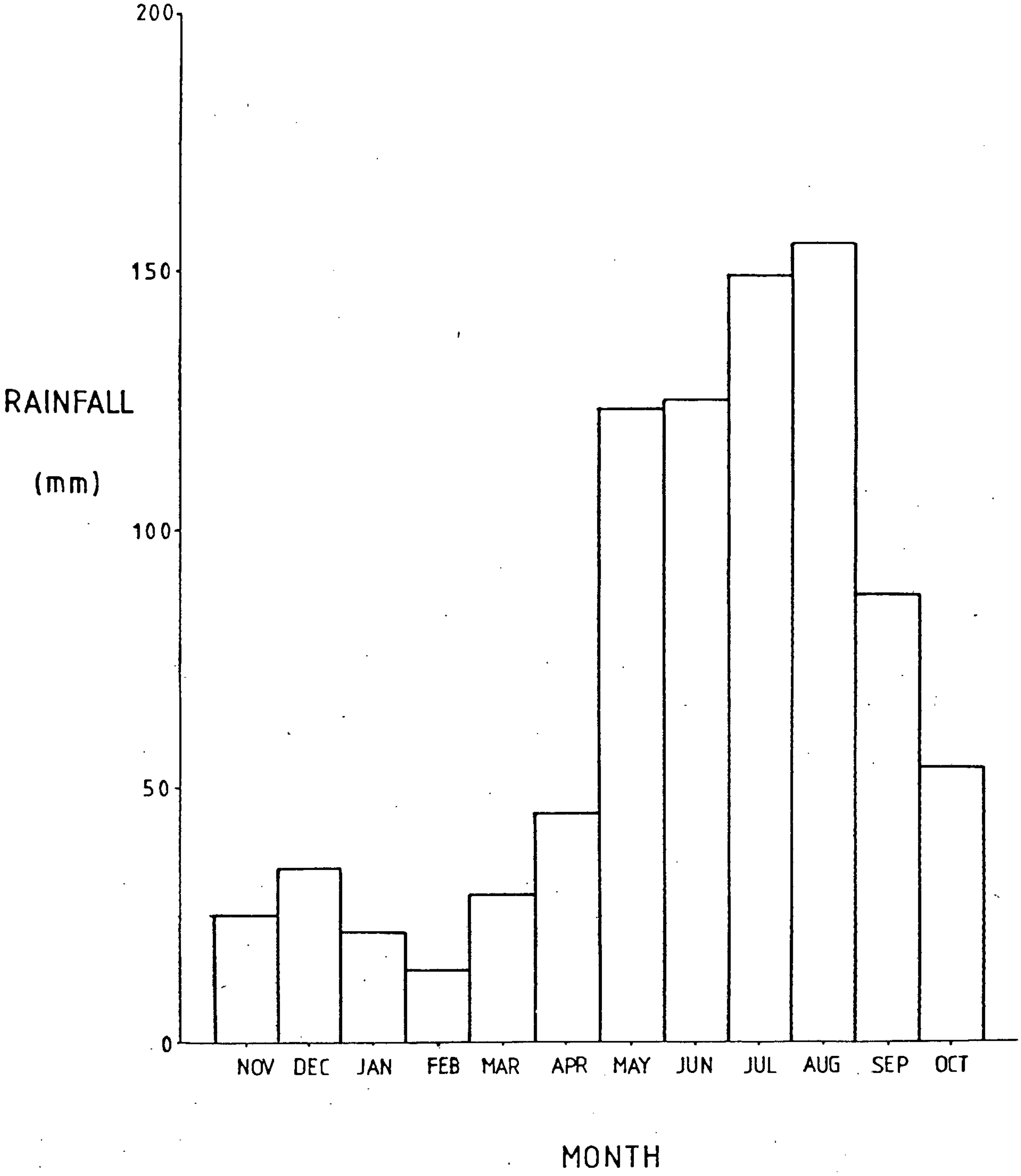



Figure 2: Mean monthly rainfall data recorded at the Lourensford Estates office gauging station from November 1970 to October 1975.

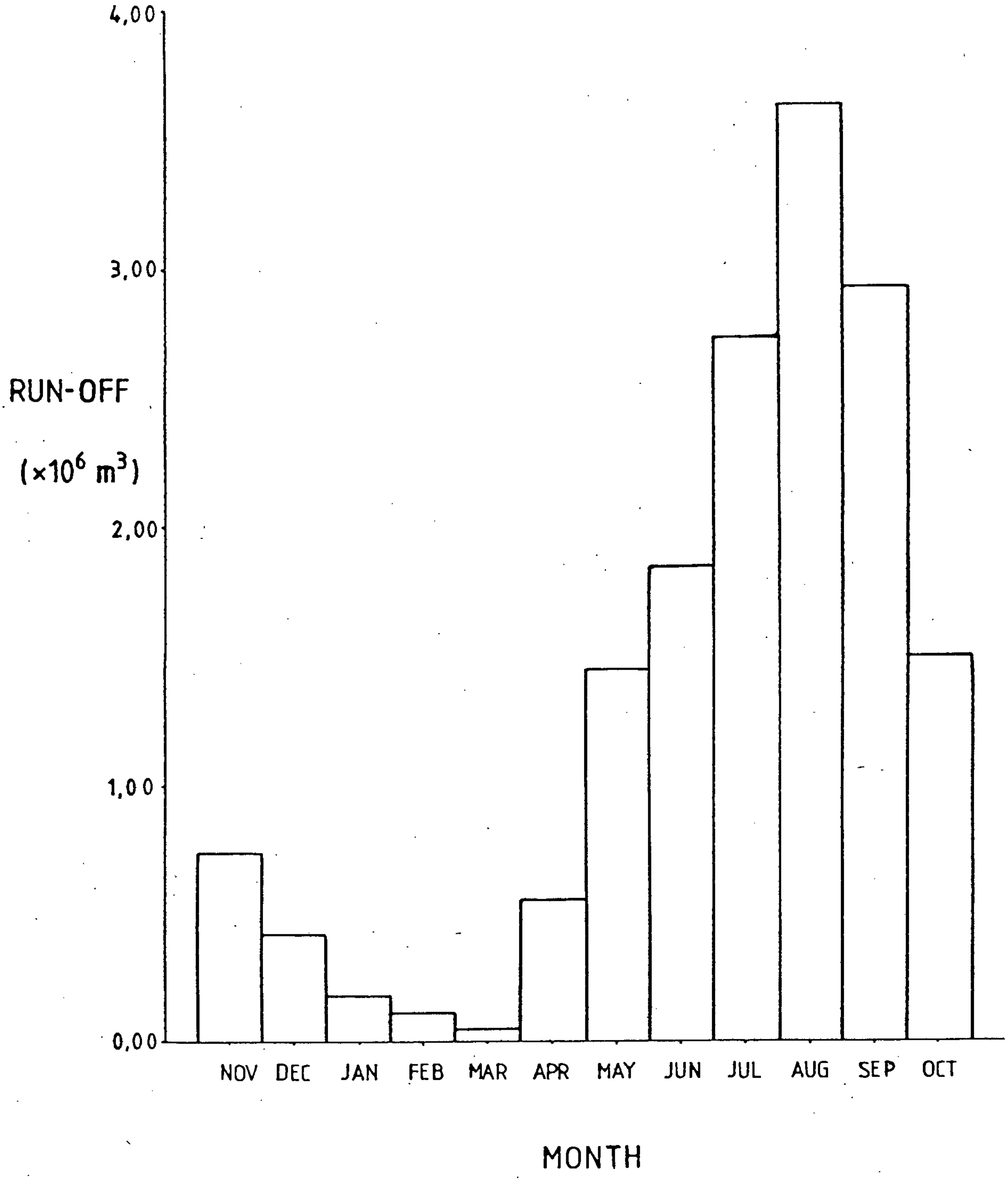



Figure 3: Mean monthly run-off data recorded by the Directorate of Water Affairs between November 1970 and October 1975.

### 2.2.4 Flow

A summary of flow rate data collected at the gauging station at Lourensford Estates (Ninham Shand & Partners, unpublished data) for the period November 1970 to October 1975, is presented in Fig. 4. A minimum average monthly value of 0,07 cumecs was obtained for February and March and a maximum value of 3,57 cumecs in August. A mean flow rate of 0,14 cumecs was calculated for the summer months, while between April and September, the flow rate was 1,17 cumecs. Flow rates during the rainy season are, therefore, on average eight times greater than during summer.

Records obtained from the Directorate of Water Affairs (unpublished data) afford minimum daily average flow rates of zero cumecs for months between January and May, from 1972 to 1975. According to Mr J.C. Ottervanger (Somerset West Municipality, pers. comm.), the river in the lower catchment usually only ceases to flow for a very short period during any one year.

During a field survey in March 1982, the river immediately above the head of the estuary was observed to be dry and reduced to small, stagnant pools. Mr R. Birch of Lourensford Estates (pers. comm.) noted that the normal winter flow level is approximately 75 cm greater than the summer level.

The considerable variations in river flow rate during the year are, therefore, evident.

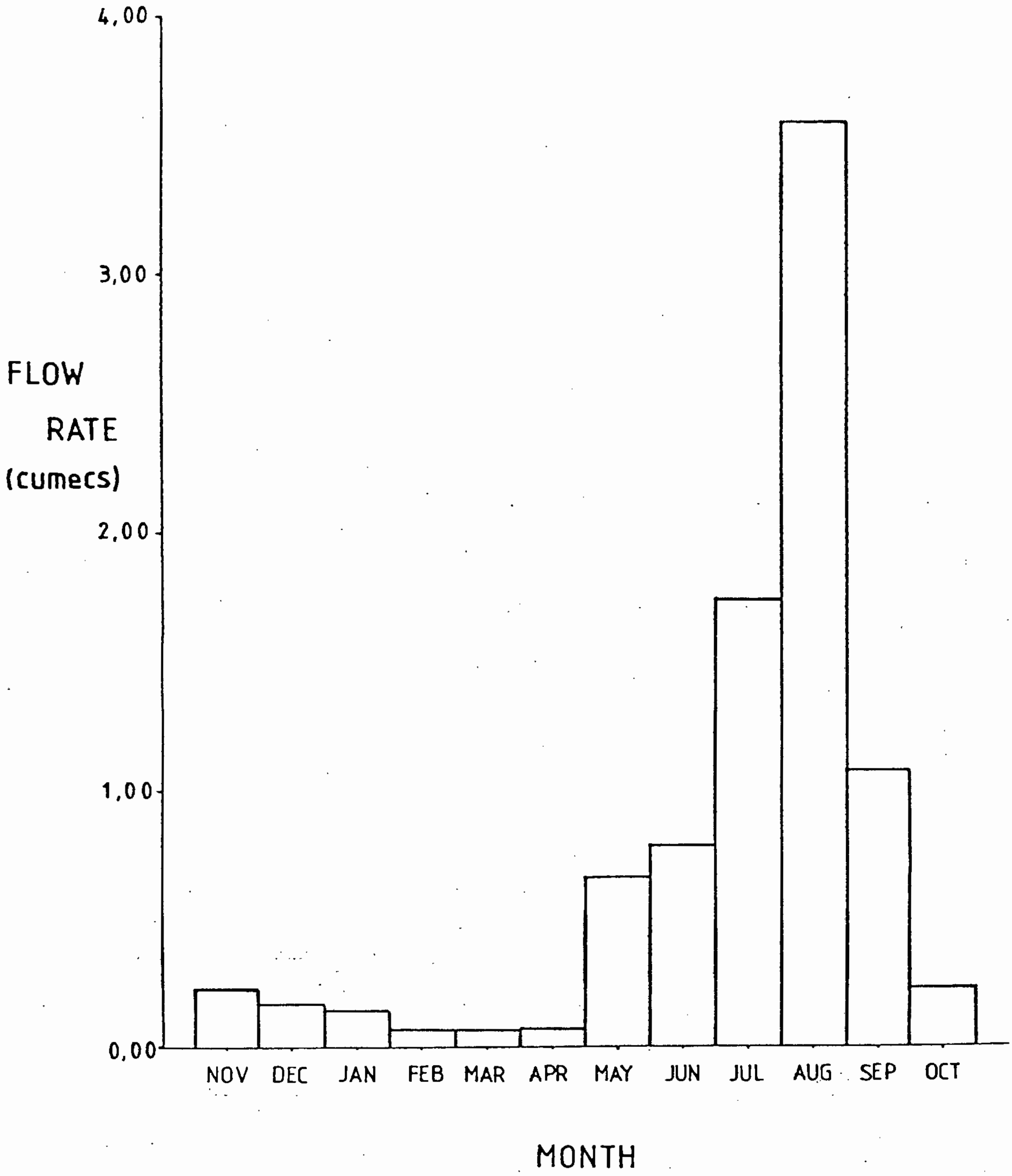



Figure 4: Mean monthly flow rate data recorded by Ninham Shand & Partners, Consulting Engineers, between November 1970 and October 1975.

### 2.2.5 Abnormal Flow Patterns

Flood levels were recorded by the Directorate of Water Affairs (unpublished data) at the gauging station above the National Monument Bridge, Somerset West, during the period October 1970 to September 1981. The height of the southern bank at the station is 1,5 m above the river-bed and flooding occurred when a peak of over one metre above the river-bed was recorded. Flood levels were indicated on six occasions between 1970 and 1981, for periods less than 12 hours. Serious flooding occurred in January 1981 when the water level at the gauging station was 2,48 m above the river-bed, resulting in the flooding of the Pick 'n Pay supermarket and Somerset Oaks Old Age Home on the northern bank, near the historic road bridge.

Intermittent flooding has occurred in Somerset West over the past 30 years (Dunlop, 1981). Hawkins, Hawkins & Osborne (1981) attribute the problem of flooding to increased agriculture and urban development, which has resulted in the removal of natural vegetation and the increase in non-absorbtive surfaces, such as roads. Thus the stability of the river system is threatened in two ways; the proportion of storm run-off and the intensity of flood discharge is increased (Beaumont, 1979).

The presence of debris, litter and fallen or cleaved trees in the river results in the obstruction of river flow, particularly at the National Monument Bridge in Somerset West. Blockage of this bridge in January 1981 resulted in the flooding of the surrounding area

(B.A. Tromp, Lourens River Conservation Society, pers. comm.).

Hawkins, Hawkins & Osborne, Consulting Civil Engineers, were commissioned by the Somerset West Municipality in 1981 to analyse the flood problems associated with the historic bridge. This is detailed in section 5.4.1.

## 2.3 ESTUARY

### 2.3.1 Definition and Description

Hodgkin (1978), Heydorn (1979) and Day (1981) consider the problems associated with the classification and definition of estuaries.

During the summer months the Lourens estuary may become closed or partially closed by a sandbar, a positive salinity gradient exists and hypersaline conditions may be recorded. During the rainy season, the fresh water discharge is such that saline intrusion only extends approximately 200 m upstream of the mouth, during HWOST. The estuary, therefore, becomes essentially reduced in area during the wet season.

Hodgkin (1978) attributes similar hydrological characteristics to the estuaries of southwestern Australia and terms such systems "seasonal" estuaries.

For the purposes of this study, an estuary may be defined as "a partially enclosed 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... at some time of the year" (adapted from Day (1981) and Hodgkin (1978)).

## 2.3.2 Geomorphology and Configuration

Begg (1978) demarcated the seaward boundary of an estuary as the high tide mark; in this study the HWONT level determined the seaward extent of the estuary. The head of the estuary was defined as the limit of saline intrusion as recorded during the dry summer months; this was at the pipe bridge in Strand.

The estuary, from the mouth to the head, is approximately 14 740 $m^2$ in area and 915 m in length, as calculated from the 1:10 000 Aerial photograph (Lourens estuary, 1979).

The estuary forms a narrow, twisting channel approximately 675 m long by 9 m wide, from the pipe bridge to Beach Road Bridge. It is lined by steep banks, rising between one and three metres above the winter flow level. The river emerges beneath Beach Road Bridge into the backshore zone where it forms a small crescent-shaped lagoon oriented east to west. The banks are predominantly steep, rising up to one metre above the water surface.

The shape and position of the mouth varies depending on the season (see section 2.3.3). However, aerial photographs taken between 1953 and 1981 show that the Lourens River has always developed a backshore lagoon from east to west.

Approximately 175 m below the road bridge an overflow pond, excavated by AECI, with an area of 1560 $m^2$, opens into the estuary via three concrete pipes approximately 90 cm in diameter. The AECI main drain containing discharge wastes, passes over a weir into a narrow channel which empties into the sea. However, this water may flow via a concrete "canal" into the overflow pond and subsequently into the estuary.

About 200 m above the road bridge, a small stream arising at Heldersig Township and draining the Provincial Main Road, opens into the estuary via a concrete pipe 150 cm in diameter.

Figure 5 illustrates some of the abovementioned features.

### 2.3.3 Mouth Dynamics

The mouth dynamics could be ascertained from aerial photographs taken in 1953, 1966, 1973, 1977, 1979, 1980 and 1981 and from observations made during field surveys from December 1981 to August 1982.

During the months of November and December in 1953, 1966 and 1980,

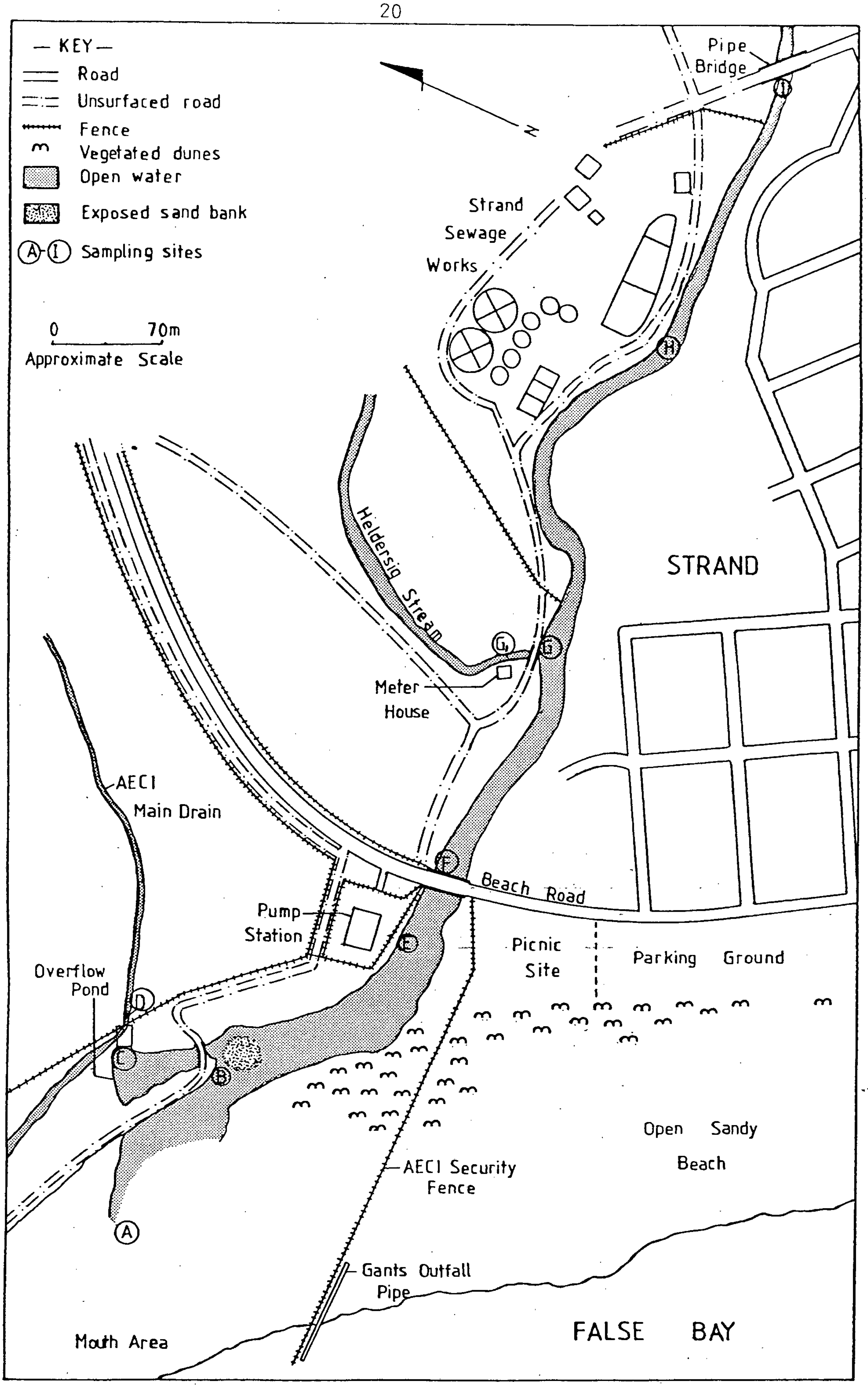



Figure 5: The Lourens River estuary. (Adapted from the 1:10 000 Aerial photograph (Lourens Estuary, 1979).)

respectively, the mouth was open and constituted a narrow channel, approximately ten metres wide, flowing parallel to the western bank for a short distance before opening into the sea.

Aerial photographs taken in February 1973 and March 1977, reveal a narrow channel or series of runnels running out to sea.

At neap tides in April 1979 the mouth was observed to be practically closed or reduced to a negligible outflow.

During spring tides on 3 December 1981 the exit channel was four metres in width, while at HWONT on 17 December 1981, the mouth was reduced to a narrow trickle approximately one metre wide.

The mouth was observed to be closed on two occasions during neap tides on 4 and 14 February 1982, but had naturally breached open at spring tides (D. Joubert, Strand Municipality, pers. comm.) on 21 January.

During neap tides on 12 February and 16 March 1982 the mouth was between two and six metres wide and entered the sea via a number of runnels.

On 15 April 1982, evidence of a channel 10 to 15 m in width and having flowed along the western bank for some distance, was recorded. The flow was reduced to a channel between two and five metres wide on this occasion.

During field surveys conducted between May and August 1982 a channel five to ten metres wide, meandering along the western bank for some distance, was observed.

The dynamics of a river mouth is closely related to the topography and geomorphology of the coast, seasonal flow rates and waves and wave-induced current regimes of the nearshore and offshore zone (Fromme, 1982a).

A build-up of sand on the shore to the east of the mouth results in the formation of a sand-bar, particularly during the summer months (see section 2.4.4). River flow is low during this period and outflow to the sea is greatly reduced and the lagoon may become temporarily closed. During February and March 1982, the influx of water via the overflow pond resulted in a substantial outflow to the sea, despite low river flow. In the normal course of events, with the onset of rains in April and May, the beach bar would be breached at the western end of the lagoon where the bar is lower, as the capacity of the lagoon in the backshore zone was exceeded. During the rainy season the exit channel runs straight down to the foreshore or forms meanders or loops before entering the sea, or runs several hundred metres along the western bank until it finds its way into the sea.

Seasonal closing of the mouth is characteristic of the smaller estuaries of the southwestern Cape Province, a region of winter rainfall and hot, dry summers (Millard & Scott, 1954). Many Australian rivers show marked seasonal variations and are characterised by spasmodic flooding and low run-off coefficients; such rivers have a reduced ability to prevent barrier formation by marine action (Jennings & Bird, 1967).

The marine processes influencing the behaviour of the mouth of the Lourens River will be discussed in section 2.4.

### 2.3.4 Sediments

At the mouth of the estuary the sand is very fine, sediments below a depth of two centimetres being grey in colour.

Beach sediments at the Lourens River mouth were investigated by Bally *et al.* (1980) at stations up to 175 m west of the AECI security fence. Mean sand grain diameters varied between 71 and 138 µm. Glass (1980) noted very fine sands occurring at the delta of the Lourens River.

Fine sediments were found on the landward bank of the lagoon, while medium-sized grains were recorded on the seaward side due to wave wash over the beach bar (Fromme, 1982b).

Within the backshore lagoon the exposed banks and shallows comprised fine, black sediments overlain by a three centimetre layer of mud and organic detritus. In the deeper channel the sediments consisted of coarse sand and gravel; these sediments were also anoxic and emitted hydrogen-sulphide ($H_2S$) when disturbed.

At the head of the estuary sheets of bed rock are exposed and covered in places by coarse sand and gravel, overlain with a fine silt layer.

The lagoon consists mainly of marine sediments over which fluvial silts have been deposited, while in the upper reaches of the estuary the deposits are mainly fluvial by nature. The action of tidal currents during dry summer months and relatively strong river flows during the wet season result in the deposition of marine and riverine sediments in the estuary.

## 2.4 INSHORE OCEANOGRAPHY

### 2.4.1 Tides

The tide levels for Simon's Bay, the nearest port to the Lourens River mouth, in 1982 were as follows (South African Tide Tables, 1982):

MHWS 1,8 m;

MLWS 0,32 m.

(These levels are in metres above Chart Datum.) The tidal range is therefore 1,48 m.

The tidal range measured between LWNT and HWNT during June 1982, 200 m upstream of the mouth, was ten centimetres. The lag time during this period was approximately 30 minutes.

### 2.4.2 Waves

It was found that the inshore wave energy for the coast at the Lourens River mouth was 20 percent above the mean value calculated for ten beaches (river mouths) around False Bay (Fromme, 1982b). The average energy-wave height at the mouth was 1,02 m. The beach at the mouth can thus be considered a medium to high energy beach.

### 2.4.3 Currents

Atkins (1970a) identified four main types of current patterns in False Bay:

i) cyclonic circulation caused by easterly and southeasterly winds predominantly during summer and resulting in cyclonic or anticyclonic gyres in the northeastern corner of False Bay;

ii) anticyclonic flow resulting fron strong northwesterly winds;

iii) & iv) during periods of calm, slow-moving currents appear to coincide with tidal conditions.

Atkins's (1970a) current tests led to the conclusion that the eastward longshore current is the predominant one. Glass (1980) reports that longshore movement in the bayhead beach area from Muizenberg to Gordons Bay is in an easterly direction, while to the east of the Lourens River there is a prevailing westward drift. Bally *et al.* (1980) indicated a longshore current from east to west, off the river mouth.

It would appear that the coastal currents along this section of the False Bay coastline, alternate from an easterly to a westerly direction depending on the prevailing winds and state of the tide.

### 2.4.4 Beach and Sand-bar Characteristics

The beach at the mouth of the Lourens River may be characterised by four components:

i) a slightly inclined foreshore leading up to a beach bar, which, during July 1982, was two metres high at the eastern end (by the AECI fence) and wedged out to 0,5 m to the west where the exit channel was flowing out to sea (Fromme, 1982b);

ii) partially vegetated dunes to the southeast of the estuary;

iii) a flat backshore containing the lagoon;

iv) an elevated dune belt altered by AECI and development in Strand.

Glass (1980) concluded that a westerly-flowing current to the east of the river mouth of the Lourens River results in the formation of a sediment bar across the mouth of the estuary. Sand is being transported in converging directions in this region, such that at the convergence, the beach berm widens and strong southeasterly seasonal winds move sand inland to form dunes that parallel the wind direction.

As mentioned in the previous section, the direction of longshore drift along this coastline varies considerably. However, bars may form in the direction of longshore transport (Day, 1981) or opposite to the direction of longshore drift (Reddering, 1981).

Onshore sediment movement occurs more frequently on flat beaches during calm periods when waves are flat and low. Although the beach near the mouth is a medium to high energy beach (Fromme, 1982b), according to the classification outlined by McLachlan (1980), the beach may be defined as "sheltered" to "very sheltered". The scores assigned to the respective rating categories used in this classification system are indicated in Appendix I. The very wide surf zone as well as the presence of very fine sand and the depth of reduced layers characterise this beach. Therefore, the medium to high energy waves carrying a fairly high sediment load are dissipated at the surf zone and onshore sediment deposition occurs.

Bally *et al.* (1980) report that the Gants outfall pipe has little effect on the sedimentology of the beach. However, the presence of the AECI fence to the south of the mouth does contribute to the deposition of wind-blown sand in this area (Sheffler, pers. comm.). This may contribute to the elevation of the sand-bar at its eastern root. Scott *et al.* (1952) consider that the formation of bars is primarily due to longshore currents but winds may also play a part.

# CHAPTER THREE

# PHYSICO-CHEMICAL FEATURES

## 3.1 INTRODUCTION

The description of physical and chemical parameters pertaining to the estuarine environment is important for the following reasons:

i) since the estuary is formed by the mixing of sea and fresh water and is not simply diluted sea water, it has unique physico-chemical features;

ii) the abundance of the estuarine biota is dependent on these parameters;

iii) physical and chemical changes in the environment are characteristic of individual estuaries and are important with respect to the flora and fauna;

iv) accepted water quality parameters may assist in the identification of human interferences.

The following parameters were investigated with due consideration to the four abovementioned points: temperature, salinity, dissolved oxygen, pH, nitrate, dissolved inorganic phosphate, dissolved organic carbon, turbidity and depth.

This chapter summarises data collected during field surveys over a nine month period.

## 3.2 METHODS

Sampling was carried out monthly between December 1981 and August 1982. Ten sampling stations (A to I) were chosen along the estuary from the mouth to the head, including the AECI main drain (station C), the overflow pond (station D) and the Heldersig stream (station $G_1$), which was flowing between May and August 1982 (Fig. 5). Measurements were taken within 45 minutes to 3 hours of HWONT, between 09h30 and 15h00.

Surface measurements were taken at all stations and bottom samples were collected at sites E to H where depths were greater than one metre at all times. A Hydro Products water sampler, Model No. XRB-135 was used for the collection of bottom samples.

### 3.2.1 Temperature

This was measured using a standard mercury-in-glass thermometer;

measurements were expressed to the nearest 0,5°C.

### 3.2.2 Salinity

Salinity was measured using an American Optical Corporation hand refractometer, which was temperature compensated. Values were expressed to the nearest whole number as parts per thousand (‰).

### 3.2.3 Dissolved Oxygen

A Yellow Springs Instrument Model 54 oxygen meter was used to carry out these determinations, whereby the partial pressure of oxygen in the water is measured. Saturation values for the respective temperature and salinity conditions were determined using an oxygen solubility table (Riley & Chester, 1971). Dissolved oxygen values were expressed as a percentage of the saturation value.

### 3.2.4 pH

pH was determined using a Radiometer Copenhagen pH meter 29; values were expressed to one decimal place.

### 3.2.5 Nutrients

Water samples for nutrient analysis were collected between December and June. They were filtered using 0,45 µm millipore filter paper and were frozen prior to analysis using a Technicon Auto Analyser II.

Nitrate and dissolved inorganic phosphate concentrations were expressed as µmol/l. Total dissolved carbon and inorganic carbon were determined and dissolved organic carbon was calculated by difference and expressed as mg/l.

The "March" samples to be analysed for nitrate and phosphate concentrations, were accidentally misplaced during analysis.

### 3.2.6 Depth and Turbidity

Depths were determined using a ranging rod and recorded in centimetres.

Turbidity was investigated using a 30 cm diameter secchi disc where the water was of sufficient depth, that is, between stations E and H; values were recorded in centimetres.

## 3.3 RESULTS AND CONCLUSIONS

Data collected at stations A, B, E, F, G, H and I are presented as three-dimensional figures and contour maps, obtained using the Saclant Graphics Package (Diedrich, 1979) for the Univac computer (Figs 6 to 15).*

The original data collected at the above stations as well as stations C, D and $G_1$ are presented in Appendices II and III.

No significant difference in surface and bottom values for all parameters, excluding salinity, was evidenced.

### 3.3.1 Temperature

Data are presented in Fig. 6.

[T]here was no overall increase or decrease in temperature from the mouth to the head for any one month and minimum and maximum values differed by between 1,5 and 3,5°C.

Mean monthly temperatures decreased from 27°C in December to 10°C in June and increased slightly to 12°C in August.

The sea exhibits a far smaller seasonal temperature variation than the river and has a lesser influence on estuarine temperatures. Sea temperatures in the northeastern corner of False Bay, over a three year period, averaged between 17,9 and 20,7°C in summer and 14,3 and 15,5°C in winter (Atkins, 1970b). River temperatures immediately above

* It must be noted that this package produces some distortions in the graphical presentations, due to the necessary inclusion of a "smoothing factor" (refer in particular to Fig. 14).

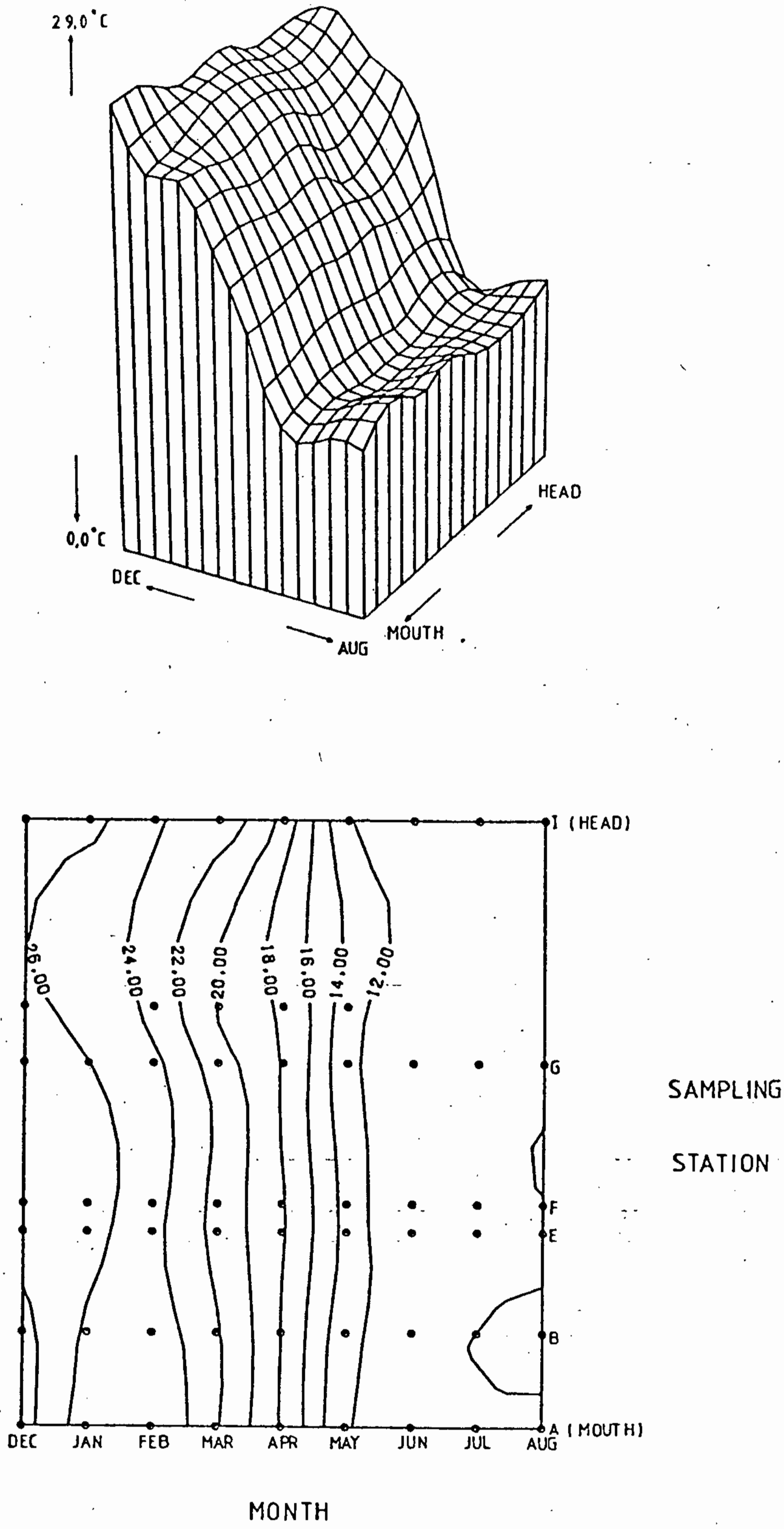



Figure 6: Temperature measurements recorded at the Lourens estuary between December 1981 and August 1982.

• represents a single datum point.

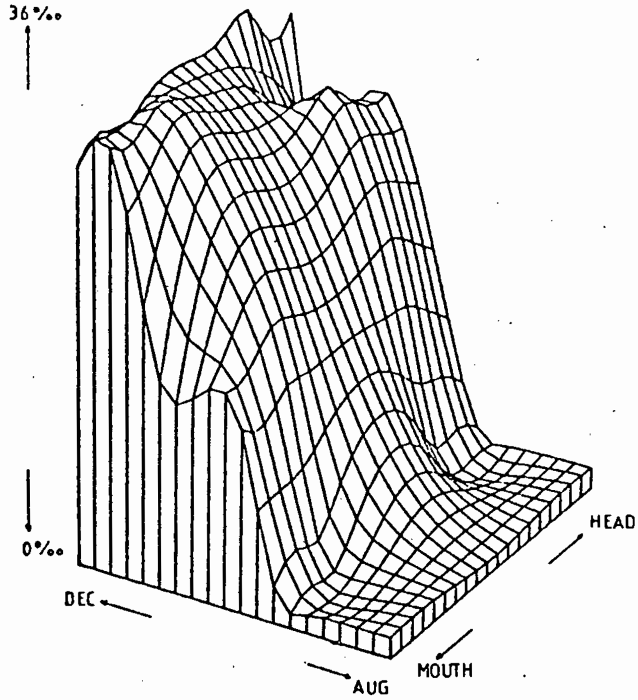
the head of the estuary were 26 and 10°C in December 1981 and June 1982, respectively. The heating effects operating in a shallow basin during the dry summer months are evidenced.

Scott *et al.* (1952) observes that landlocked water bodies along the Southwestern Cape coast exhibit an annual temperature range between 12 and 28°C.

3.3.2 Salinity

Surface and bottom salinity values differed significantly ($p < 0,05$) between December and April, bottom values being between 1 and 18‰ greater than those at the surface. From May to August surface and bottom salinities were indistinguishable.

Figure 7 illustrates the decrease in mean bottom salinity from approximately 33‰ during summer to 0‰ during the rainy season. Wave wash over the beach bar and tidal currents during high tides result in the inflow of saline water into the estuary; evaporation during the summer months causes slightly hypersaline (36‰) conditions. The decrease in this parameter at station H during January, may be attributed to the influx of fresh water subsequent to the sewage spill that occurred earlier that month. Similarly, the decrease in salinity at station E during February, was probably due to the influx of water of salinity 1‰ from the overflow pond.



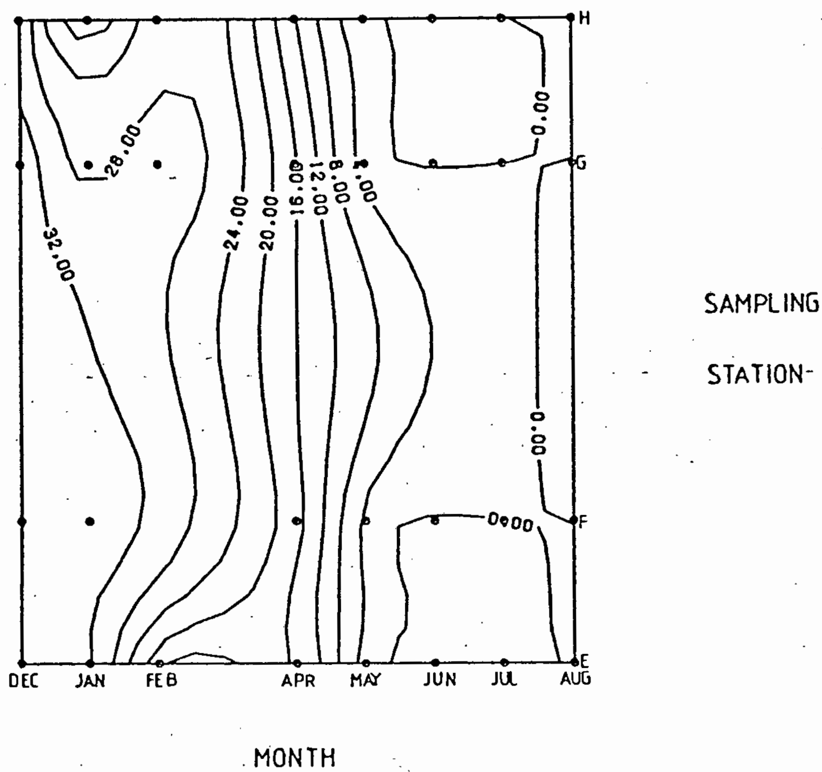




Figure 7: Bottom salinity measurements recorded at the Lourens estuary between December 1981 and August 1982.

• represents a single datum point.

Surface salinities decreased from a mean value of 27‰ in summer to 0‰ during the rainy season (Fig. 8). Salinities were generally lower at stations H and I between December and February, indicating minimal saline intrusion at the head of the estuary. However, during March, river flow into the estuary had ceased and the salinity level increased to 19‰, similar to that at the mouth, due to high evaporation. During the rainy season salinities throughout the estuary were zero.

Salinities at station C varied between 22‰ and 0‰, during the study period, while at stations D and $G_1$ they were zero throughout (Appendix III).

At LWOST on 7 July 1982, Fromme (1982b) recorded salinities of 0‰ throughout the estuary, while during HWOST surface salinities decreased rapidly from 35‰ at the mouth to 12‰ near station B and 0‰ at the Beach Road Bridge (station F).

Similar seasonal salinity regimes have been described for the Umgababa estuary in Natal (Day, 1981) and the Hermanus Lagoon in the Cape (Scott *et al.*, 1952); both of which are periodically closed, especially during the dry season. Hodgkin (1978) states that during summer, river flow into the Blackwood estuary, Australia, is negligible and sea water penetrates upstream, while during winter the incursion of saline water is prevented and the estuary is fresh throughout.
In the Berg River, Cape, saline water has been reported nearly 50 km from the mouth during the dry season, but after the rains the water at the mouth at low tide may be fresh enough to drink (Day, 1952).

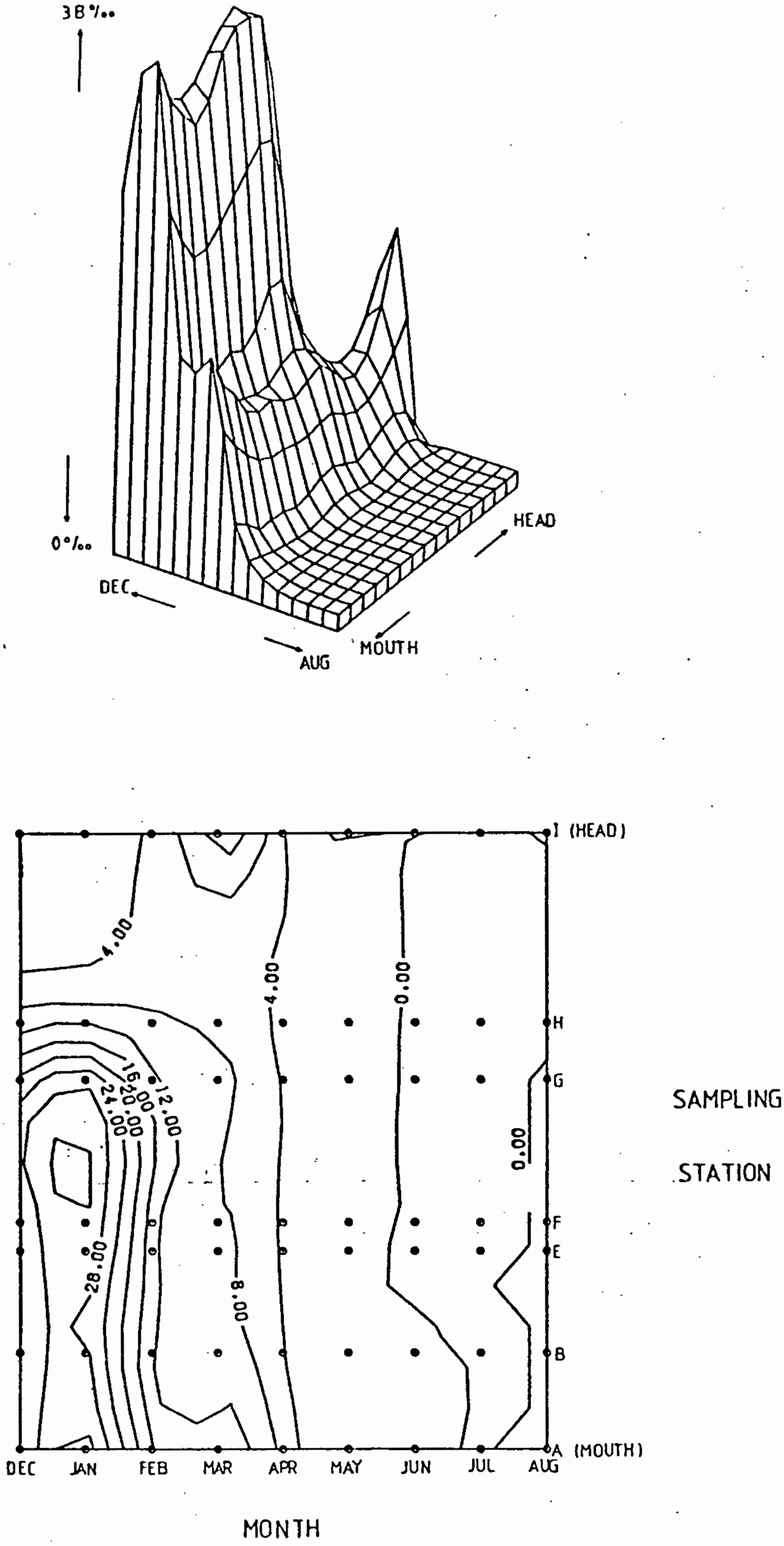



Figure 8:- Surface salinity measurements recorded at the Lourens estuary between December 1981 and August 1982.

• represents a single datum point.

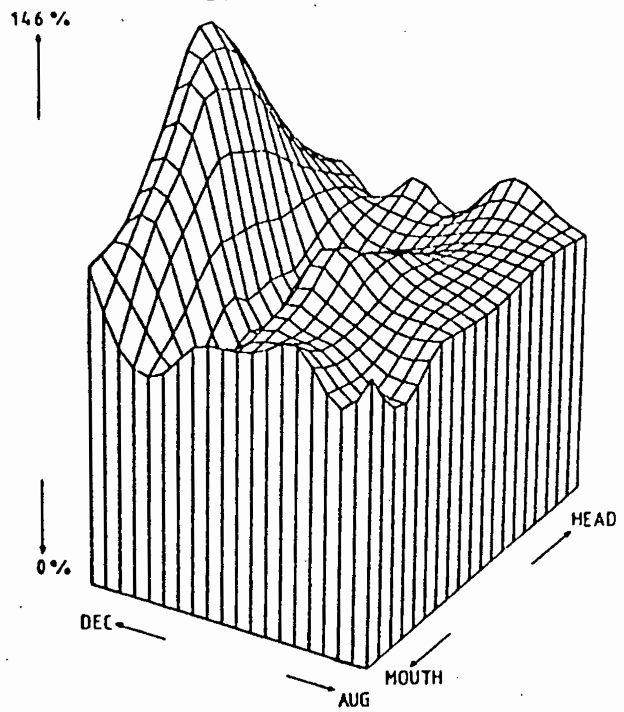
The salinity regime of the Lourens estuary may be determined to a large extent by the markedly seasonal rainfall patterns of its drainage basin; the estuary is river dominated in the wet season and marine dominated during the dry periods. The lack of strong river or tidal currents during the dry season contributes to the vertical salinity differential observed in the channels deeper than 100 cm.

### 3.3.3 Dissolved Oxygen

Dissolved oxygen levels were above 75 percent saturation throughout the study period (Fig. 9).

During the summer months of December and January dissolved oxygen levels were consistently high (83 - 146 percent) and reached super-saturation at most stations; during this period dense algal mats were observed on both the bed and the surface of the estuary. During February and March the influx of water 64 - 73 percent saturated, contributed to the lower dissolved oxygen levels recorded for those months. From May to August values averaged between 84 and 93 percent saturation and algal mats were greatly reduced as to be almost non-existent.

There was little horizontal variation in dissolved oxygen values during this period, although percentage saturation levels were greater in the middle reaches during the summer months, probably due to the greater proliferation of algae in this region.



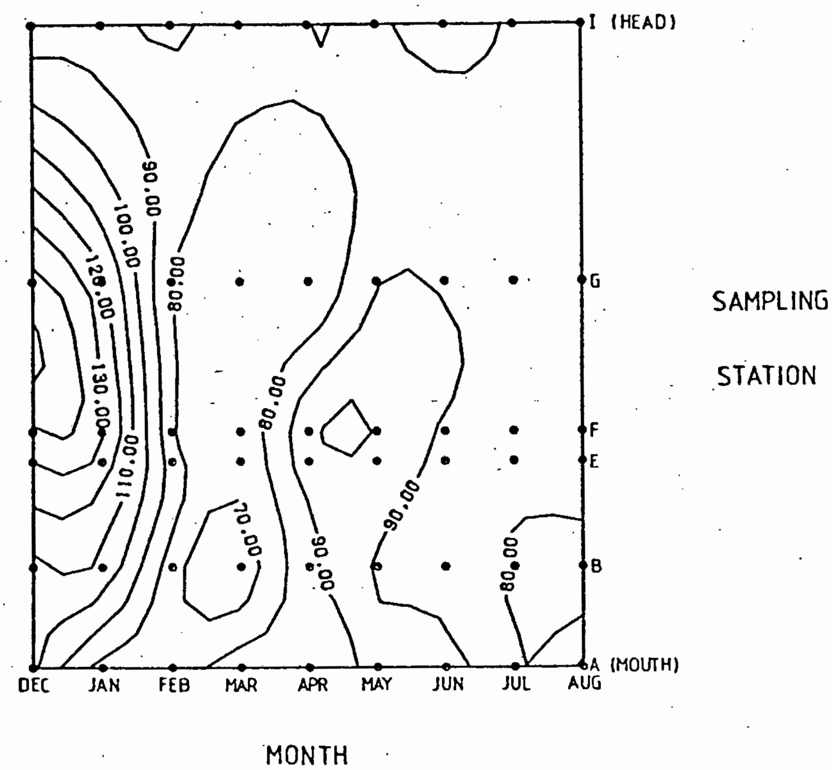




Figure 9: Percentage oxygen saturation levels recorded at the Lourens estuary between December 1981 and August 1982.

• represents a single datum point.

Percentage dissolved oxygen values recorded at stations C and D varied between 50 and 143 percent and 58 and 80 percent, respectively. Values at station $G_1$ ranged between 74 and 91 percent (Appendix III).

Nicol (1935) demonstrated 200 percent oxygen saturation levels in salt marsh pools in the early afternoon in Scotland. The high oxygen levels (greater than saturation) measured throughout the Groen estuary, were due to dense concentrations of algae and phytoplankton (Bickerton, 1981). The findings from this study compare favourably with those recorded in the literature.

In June 1982, an investigation of the oxygen levels of the sediments at stations B and C, revealed respective values of 43 and 8 percent saturation. The black colouring of sediments throughout the upper reaches of the estuary as well as the strong odour of $H_2S$ noted when these sediments were disturbed, suggest that anoxic conditions are prevalent.

It has been noted that when organic matter is supplied at a rate which exceeds the oxygen supply, anaerobic bacteria flourish and sulphates are reduced to $H_2S$ (Day, 1981). However, Head (1976) suggests that the oxidation of organically polluted water does not usually occur fast enough to exceed the supply of oxygen from surrounding water masses and the atmosphere. Broekhuysen (1935) records that daytime oxygen tensions may be high in water overlying black, anoxic mud from which $H_2S$ is released at night.

The periodic input of high nutrient loads into the estuary (see sections 3.3.5 and 3.3.7) and the subsequent eutrophication resulted in supersaturated daytime oxygen tensions in summer, whilst in winter the supply of fresh river water maintains the oxygen saturation levels of the water overlying anoxic sediments.

3.3.4 pH

A maximum pH of 8,5 was recorded in December and a minimum of 2,4 in August (Fig. 10).

During December and January pH values were consistently high (6,5 - 8,5) throughout the estuary. In February and March values ranged between 3 and 5,9, excluding values of 7,2 recorded at the head of the estuary where tidal influence was minimal. Values between 6,7 and 8,0 were recorded during the remaining five months, excluding low values of 2,4 to 4,5 noted at stations A and B in July and August.

The low pH levels recorded in the estuary are attributed to the influx of low pH water from the AECI main drain and overflow pond (Appendix III). During the winter months this water was prevented from moving upstream due to the relatively strong river flow and reduced tidal currents.

The pH of the river during the study period was between 6,5 and 7,2, while values between 7,1 and 7,5 were recorded in the sea 300 m to the

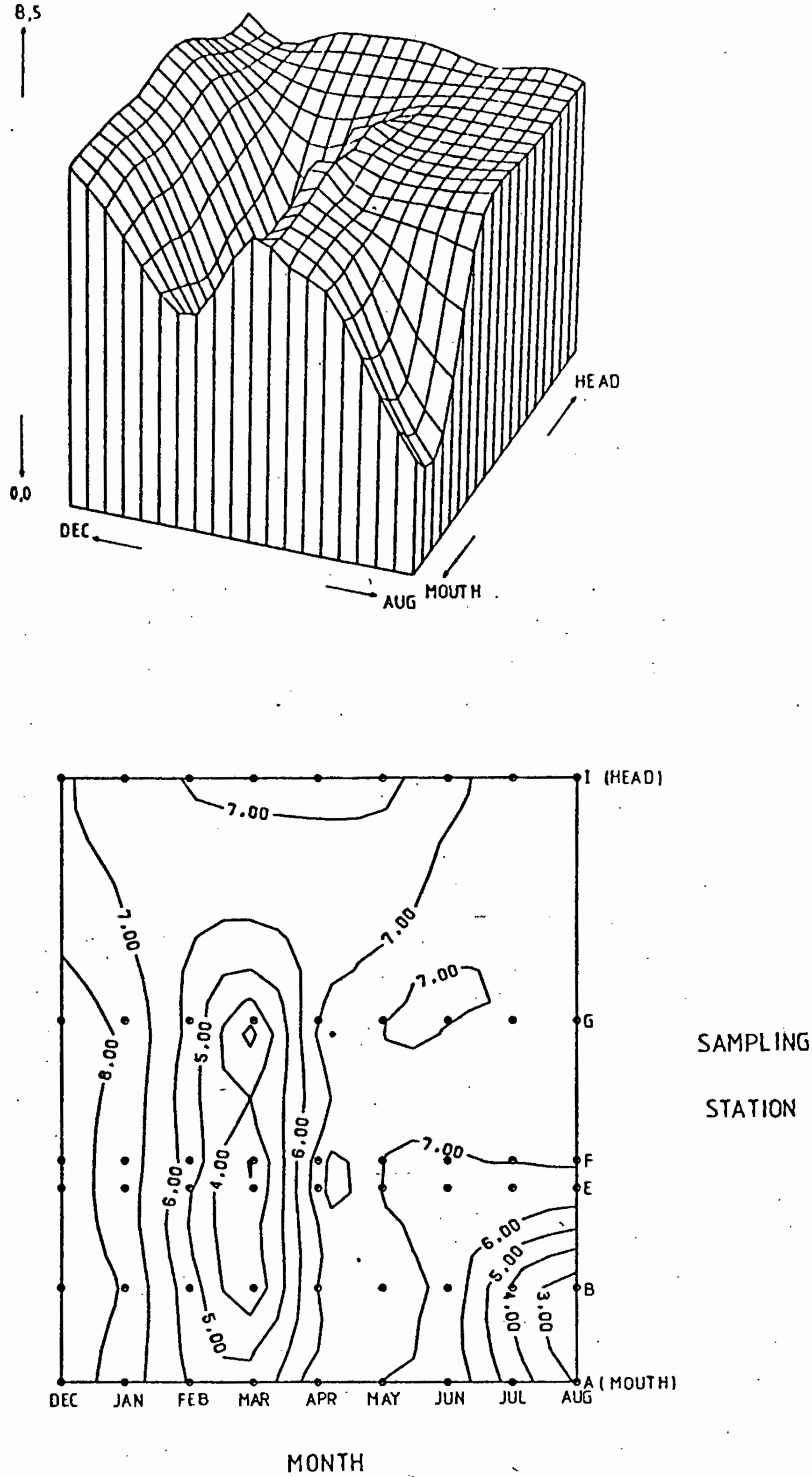



Figure 10: pH levels recorded at the Lourens estuary from December 1981 to August 1982.

• represents a single datum point.

east of the Lourens River mouth, in November (Bartlett, 1979). Scott *et al.* (1952) report that large quantities of acidic water (pH 5) enters the Klein River Lagoon via mountain streams, but this is rapidly neutralised and the lagoon is alkaline at all times.

The Lourens River estuary does not always approximate the estuarine pH limits of 7,5 to 8,4 (according to Perkins, 1974) and the influx of acidic waters from pollution sources is not rapidly neutralised. The dilution of acid waters is negligible due to the smallness of the estuary.

### 3.3.5 Nitrate

Nitrate values ranged from 0,9 to 1470,6 µmol/l (Fig. 11).

During December and January nitrate levels were fairly low and varied between 0,9 and 14,8 µmol/l. During February high nitrate levels were recorded in the lower reaches of the estuary and similar results would be expected for March, since low pH water from the AECI main drain and overflow pond was flowing into the estuary. Between April and June concentrations ranged between 2,5 and 1470,6 µmol/l, the river and overflow pond being the major sources of nitrate enrichment during these rainy months.

Eagle (1976) and Bartlett (1979) recorded nitrate values of 115,5 and 490,0 µmol/l, respectively, at the AECI main drain outlet to the sea.

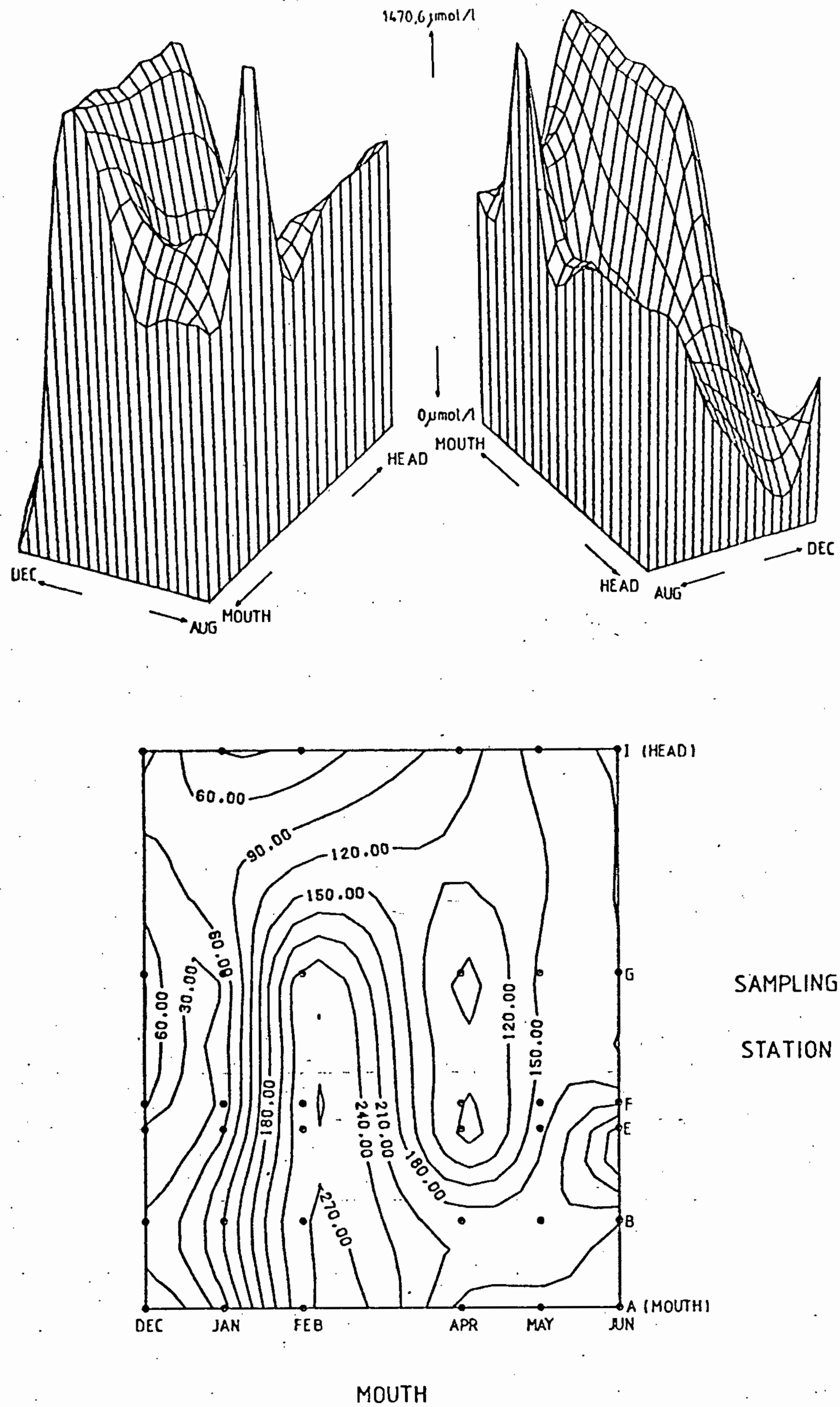



Figure 11: Nitrate levels recorded at the Lourens estuary from December 1981 to June 1982.

• represents a single datum point.

The presence of *Typha* beds lining this channel (see section 4.3.3.2) may contribute significantly to the reduction in nitrate levels. (A mean nitrate concentration of 4300,1 µmol/l was obtained at station D, during this study.)

Bally *et al.* (1980) found that subtidal nitrate values decreased from 74,29 to 10,36 µmol/l from the Gants Foods outfall pipe to the river mouth. The values obtained at this discharge pipe are an order of magnitude greater than the average for sea water and this may serve as a source of nutrient input to the estuary, especially during summer months. However, such inputs would be negligible in comparison with the AECI main drain. Run-off from arable land contributes significantly to nutrients in rivers (Hobbie, 1976) and the fluvial supply to estuaries is mainly in the form of organic detritus carried during the rainy season (Day, 1981). Harrison and Elsworth (1958) obtained nitrate values, in the Berg River, of 90 (20,3 µmol/l), 70 (38,4 µmol/l) and 250 µg/l (56,5 µmol/l) in summer, autumn and winter, respectively.

The seasonal change in nitrate levels (partly masked by local pollution inputs) at the Lourens estuary may be attributed to fertiliser leach from the upper catchment; this will be discussed further in section 5.6.2.

Day (1981) reported levels as high as 1400 µg/l (316,3 µmol/l) in the Mgeni estuary, Natal, and indicates that these values are ten times greater than those for unpolluted estuaries along the Natal coast.

Orren *et al.* (1981) gives a value of 48,0 μmol/l for the Salt River discharge into Table Bay and indicates that this is 25 times greater than reference beach concentrations.

Values obtained in this study were often greater than any recorded in other South African estuaries, as far as could be ascertained from the literature. The periodic input of nitrate-rich water from the AECI main drain results in severe pollution due to the slow dilution rates in a small estuary.

3.3.6 Phosphate

Dissolved inorganic phosphate concentrations varied between 0,2 and 7,3 μmol/l during the study period (Fig. 12).

No seasonal change in phosphate levels was identified and no horizontal distribution in values was evident. During January anomalously high levels were recorded at stations B (7,3 μmol/l) and C (11,1 μmol/l).

Eagle (1976) and Bartlett (1979) obtained values of 1,97 and 34,6 μmol/l, respectively, at the mouth of the AECI discharge channel, whereas a mean level of 64,4 μmol/l was recorded at station D during the study period. Phosphate levels recorded at stations C and D are presented in Appendix III.

Bally *et al.* (1980) recorded subtidal total phosphorus as being less

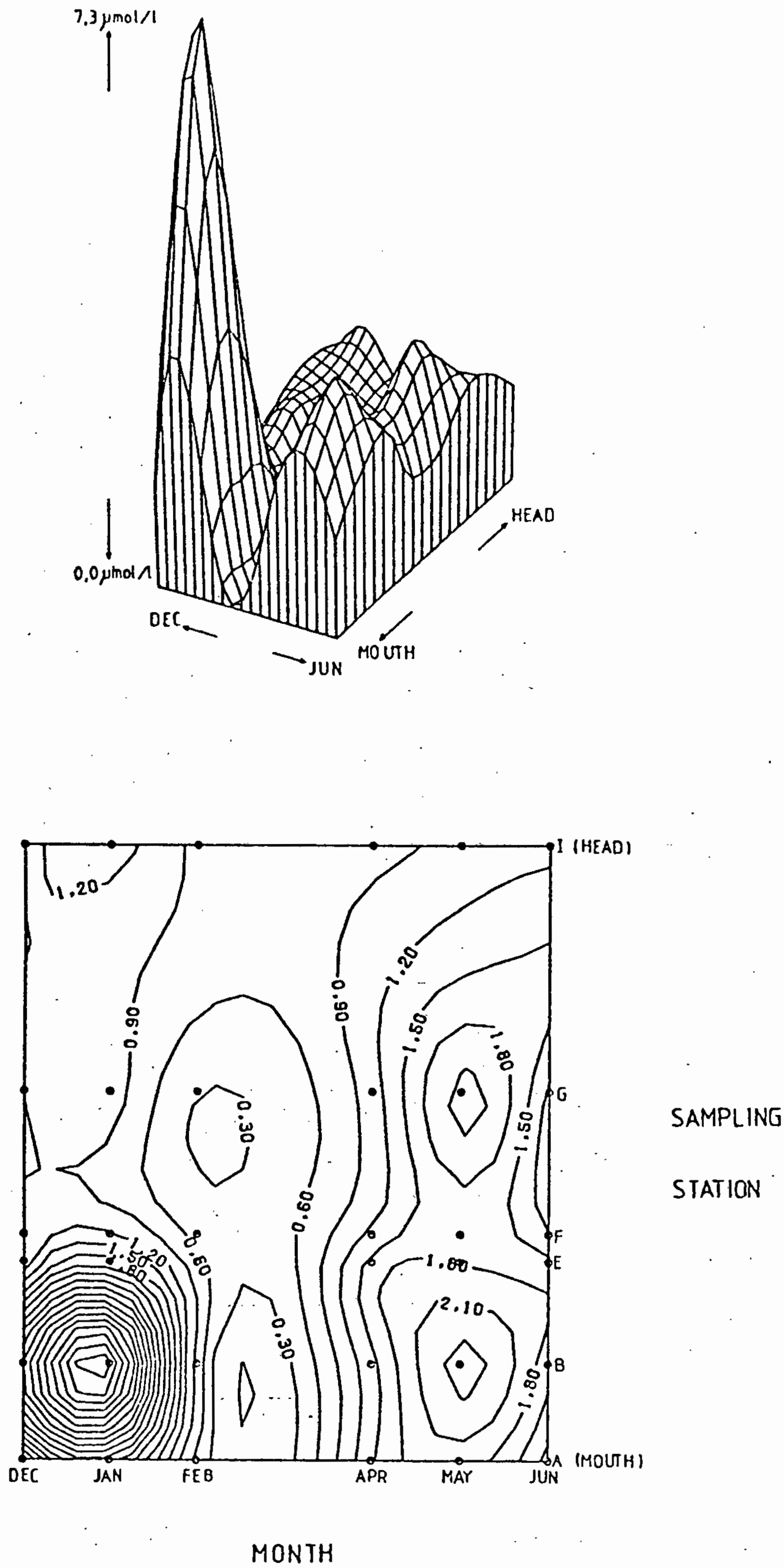



Figure 12: Dissolved inorganic phosphate measurements recorded at the Lourens estuary between December 1981 and June 1982.

• represents a single datum point.

than 0,72 µmol/l to the east of the estuary mouth. Harrison and Elsworth (1958) measured 1 µg/l (0,32 µmol/l) of soluble reactive phosphate in autumn and 60 µg/l (19,6 µmol/l) during autumn, for the Berg River. Worldwide average values of phosphate for river and sea water are 6,5 and 22,8 µmol/l, respectively (Liss, 1976).

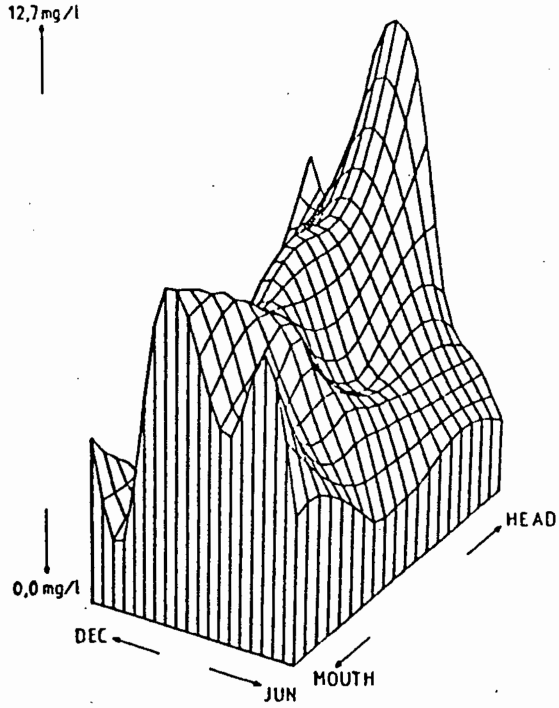
Phosphate concentrations in the Lourens River estuary were consistently low, although periodic wash in of phosphate-enriched water from the AECI discharge or the sea may result in an increase in the levels.

### 3.3.7 Organic Carbon

Values obtained ranged between 1,7 and 12,7 mg/l (Fig. 13).

No horizontal distribution or seasonal trend in values was evident. During February and March organic carbon concentrations were between 5,2 and 12,7 mg/l. Water of concentration 9,4 and 15,5 mg/l was flowing into the estuary from the overflow pond on 12 February and 16 March, respectively (Appendix III).

Bartlett and Hennig (1982) reported values between 5,9 and 12,1 mg/l in the Eerste River lagoon where a sewage works is the source of organic pollution. The concentration of organic carbon occurring in natural estuarine waters is between 1,0 and 5,0 mg/l (Head, 1976). Riley and Chester (1971) suggest that dissolved organic carbon levels may reach 20 mg/l, but values greater than 5 mg/l are usually only associated with polluted waters.



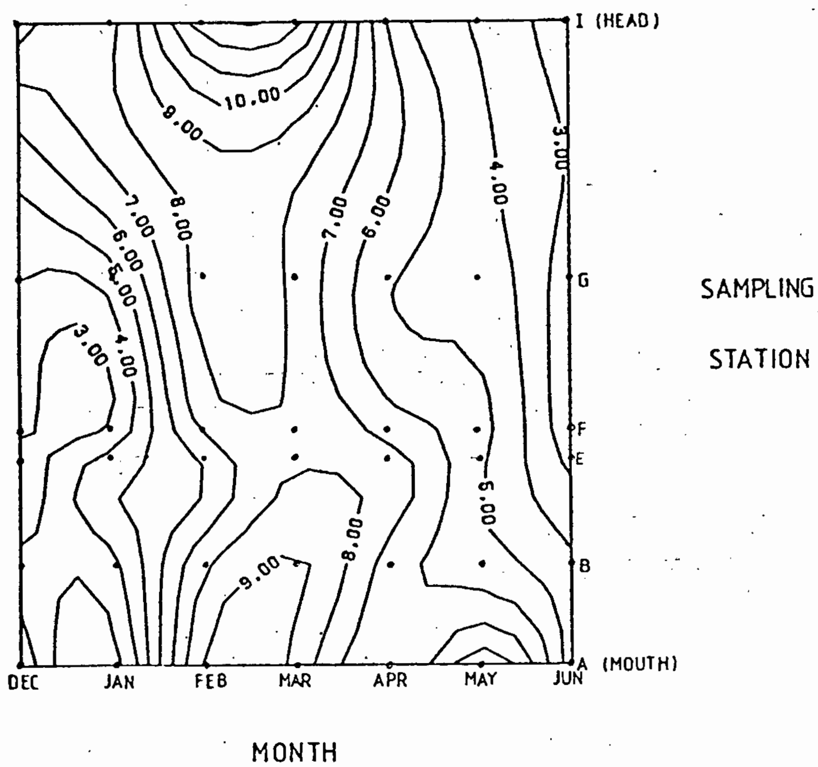




Figure 13: Dissolved organic carbon levels recorded at the Lourens estuary from December 1981 to June 1982.

• represents a single datum point.

The AECI main drain discharge is a source of organic pollution to the estuary.

### 3.3.8 Depth

The estuary shows marked seasonal changes in depth as well as horizontal variations from the mouth to the head (Fig. 14).

In December and January, there was a gradual increase in depth from the mouth (five centimetres) to stations E to G at 160 cm and a gradual decrease to 60 cm at the head. During February and March, although river flow was minimal, the influx of water via the overflow pond resulted in a five to ten centimetre increase in water level at stations E to G. The sand-bar served to dam the lagoon behind it. With the onset of the first winter rains in April, the mouth (10 to 15 cm deep) was partially scoured open and levels in the deep channels fell by approximately 35 cm. By mid-winter the mouth had been further scoured to between 50 and 75 cm, while levels in the deeper channel decreased by a further 25 cm.

Both the Hermanus lagoon (Scott *et al.*, 1952) and the Milnerton lagoon (Millard *et al.*, 1954) show a decrease in water levels during summer and autumn, when a sand-bar dams the mouth; the level increases with the winter rains until the mouth is breached. There is no additional influx of water into these two estuaries, as occurs in the Lourens estuary.

The sand-bar across the Lourens estuary mouth was only partially

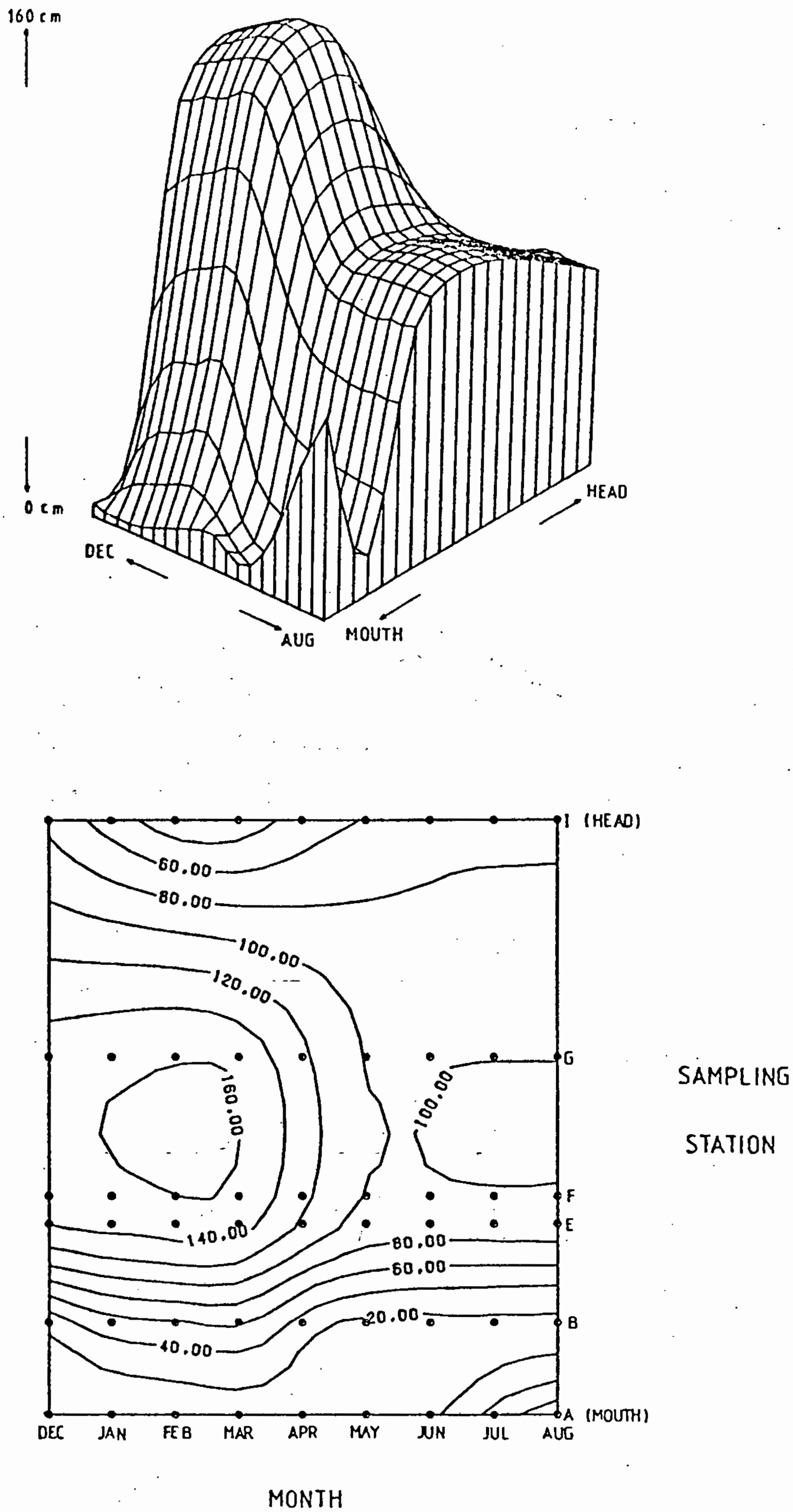



Figure 14: Depth measurements recorded at the Lourens estuary from December 1981 to August 1982.

• represents a single datum point.

developed due to the periodic influxes of water from the main drain discharge. Nevertheless, during the summer months the sand-bar served to dam the lagoon behind it and with increased river flow during the winter months, the western root of the bar was breached and water levels dropped by 50 to 60 cm.

### 3.3.9 Turbidity

There was little variation in secchi disc readings during the study period and these ranged from 75 cm to more than 100 cm (Fig. 15).

The relatively low readings obtained in December and January, may be attributed to the presence of phytoplankton blooms resulting from eutrophic conditions.

It is expected that maximum turbidities would occur during the winter rains and minimum turbidities during low flow periods in summer. The presence of retaining structures lining the banks of the upper catchment is indicative of bank erosion. However, the rainfall recorded at Lourensford Estates (unpublished data) for April to August 1982, was lower than the average values obtained for those months during the past 67 years. Relatively low winter flows may have accounted for the anomalous results obtained.

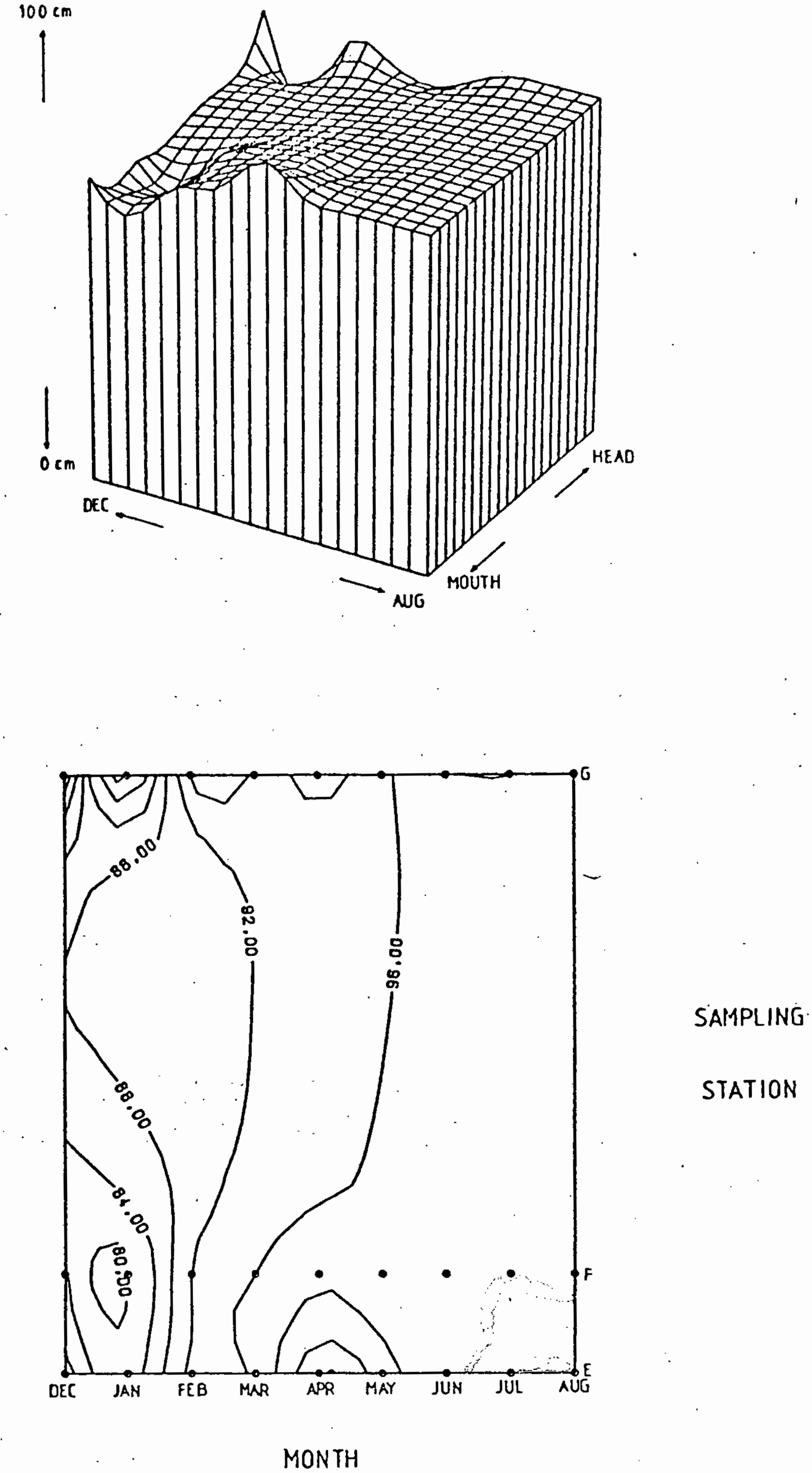



Figure 15: Secchi disc readings recorded at the Lourens estuary from December 1981 to August 1982.

• represents a single datum point.

# CHAPTER FOUR

# BIOTIC CHARACTERISTICS

## 4.1 INTRODUCTION

Estuarine biota are generally poor in number of species since an estuarine environment is one of constant change and biologically-significant environmental parameters may vary over an extreme range, both spatially and temporally. Human activities and disturbances may serve to further reduce species diversity in an estuarine environment.

A biological criterion whereby the health or welfare of an estuary can be judged, may be based on the species diversity principle. A complete structural and functional study of the ecosystem (Ward, 1978), which was beyond the limits of this task is, however, a more satisfactory means of characterising the ecological quality of the estuarine ecosystem.

## 4.2 METHODS

### 4.2.1 Bacteria

On 24 May 1982, five water samples were collected at stations A, B, C, D and E (Fig. 5) for bacteriological examination at the Government Pathological Laboratories, Cape Town. The presence or absence of *Escherichia coli* and organisms of the coliform group was investigated.

Samples were collected at LWOST according to directions stipulated by the Department of Health (South Africa, 1973-74).

4.2.2 Fauna

4.2.2.1 Zooplankton

On 8 February 1982 two plankton samples were collected in the lagoon at LWOST, each during two minute hauls.

Non-quantitative analysis of the samples was carried out, whereby relative numbers of species and developmental stages were estimated and expressed by symbols (+ to ++++) indicating presence to abundance.

4.2.2.2 Benthos

Observations were made throughout the study period (December 1981 to August 1982) as to the presence of macro-invertebrates.

On 8 February four two-minute trawls using a drag net were carried out across the width of the lagoon at LWONT. Fauna was collected and counted.

During LWONT on 27 July, macro- and meiofauna were collected on exposed sand and mud flats near stations A, B, I and C, respectively (Fig. 5). Duplicate cores were taken using a hand-operated PVC coring tube, to a depth of ten centimetres. The cores were pooled and mixed and the fauna was extracted according to Lobb's decanting and sieving technique (Furstenberg *et al.*, 1978). Meiofauna was defined as that section of the benthos that passes through a 1,0 mm mesh sieve but is retained on a 0,045 mm mesh; macrofauna is retained by a 1,0 mm mesh.

Non-quantitative analysis of the samples was carried out, whereby relative numbers of species was estimated and expressed by symbols (+ to +++) indicating presence to abundance.

#### 4.2.2.3 Fish

As mentioned in the above section, four drag net trawls were undertaken.

A gill net was set across the width of the lagoon for four hours at LWONT on 8 February. Fish were counted and measured.

#### 4.2.2.4 Avifauna

Monthly counts were carried out on the beach and lagoon below the Beach Road Bridge. Nomenclature and numbers follow McLachlan and Liversidge (1978).

4.2.2.5 Amphibians, reptiles and mammals

Observations were made as to the presence of these throughout the study area.

### 4.2.3 Flora

4.2.3.1 Phytoplankton and algae

Four surface and bottom water samples were collected on 8 February and analysed for phytoplankton and algae.

4.2.3.2 Saltmarsh and terrestrial vegetation

Specimens were collected by Mr M. O'Callaghan, Botanical Research Institute, Stellenbosch, on 30 March, with the assistance of the author and were identified by the Institute.

## 4.3 RESULTS AND CONCLUSIONS

### 4.3.1 Bacteria

Organisms of the coliform group and *E. coli* were innumerable at stations A, B, C and D where salinities were 1 and 0‰, respectively. At station E, at 0‰, *E. coli* and organisms of the coliform group were absent in 100 ml. The AECI main drain discharge containing biologically-treated sewage, is the likely source of faecal bacteria.

Bally *et al.* (1980) recorded a decrease in the numbers of coliform bacteria to the west of the Gants Foods outfall pipe; *E. coli* was absent in this area.

Although the presence of these bacteria does not constitute conclusive evidence of pathogens, it is nevertheless sufficient to indicate that the water is potentially dangerous (Grabouw, 1970). These bacteria may not be important in the estuary itself since it has limited recreational value, but the release of faecal-polluted water with the possibility of waterborne disease transmitters, into the sea, is possibly more serious. However, the sudden change in temperature and salinity from the near-fresh estuary to the sea, would probably combine to kill a large proportion of the organisms quite rapidly (Bally *et al.*, 1980).

4.3.2 Fauna

4.3.2.1 Zooplankton

Results of the analysis are presented in Table 1. Rotifers, harpacticoid copepods and developmental stages of the copepod *Acartia* dominated the samples which were poor in numbers of species. Salinity was between 6 and 8‰.

TABLE 1 The relative abundance of species and developmental stages of zooplankton, as indicated by the number of + symbols. Samples were collected on 8 February. (+ = present; ++++ = abundant)

| CLASS/PHYLUM | SPECIES/DEVELOPMENTAL STAGE | ABUNDANCE |
|---|---|---|
| PROTOZOA | *Noctiluca scintillans* | + |
| | Amoeboid protozoan | + |
| ROTIFERA | Rotifer | ++++ |
| COPEPODA | *Acartia longipatella* adult | ++ |
| | *A. longipatella* juvenile | ++++ |
| | *A. africana* | + |
| | *Acartia* nauplius larva | ++++ |
| | *Oithonia brevicornis* | + |
| | *Saphirella* stage | + |
| | Harpacticoid | ++++ |
| | Harpacticoid bearing eggs | +++ |
| | Copepod nauplius | + |
| CIRRIPEDIA | Cypris larva | + |
| OSTEICHTHYES | Fish egg | + |

All species recorded are characteristic of the south coast of South Africa (Grindley, 1981), and rotifers, although more abundant in fresh water, are found in salt water (Ward & Whipple, 1966).

Estuaries are richest in species when they are permanently open and marine dominated; diversity therefore decreases with decreasing salinity (Grindley, 1981). The severe hydrological fluctuations and low salinities noted for many months at the Lourens estuary contribute to the small number of species recorded.

4.3.2.2 Benthos

The only macrofauna revealed by drag net trawls was the crown crab (*Hymenosoma orbiculare*); 13 specimens were identified.

During May to August, a few burrows of the sand prawn (*Callianassa kraussi*) and empty casings of chironomid larvae (*Polypedilum* sp.) were recorded on the exposed sand flats above station B, at LWONT.

The results of the analysis of meio- and macrofauna from stations A, B, C and I are presented in Table 2. Harpacticoids, nematodes, aquatic mites and an unidentified insect larva were the only meiofaunal representatives to be found. The characteristic estuarine meiofauna, namely nematodes and harpacticoids, was absent from the estuary except in coarse, fairly anoxic sediments in the upper reaches of the lagoon. The faunal samples were dominated throughout by chironomid larvae of the Dipteran order.

TABLE 2 Meio- and macrobenthic fauna recorded at the Lourens estuary on 27 July 1982, as indicated by + symbols. (+ = present; +++ = abundant)

| SAMPLING STATION | A | B | C | E | I |
|---|---|---|---|---|---|
| FAUNA | | | | | |
| NEMATODA | | | | | |
| Nematode | | | | +++ | |
| ANNELIDA | | | | | |
| Oligochaeta | | | | | |
| immature Oligochaeta | | | | | + |
| *Tubifex tubifex* | | | ++ | | +++ |
| ARTHROPODA | | | | | |
| Crustacea | | | | | |
| Harpacticoid Copepod | | | | +++ | |
| Insecta | | | | | |
| *Heterotrissocladius* sp. | | ++ | | | |
| *Chironomus* | | +++ | +++ | | |
| *Dicrotendipes modestus* | | | + | | |
| *D. nervosus* | | | + | | |
| *Micropsectra* sp. | | | + | | |
| *Polypedilum* sp. | | | + | | |
| dipteran larva | | | + | | |
| insect larva | +++ | | | | + |
| Arachnida | | | | | |
| aquatic mite | +++ | | | | |

Bally *et al.* (1980) recorded the following macrofauna on the sandy beach between high and low tide to the southeast of the river mouth; *Scololepis squamata, Eurydice longicornis, Nephthys capensis, Bullia rhodostoma* and *B. pura*. Nematodes were found to dominate the meiofaunal samples, harpacticoid copepods being found in low numbers due to the fineness of the sand.

Although the presence of insect larvae, especially of the Chironomidae family, have been recorded in a number of estuaries (Begg, 1978; Day, 1981), little discussion has ensued. Tubificids and chironomids are characteristic of aquatic habitats, but only when they occur in very large numbers are they indicators of organic pollution (Williams, 1980).

The benthic fauna of unpolluted, blind estuaries, such as the Hermanus lagoon (Scott *et al.*, 1952), Milnerton lagoon (Millard & Scott, 1954) and the Bot River estuary, Cape Province (Koop *et al.*, 1982), is impoverished in comparison with permanently open estuaries.

Brown (1959) attributes the paucity of fauna in the Orange River estuary, Cape Province, largely to the greatly increased summer flows which reduce the mixing zone of the estuary. In the Blackwood estuary, Australia, the duration and extremes of salinity are certainly overriding factors in respect of the diversity and composition of the biota. The organisms living there are exposed to greatly different conditions for several months at a time (Hodgkin, 1978).

The paucity of benthic fauna is ascribed to periodic chemical pollution inputs, the presence of anoxic sediments and seasonal hydrological fluctuations exhibited by the estuary.

4.3.2.3 Fish

The following fish were identified from gill net and drag net catches: six haarder (*Liza richardsoni*) (3 to 23 cm); one leervis (*Lichia amia*) (17 cm); one white stumpnose (*Rhabdosargus globiceps*) (three centimetres) and two gobies (*Psammagobius knysnaensis*) (1,5 cm).

Shoals of up to 1000 juvenile *L. richardsoni* were observed in the shallows and swimming into the mouth during February.

Following the discharge of raw sewage into the estuary during January 1981 (see section 5.6.1), five species of fish were identified (M.R. Brett, Cape Department of Nature and Environmental Conservation, pers. comm.). These were: white steenbras (*Lithognathus lithognathus*); haarder; sea barbel (*Arius feliceps*); elf (*Pomatomus saltator*) and leervis. A net sample collected in May 1982 by Brett (pers. comm.) revealed Cape silverside (*Hepsetia breviceps*) and the goby (*Glossogobius platygobius*).

All of the above nine species are common in Cape estuaries (Van der Elst, 1981), the leervis, stumpnose, steenbras and elf being important angling fish in the Cape or in Natal, whence some migrate during autumn.

The importance of estuaries as nursery grounds for juvenile fish is generally accepted, and juveniles might enter estuaries in spring or summer when the mouth is open.

The small number of species recorded in the estuary may be explained by the reasons given in the preceding section.

4.3.2.4 Avifauna

Thirty species of birds were recorded at the mouth of the estuary between December and August (Table 3).

Between December and February flocks of up to 11 000 Common, Arctic and Sandwich Terns were seen roosting on the beach. Large numbers of Reed Cormorants, Silver and Southern Black-backed Gulls were recorded at the estuary at all times.

During counts of wader species, Summers *et al.* (1977) recorded White-fronted Sandplover, Stilt and Sanderling at the estuary. They noted that the banks of the estuary were too steep and well-vegetated to be suitable for wader species. Approximately 30 000 Common and Arctic Terns were recorded at the mouth in January 1981 (Underhill and Cooper, 1982).

Bally *et al.* (1980) documented that almost no birds occurred to the east of the AECI security fence on the beach, but that relatively large numbers were observed within the undisturbed AECI property.

TABLE 3 Birds recorded at the Lourens estuary between December 1981 and August 1982

| Roberts No. | Species Common Name | 17.12.81 | 14.1.82 | 8.2.82 | 16.3.82 | 15.4.82 | 28.5.82 | 23.6.82 | 27.7.82 | 13.8.82 |
|---|---|---|---|---|---|---|---|---|---|---|
| 47 | White-breasted Cormorant | 0 | 1 | 0 | 2 | 2 | 11 | 5 | 2 | 6 |
| 50 | Reed Cormorant | 36 | 37 | 146 | 64 | 50 | 57 | 0 | 28 | 20 |
| 54 | Grey Heron | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 |
| 59 | Little Egret | 1 | 1 | 3 | 0 | 1 | 1 | 1 | 0 | 1 |
| 60 | Yellow-billed Egret | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 89 | Egyptian Goose | 0 | 2 | 1 | 0 | 2 | 0 | 2 | 2 | 2 |
| 212 | Coot | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 231 | Black Oyster-Catcher | 1 | 2 | 3 | 12 | 0 | 3 | 2 | 9 | 2 |
| 235 | White-fronted Sandplover | 4 | 17 | 1 | 0 | 3 | 0 | 0 | 3 | 2 |
| 245 | Blacksmith Plover | 22 | 0 | 7 | 28 | 1 | 7 | 4 | 0 | 1 |
| 251 | Curlew Sandpiper | 0 | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 0 |
| 255 | Sanderling | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| 263 | Greenshank | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 269 | Avocet | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| 270 | Stilt | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 |
| 275 | Dikkop | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 287 | Southern Black-backed Gull | 15 | 3 | 6 | 4 | 160 | 51 | 57 | 32 | 35 |
| 288 | Grey-headed Gull | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 2 |
| 289 | Silver Gull | 43 | 91 | 26 | 11 | 85 | 4 | 93 | 55 | 74 |
| 291<br>294<br>296 | Common Tern<br>Arctic Tern *<br>Sandwich Tern | 11 000 | 7-10 000 | 5000 | 0 | 60 | 0 | 0 | 0 | 0 |
| 298 | Swift Tern | 0 | 2 | 0 | 0 | 80 | 0 | 0 | 22 | 8 |
| 311 | Rock Pigeon | 3 | 6 | 1 | 0 | 3 | 0 | 3 | 0 | 2 |
| 394 | Pied Kingfisher | 2 | 1 | 1 | 1 | 4 | 4 | 2 | 2 | 1 |
| 397 | Malachite Kingfisher | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 493 | European Swallow * | 0 | 0 | 1 | 10 | 0 | 0 | 0 | 0 | 0 |
| 509 | African Sand Martin | 0 | 0 | 35 | 20 | 0 | 0 | 0 | 0 | 2 |
| 543 | Cape Bulbul | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| 686 | Cape Wagtail | 0 | 1 | 1 | 2 | 2 | 1 | 0 | 3 | 0 |

* Indicates approximate numbers.

Siegfried (1980) remarked on the large sea bird roost of terns and cormorants in particular, within the restricted beach area of the Lourens River mouth.

One hundred and sixteen species of bird have been noted at the AECI bird sanctuary above the head of the estuary (H.H. van Niekerk, AECI, pers. comm.).

Although the Lourens River is depauperate in numbers of species, it serves as an important roosting site for sea birds. It may become geographically linked to the AECI bird sanctuary if the latter is extended (Van Niekerk, pers. comm.).

4.3.2.5 Amphibians, reptiles and mammals

A Common or Brown Water Snake (*Lycodonomorphus rufulus*) approximately 50 cm in length, was identified at the head of the estuary on 12 February. The snake caught and constricted a seven centimetre long haarder (probably *L. richardsoni*).

Appendix IV lists the amphibians and reptiles recorded for the area covered by the South Africa 1:50 000 Sheet, Somerset West (1981). Records were obtained from Poynton (1964), Greig and Burdett (1976), Fitzsimons (1943 & 1962) and unpublished records from the Cape Department of Nature and Environmental Conservation. Endangered species according to McLachlan (1978) are indicated.

The spoor of two Cape Clawless Otter (*Aonyx capensis*) was observed on the exposed sand flats on 28 June; there was also evidence of the Cape Dune Molerat (*Bathyergus sucillus*) near the pump station. The spoor of Water Mongoose (*Atilax paludinosus paludinosus*) was recorded on the sand flats on 13 August.

Van Niekerk (pers. comm.) has identified Steenbok (*Raphicerus campestris campestris*), Grysbok (*Raphicerus melanotis*), Cape Clawless Otter and Water Mongoose in the vicinity of the river mouth.

A list of the mammals recorded to be present in the area covered by the South Africa 1:50 000 Sheet, Somerset West (1981), within which the Lourens estuary and catchment fall (Stuart *et al.*, 1980), is given in Appendix V. Rare and threatened species are indicated according to Meester (1976) and Skinner *et al.* (1977).

### 4.3.3 Flora

#### 4.3.3.1 Phytoplankton and algae

During the field surveys in February and March, the estuary was observed to be turbid with a brown suspension caused by a filamentous organism that may have been part of a fungal mycelium. Unicellular and colonial green algae including *Scenedesmus* sp. and *Coelastrum* sp., as well as various planktonic and epiphytic diatoms, were prolific.

Dense algal mats covering both the surface and the bed of the estuary were recorded from the mouth to the head between December and March. These were identified as *Cladophora* sp., *Enteromorpha* sp., *E. plumosa* and *Chaetomorpha* sp. During April the surface mats were greatly reduced and by May only isolated patches were observed on the bed of the estuary. By July and August little macroscopic algae remained.

Algal blooms occurred in the estuary during the summer months as a result of eutrophication.

4.3.3.2 Saltmarsh and terrestrial vegetation

Plant species identified at the Lourens estuary are presented in Appendix VI.

There are few areas along the estuary of low lying, muddy banks suitable for colonisation by saltmarsh plants and *Paspalum vaginatum* dominates such areas, where they are present. *Juncus kraussii*, *Phragmites australis* and *Cyperus textilis* (kooigoed) are found along the river banks; beds of *Typha capensis* line the AECI main drain channel out to sea.

Dune vegetation

The fore dunes are sparsely covered by typical dune plants, such as *Ehrharta villosa* (pypgras), *Senecio elegans* (strandblommetjie), *Tetragonia fruticosa* (kinkelbossie) and *Trachyandra divaricata*.

There is little natural vegetation to be found along the Lourens estuary and disturbed areas, with alien vegetation, or tended areas prevail.

Elevated dune belt - AECI mouth area

Excavations and the dumping of sand and gravel have been noted at various sites. *Pennisetum clandestinum* (kikuyu) covers large areas of ground, while *Tetragonia fruticosa, Geranium incanum* (bergtee), *Carpobrotus edulis* (Hottentots fig) and *Pelargonium capitatum* occur in patches on both sides of the lagoon. An area below the pump station comprises *Stenotraphum secundatum* (buffalo grass), young *Acacia cyclops* and *A. saligna* plants as well as various bulbs.

Disturbed vegetation - Beach Road Bridge to pipe bridge.

The land on the southern bank includes mainly tended plots and undeveloped sites which are covered predominantly in *Pennisetum clandestinum.*

On the northern bank, above the road, an area consisting mostly of weeds, such as *Conyza* cf. *ambigua*, *Cynodon dactylon* and *Sonchus oleraceus* was identified. Beyond this *Pennisetum clandestinum* maintains extensive cover, but numerous shrubs, such as *Colpoon compressum* (basbessie), *Rhus glauca* (korentebessie), and exotic trees, such as *Metrosideros excelsa, Eucalyptus lehmanii* (spider gum), *Populus canescens, Acacia cyclops* and *A mearnsii* were recorded. Smaller plants including *Datura stramonium* (stinkblaar), *Cynadon dactylon* and

*Nasturtium* sp. occur near the waters edge.

In September 1982 the entire northern bank was enclosed within an AECI fence and a programme to remove problematical alien vegetation, such as *Acacia* spp., and to replace these with indigenous varieties and harmless exotics, was initiated (Van Niekerk, pers. comm.).

According to Boucher (1981) the Lourens estuary falls within the Southwestern Cape veld type - coastal macchia. A number of species are listed as still occurring in the southern coastal part of the coastal macchia; of these only *Ehrharta, Rhus, Pelargonium, Geranium, Watsonia* and *Senecio* species were identified at the Lourens estuary.

The highly disturbed nature of the area adjacent to the Lourens estuary has resulted in a reduction in the extent of the indigenous vegetation.

# CHAPTER FIVE

# HUMAN INFLUENCES

## 5.1 INTRODUCTION

Effective conservation of estuaries, once the pollution inputs, recreation pressures, urban and industrial developments and human activities in the catchment have been identified, is often impaired by the complexity of administrative controls responsible for these systems. Numerous local authorities and state departments are involved in the management of estuaries, and the problems associated with private land ownership further complicate attempts to preserve estuaries for the optimum benefit of all.

## 5.2 LOCAL AUTHORITIES AND LAND-OWNERS

The river, from the high-water mark to its sources, falls under the jurisdiction of the Stellenbosch Divisional Council.

In the upper catchment, the Landdroskloof and Sneeukopkloof streams which feed into the river, rise on State land within the Hottentots Holland Nature Reserve, which is administered by the Directorate of Forestry, Department of Environment Affairs. The remainder of the land in the upper catchment is private agricultural land, the Strand and Somerset West Municipalities being responsible for the major part of the lower river.

The Somerset West Municipality extends from Broadway to the boundary of private agricultural land on the northern bank and from the railway line to the bounds of residentially-zoned land on the southern bank. The Strand municipal area extends along the southern bank of the river from the high-water mark to the railway line and includes the disused sewage works and pump station on the northern bank.

The remainder of the land bordering the northern bank of the river from the boundary of the Somerset West Municipality to the low-water mark, is controlled by AECI.

Figure 16 shows the boundaries of the local authorities in the Lourens River basin, as adapted from the Stellenbosch Divisional Council Ground Plan (1966) and South Africa, 1:50 000 Sheet (1981).

The land owned by AECI ranges from the Somerset West boundary to the old Strand Sewage Works; this area includes the maturation ponds. This land as well as that on which the sewage works stands, was bought from AECI by the Strand Municipality for the sole purpose of establishing a sewage purification works. It was discontinued in

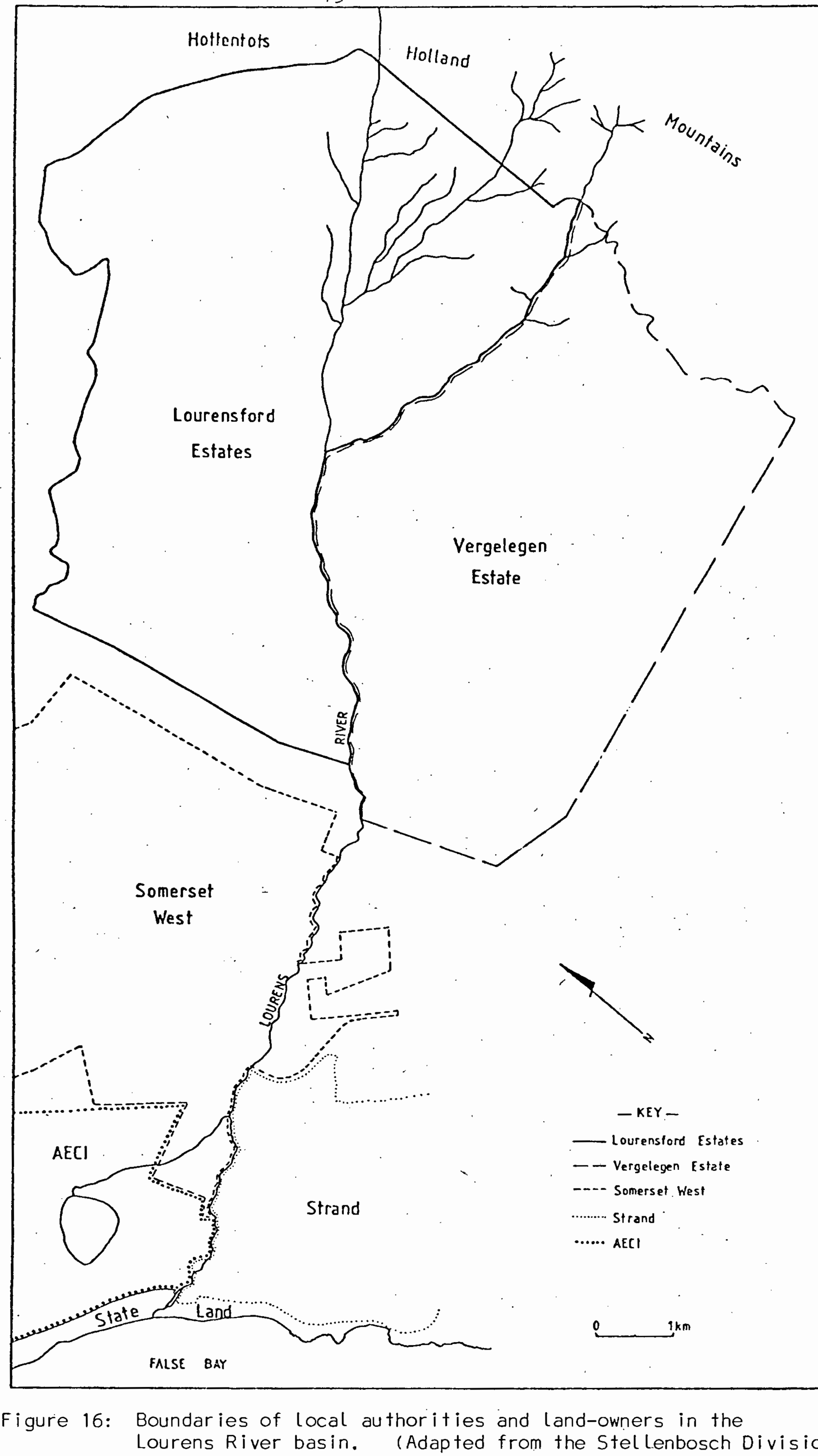



Figure 16: Boundaries of local authorities and land-owners in the Lourens River basin. (Adapted from the Stellenbosch Divisional Council Ground Plan (1966) and South Africa 1:50 000 Sheet, Somerset West (1981).)

1978 and the land is at present lying waste, although the plot is soon to be returned to AECI (Sheffler, pers. comm.). The land below this site up to Beach Road is also owned by AECI.

Below Beach Road, the pump station site was purchased from the State by the Strand Municipality in 1977 (R.C. Venter, Strand Municipality, pers. comm.). Ownership of the remainder of the beach area (sea-shore) is vested in the State President, although it is presently administered by AECI.

Millar (1981) interprets the "sea-shore" (as defined by the Sea-shore Act (South Africa, 1935)) as "the water and the land between the low- and high-water marks, both along the coastline and in tidal and/or saline areas of rivers, estuaries or lagoons". The estuary and beach area were therefore, accordingly administered for the State President by the Land Tenure Branch of the Department of Agricultural Credit and Land Tenure, the responsible official being the Minister of Agriculture. In 1964, however, a regulation was passed whereby AECI was granted permission to enclose the beach area within a security fence and to prohibit public access (South Africa, Department of Lands, 1964).

## 5.3 LAND AND RIVER USES

### 5.3.1 Catchment

The Hottentots Holland Nature Reserve was proclaimed in 1979 and is managed for its fynbos and water resources and also serves as a recreational area (South Africa, Department van Bosbou, 1979).

At least ten kilometres of river in the upper catchment is bounded to the west and east by the private agricultural estates of Lourensford and Vergelegen, respectively (Fig. 16). The management of these two estates is, therefore, particularly important.

The high-lying land on Lourensford Estates is afforested with *Pinus radiata* plantations, while low-lying regions are planted with fruit trees, such as pears, apples, plums, kiwis, lemons and grapes. A number of dams have been built on tributaries which led into the river. Irrigation is carried out by means of numerous furrows which lead off the storage dams or the river itself; this network of furrows collects run-off from roads, dam outlets and agricultural land and returns the water to the river (Birch, pers. comm.).

Agricultural practices on Vergelegen Estate are quite different - sheep are kept on pastures and cattle in yards. However, a similar irrigation system, comprising dams and furrows exists (P. Nel, Vergelegen Estate, pers. comm.).

Fynbos and indigenous forest vegetation may still be found in the kloofs and mountains, but various alien species are fairly common. *Hakea sericea* is encroaching on higher ground and regular eradication programmes are in operation. *Acacia longifolia*, *A. saligna* and *A. mearnsii* and *Lantana camara* line the river course and although

Lourensford Estates remove these noxious plants, they are preferred by the neighbouring estate since they prevent bank erosion (Nel, pers. comm.).

The remaining agricultural land consists of a number of smaller farms where orchards, vineyards, and kikuyu are cultivated and sheep, cattle and pigs are kept. Alien invaders, such as *Acacia* spp. *Lantana camara* and *Sesbania punicea* proliferate along the river bank, but few farmers institute the necessary control measures.

Fertilisers and top-dressings are applied to the agricultural fields mainly during autumn and the end of winter, although dressings are applied throughout the year (F. Smit, Agricultural Extension Officer, Stellenbosch, pers. comm.).

Within the Somerset West Municipality, riparian land is mostly privately owned and residential, but is zoned public open space (Hottentots Holland Basin, Zoning Map, 1979). There are a few business and light industrial sites adjacent to the river as well as several public service sites, such as a power substation and ambulance station; dumping and littering is prevalent on all these sites as well as on undeveloped plots where vagrancy also occurs. A large public park (Radloff Park) is a centre for recreation and dumping and is used by picnickers and vagrants alike. Noxious weeds line the river banks.

The majority of riparian land in Strand is designated public open space

(Hottentots Holland Basin, Zoning map, 1979).and numerous undeveloped residential plots exist; these are used by children for recreation, by vagrants and as sites for dumping and littering. A light-industrial company situated below the Provincial Main Road is responsible for the dumping of concrete and cement dust into the river (Van Niekerk, pers. comm.).

The old maturation ponds site owned by AECI serves as a bird sanctuary.

The river, including all associated tributaries and dams, from its sources to tidal waters is scheduled a trout area as proclaimed by the Cape Nature Conservation Ordinance of 1974 (Cape Provincial Administration, 1974). Trout fishing is carried out particularly in the upper catchment and fish up to 47 cm have been caught (Nel, pers. comm.); however, much illegal fishing occurs (Botha, 1980).

A Water Court Order of 1936 ruled how the water of the Lourens River should be apportioned amongst the network of furrows from which the riparian owners would subsequently draw their share (Ninham Shand & Partners, 1974). Riparian owners still making use of water from furrows share the amount available by agreement with themselves and the municipality levies the necessary tariff.

Strand Municipality has water rights for domestic use on private farmland, but most of its water is supplied by Steenbras Dam, particularly during summer (Sheffler, pers. comm.). From 1980 to 1982 the municipality obtained between 40 x $10^6$ and 60 x $10^6$ l of water per month from the river.

The Somerset West Municipality receives most of its water from the river during both the dry and rainy seasons (C.F.B. Krige, Somerset West Municipality, pers. comm.). During winter months the demand is on average 5,5 x $10^6$ l per day. Approximately 400 x $10^6$ l is also pumped from the river into a storage dam to be used during the summer months. A permit allowing 1300 x $10^6$ l per annum of surplus water to be drawn during the winter months has been obtained from the Department of Water Affairs. During the summer months the demand increases to an average of 11 x $10^6$ l per day, only 4,5 x $10^6$ l being obtained directly from the river.

Approximately 70 percent of the river flow is apportioned to private land-owners in the upper catchment and to the municipalities, while AECI is entitled to the balance of the river flow reaching Melcksloot, which runs into Paardevlei.

It has been indicated that the distribution of water from the Lourens River is very complex (Krige, pers. comm.) and that the above discussion is not complete. A spokesman for AECI (pers. comm.) has commented that the company are hoping to reconvene the water court, since "water stealing" is occurring upstream.

5.3.2 Estuary

Strand municipal land on the southern bank is zoned private residential and public open space (Hottentots Holland Basin, Zoning map, 1979). A number of undeveloped sites, used by children for recreational purposes and frequented by vagrants, exist.

Below Beach Road a municipal picnic area and parking ground bounds the AECI security fence which extends into the sea below the low-water mark (Fig. 5). An outfall pipe from Gants Foods (Pty) Ltd discharges effluent wastes into the sea to the south of the AECI fence. The pipe reaches the level of low equinoctial tides such that the effluent almost always discharges into the sea (Bally *et al.*, (1980).

A pipe bridge bearing a sewer pipe from Strand and a waterworks pipe from Steenbras Dam to Cape Town, crosses the river at the head of the estuary. Sewage pipes from Strand and Somerset West pass along the length of the northern bank to the pump station near the mouth. Beach Road Bridge supports sewage pipes from the Strand beachfront to the abovementioned station which transmits effluent to the treatment works at Macassar. Two emergency sewage overflow pipes 1,5 and 1,0 m in diameter, lead into the estuary above and below Beach Road, respectively.

The AECI land above Beach Road was enclosed within a security fence to prevent dumping and vagrancy. The present bird sanctuary may be extended to include this area (Van Niekerk, pers. comm.).

The mouth area is enclosed within a fence for security reasons and serves as an outlet for AECI, Somchem and Triomf Fertiliser discharges (see sections 2.3.2 and 5.6.3).

## 5.4 OBSTRUCTIONS

### 5.4.1 Catchment

Eight bridges, mostly double-span in type, were identified in the catchment.

The flooding problems associated with the National Monument Arch Bridge on Main Road, Somerset West, were investigated by Hawkins. Hawkins & Osborne, Consulting Engineers, Cape Town (1981).

A flood associated with a 1 in 50 year recurrence interval is generally accepted as the basis for determining the waterway area of a bridge in an urban area; this allows for the natural flow capacity of the river to be greatly exceeded. The old historic bridge is built at the present one in two year flood recurrence level. It is estimated that the flow capacity of the river in its natural condition prior to the construction of any bridges was 86 cumecs, while the present flow capacity of the bridge is only 36 cumecs. Without any blockages, the bridge can only pass a flood of 36 cumecs without overtopping the banks, whilst a flood of 83 cumecs results in the banks being overtopped by approximately one metre.

It was suggested that a bypass canal providing for a 1 in 50 year flood be constructed; additionally it was recommended that flood control measures be undertaken along the length of the river (Hawkins, Hawkins & Osborne, 1981).

Subsequent to the decision made by the Somerset West Municipality to proceed with the canalisation, concern for the preservation of the river in its natural state was expressed by the public and the Lourens River Conservation Society. The society sought the advice of Dr R.D. Beaumont (Hill Kaplan Scott Incorporated, 1982), who viewed the planning proposals to be ecologically sound. A shortage of funds has since prevented the canalisation from proceeding (A.B. Smit, Somerset West Municipality, pers. comm.).

Six stone weirs were identified in the catchment; one weir comprising sand-filled plastic bags was partially broken and strewn along the river bed. Two concrete walls placed along the bank of the river in order to maintain its course, were cracked and broken and represented potentially dangerous obstructions during times of flooding. Dumped concrete blocks, walls and pipes were also identified as obstructions to flow.

Logs, branches and fallen or cleaved trees were recorded in the water or on the banks, along the length of the river. Farmers often stabilise the river banks with logs which are washed down the river during floods (Van Niekerk, pers. comm.), and cleft trees that are not removed from the banks also provide problems (Nel, pers. comm.). The blockage of the river, especially at the National Monument Arch Bridge, increases the vulnerability of land in the catchment to flooding.

A minimum building line of 15 m from the centre of the river is enforced by the Somerset West Municipality (Smit, pers. comm.). This is far below the 50-year flood line in many cases and buildings such as the Somerset Oaks Old Age Home and Pick 'n Pay supermarket, Somerset West, are sited on the floodplain, the consequence of this is serious during times of flooding.

The susceptibility of riverside plots to flooding and the significance of the floodplain in the attenuation of flood flows has only recently been realised (Beaumont, 1979). The Water Amendment Act of 1978 (South Africa, 1978) states that the 50-year flood line must be marked on development plans for catchments larger than five square kilometres, but the enforcement of these constraints rests with provincial planning authorities.

### 5.4.2 Estuary

There are only two single-span bridges crossing the estuary and both are of such height and width that they will not impede heavy flows, unless blockages occur.

Fallen trees and logs are evident along the banks of the estuary.

## 5.5 SILTATION AND EROSION

Concrete retaining walls, barrels, sandbags and boulders have been used in the upper catchment to support the banks of the river, where erosion has occurred during times of flooding. At the mouth of the estuary the northwestern bank has been consolidated with loose bricks and concrete slabs to prevent erosion from river and tidal wash.

The river may become muddy during winter, resulting in the clogging of filters used during the filtration of water prior to domestic use (Scheffler, pers. comm.). Nevertheless, there is little observable evidence of siltation of the estuary.

## 5.6 POLLUTION

### 5.6.1 Sewage

The Strand Sewage Works operated for 30 years until 1978, when it became overloaded due to population pressures. Dissolved oxygen levels as low as 2,5 ppm were recorded at the estuary between 1971 and 1978 (Strand Municipality, unpublished data). The discharge of biologically-treated sewage into the estuary may have been detrimental to the biota, especially during the latter years of operation.

On 4 January 1982, a fracture in the rising main carrying raw sewage from the Strand pump station to the treatment works at Macassar, resulted in the discharge of this effluent into the estuary via the aforementioned emergency overflow pipes. This "spill" lasted for sixteen hours, during which time the mouth was dredged open and water redirected down the river by the closure of the AECI Melcksloot sluices, in order to clear the system (Joubert, pers. comm.).

The resultant low oxygen levels in the estuary caused the death of large numbers of fish, while the nutrient-rich water caused algal blooms.

### 5.6.2 Fertilisers

The application of fertilisers during autumn and winter has already been mentioned (Section 5.3.1). Mr G.C. Kies (Directorate of Water Affairs, pers. comm.) observes that leaching of agricultural lands during spring results in algal blooms in the estuary. Some leaching will occur during winter resulting in the relatively high levels recorded at the estuary during May and June (Appendix II).

### 5.6.3 Chemical Discharge

The AECI main drain effluent comprises cooling water used at the power station and in nitrate and sulphate treatments, storm water from AECI, Somchem (Pty) Ltd (armaments factory) and Triomf Fertiliser (Pty) Ltd, as well as biologically-treated sewage. A standard volume of 953,4 $m^3$ per day is released into this outflow, but this may be increased to 1000 $m^3$ per day (Kies, pers. comm.). Seepage from the fertiliser factory and AECI nitric acid and ammonium nitrate plants accounts for the high nitrate and low pH levels recorded (Appendices II and III).

The quality of the AECI effluent should comply to some extent, with the general standards for industrial effluents as described in Government Gazette No. 217 (South Africa, Department of Water Affairs, 1962). However, a permit supplied by the Directorate of Water Affairs allows for the waiving of certain requirements, for example, the pH requirement for the effluent is waived.

Physico-chemical data indicate that the existing standards are inadequate. The Directorate are at present investigating the need for a more stringent permit (J.A. Lusher, Directorate of Water Affairs, pers. comm.).

Water from this drain was observed to be flowing into the estuary during field surveys conducted in February, March, July and August and appears to be the most significant pollution input at present.

### 5.6.4 Miscellaneous Sources

The Gants Foods outfall was investigated by Bally *et al.* (1980). The effluent consists of washings from the production of canned jams, fruits, vegetables and meats. Although the effluent has a small and very localised impact, it may contribute to the pollution of the estuary during incoming tides particularly during spring, when the mouth is open.

A number of storm water drains empty into the river; these could be a source of pollution or enrichment.

The dumping of waste products and debris including bricks, rubble, concrete, polystyrene, cans, plastics, tyres and clothing occurs along the length of the river. The beach is consequently strewn with litter.

Apart from the dumping of concrete into the river (section 5.3.1), the extent of pollution contributed by light industrial companies bordering the river, was not ascertained. Mr Smit (Somerset West Municipality, pers. comm.) reports that light industrial firms discharge illegally into the river. The Directorate of Water Affairs no longer monitors the river for pollution, since no major discharges into the estuary have been identified (Kies, pers. comm.).

The discharge of industrial waste water or effluent into the Lourens River, from its sources to tidal waters, should comply with the special water quality standards as specified in the aforementioned Government Notice.

# CHAPTER SIX

## PLANS AND RECOMMENDATIONS

The Lourens River falls under the jurisdiction of multiple authorities and private land-owners namely, State Forestry Reserve, private agriculture, AECI and the municipalities of Strand and Somerset West. These bodies are fairly autonomous and their primary concern is with matters within their own boundaries. Additionally, no overall, detailed plan or management policy exists for the development and use of the river (Beaumont, 1982).

A number of problems requiring immediate attention have been identified as arising from this lack of co-ordinated management of the river system:

i) dumping and littering occur along a major part of the river, both on riparian land and in the water;

ii) chemical effluent is periodically discharged into the estuary;

iii) inadequate flood control measures exist;

iv) blockage of the river by logs, trees and temporary weirs occurs;

v) encroachment of the river banks by alien vegetation is evident;

vi) undeveloped sites and public open spaces are neglected;

vii) vagrancy is prevalent on riparian land;

viii) alteration of the river course and "water stealing" have been indicated;

ix) accidental discharges of sewage into the estuary, such as occurred in January 1982, may be repeated.

In December 1980, the Lourens River Conservation Society was formed by the Lions Club in Somerset West in an effort to bring about the conservation of the Lourens River.(Tromp, pers. comm.). Although attempts were made to rectify some of the aforementioned threats to the river and the co-operation of the local authorities was partly realised, it was soon recognised that the existing legislation regarding the conservation of water bodies in South Africa, is totally inadequate.

The Cape Metropolitan Planning Committee is an existing body, which could assist in the execution of a co-ordinated resource management policy for the Lourens River. The Committee's functions include the co-ordination of activities which transcend the boundaries of individual control and the initiation and promotion of policies and projects, to be collectively executed by local authorities (Gasson, 1980).

There is, however, a need for a statutory body such as a River Authority or River Management Board to integrate plans and methods of control from the source to the head of the river. Such an authority may be constituted along the lines of the Lake Areas Development Board, with powers to expropriate land, consolidate new boundaries, plan and develop the river system independently of municipal boundaries and prevent *ad hoc* developments from taking place. Although a request for the establishment of such a board was made to the Minister of Environment Affairs in March 1982, present legal constraints prevent such developments.

In August 1982 members of the society, representatives of the municipalities and AECI and a few land-owners, decided, on the advice of the Department of Environment Affairs, that a River Trust should be formed (Tromp, pers. comm.). Such a trust, although having no statutory powers, would be constituted from representatives of the local authorities, riparian owners, AECI and conservation authorities such as the Directorate of Environmental Conservation, and could advise the respective control bodies regarding the conservation and development of the river system. Thus a river trail, similar to that developed by the Braamfontein Spruit Trust (COCCOS, 1981), could be created.

The tremendous recreational asset that a natural river can provide to an urban environment, is being appreciated more and more as easily accessible leisure space is diminishing. Since a major part of the riparian land within the two municipalities is zoned public open space (Hottentots Holland Basin, Zoning map, 1979), a river trail developed for recreational purposes could maintain the aesthetic appeal of a natural or landscaped water course, particularly if the co-operation of private land-owners was obtained.

AECI have already established a bird sanctuary on the banks of the river and may extend this to include the upper reaches of the estuary (Van Niekerk, pers. comm.). Nevertheless, the estuary provides no recreational or aesthetic benefit to the public due to its restricted access and severe pollution and unless it be included within an overall management scheme for the river, it will continue to be mis-used and degraded.

# CHAPTER SEVEN

# SYNTHESIS

There is very little published information on the Lourens River and its estuary and this thesis was, therefore, compiled mainly from field observations and personal communications.

The Lourens River rises in the Hottentots Holland Mountains, South-western Cape, and has a catchment area of 92 km²; it empties into False Bay. It falls within a winter rainfall region with approximately 87 percent of the annual run-off for the area occurring during the seven months of the rainy season, during which time there may be intermittent flooding. Run-off is low during summer and river flow rates may be reduced to zero for short periods. These seasonal hydrological fluctuations have a pronounced effect on this small estuary.

The estuary exhibits seasonal variations in physical and chemical parameters and is marine dominated during summer and river dominated during winter. During dry summer months the estuary may become periodically closed or reduced to a small outflow, due to the formation of a beach bar which dams the lagoon. The estuary can become hypersaline and vertical salinity gradients may develop in the deeper channels. With increased flow rates in winter, the bar is breached at the lower western end, the water level is lowered (by 0,5 m in May 1982) and the water is practically fresh throughout.

The major pollution inputs into the estuary were identified as: nitrate- and organic-rich, acidic water from the AECI, Somchem and Triomf Fertiliser discharge; nitrate-enriched river water resulting from agricultural leach, and litter and debris dumped along the extent of the river. The industrial chemical discharge is particularly serious in summer, when there is little dilution of the discharge. The water quality standards for this effluent should be altered, such that the pollution input is markedly reduced.

The mouth of the estuary is enclosed within an AECI security fence, thereby providing a protected roosting site for birds and large flocks of terns, gulls and cormorants are found on the beach. The estuary serves as a nursery ground for several fish species, but is generally poor in both aquatic and terrestrial fauna. There are no wetland areas present and the terrestrial vegetation includes numerous alien species.

The duration and extremes of environmental conditions experienced at the Lourens estuary, as well as the pollution inputs, almost certainly account for the low diversity of estuarine biota. The presence of urban (Strand) and industrial (AECI) developments on the banks of the estuary contributes to the paucity of terrestrial species.

No overall management policy exists for the Lourens River (including the estuary) and the complex land ownership arrangements and the multiplicity of administrative control structures responsible for the system, hinder conservation measures. It has been recommended that a River Trust be established to allow for the integrated and co-operative planning and management of the river system and to prevent *ad hoc* development from taking place. The establishment of a River Management Board with statutory powers is, however, required to ensure that a satisfactory management policy for the river is devised and enforced.

The Lourens River estuary is not an independent ecosystem, but forms an integral part of the river and coastal systems and should be managed as such.

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## Aerial Photography

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APPENDIX I. The degree of exposure of the sandy beach near the Lourens River mouth, assessed using the rating scheme outlined by McLachlan (1980).

| PARAMETER | RATING | SCORE |
|---|---|---|
| Wave action | Continuous, moderate | 2 |
| Surf zone width | Very wide | 0 |
| % very fine sand (62 - 125 μm) | > 5% | 0 |
| Median particle diameter (μm) | Slope of intertidal zone | |
| 180 | $\frac{1}{25} - \frac{1}{50}$ | 2 |
| | $< \frac{1}{50}$ | 3 |
| Depth of reduced layers | 0 - 10 cm | 0 |
| | 10 - 25 cm (Bally *et al.*, 1980) | 1 |
| Stable burrows | Present (Bally *et al.*, 1980) | 0 |
| TOTAL | | 4 - 6 |

A total of 1 - 5 indicates a "very sheltered" beach, while 6 - 10 indicates a "sheltered" beach.

APPENDIX II. Physico-chemical data collected between December 1981 and August 1982.

12 December 1981

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 29,0 | 29,0 | 27,0 | 27,0 | 27,5 | 26,0 | 26,0 |
| Surface salinity (‰) | 24 | 24 | 23 | 23 | 22 | 10 | 0 |
| Bottom salinity (‰) | – | – | 32 | 32 | 36 | 32 | – |
| Dissolved oxygen (% saturation) | 102 | 106 | 129 | 138 | 143 | – | 83 |
| pH | 8,5 | 8,5 | 8,4 | 8,3 | 8,5 | – | 7,2 |
| Nitrate (µmol/l) | 1,1 | 3,0 | 1,1 | 6,5 | 8,7 | – | 11,1 |
| Phosphate (µmol/l) | 1,1 | 3,9 | 0,7 | 0,9 | 0,9 | – | 1,1 |
| Organic carbon (mg/l) | 4,9 | 3,5 | 2,1 | 3,4 | 4,0 | – | 8,6 |
| Secchi Disc Reading (cm) | – | – | 90 | 85 | 100 | – | – |
| Depth (cm) | 5 | 20 | 150 | 150 | 150 | 150 | 75 |

14 January 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | CLOSED | | | |
| Temperature (°C) | 24,5 | 25,0 | 27,0 | 27,0 | 26,0 | 26,0 | 27,0 |
| Surface salinity (‰) | 38 | 33 | 37 | 38 | 37 | 10 | 4 |
| Bottom salinity (‰) | – | – | 35 | 36 | 35 | 15 | – |
| Dissolved oxygen (% saturation) | 75 | 114 | 130 | 146 | 129 | – | 87 |
| pH | 7,5 | 7,9 | 7,4 | 7,6 | 7,7 | – | 6,5 |
| Nitrate (µmol/l) | 4,3 | 14,5 | 2,3 | 0,9 | 1,1 | – | 1,7 |
| Phosphate (µmol/l) | 2,7 | 7,3 | 1,6 | 1,1 | 1,2 | – | 1,4 |
| Organic carbon (mg/l) | 1,7 | 3,0 | 5,5 | 1,9 | 4,0 | – | 7,2 |
| Secchi Disc Reading (cm) | – | – | 80 | 75 | 70 | – | – |
| Depth (cm) | 3 | 50 | 155 | 155 | 155 | – | 50 |

12 February 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 26,0 | 25,5 | 24,5 | 25,0 | 25,0 | 23,5 | 24,0 |
| Surface salinity (‰) | 11 | 6 | 8 | 9 | 9 | 9 | 2 |
| Bottom salinity (‰) | – | – | 15 | 26 | 32 | 28 | – |
| Dissolved oxygen (% saturation) | 73 | 68 | 86 | 71 | 74 | – | 74 |
| pH | 5,9 | 5,4 | 5,0 | 5,6 | 5,8 | – | 7,1 |
| Nitrate (µmol/l) | 497,4 | 753,9 | 532,9 | 736,2 | 750,0 | – | 2,5 |
| Phosphate (µmol/l) | 0,4 | 0,4 | 0,7 | 0,4 | 0,2 | – | 0,8 |
| Organic carbon (mg/l) | 9,5 | 8,4 | 5,2 | 7,9 | 8,9 | – | 12,7 |
| Secchi Disc Reading (cm) | – | – | 95 | 95 | 100 | – | – |
| Depth (cm) | 5 | 50 | 160 | 160 | 160 | – | 25 |

16 March 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 22,0 | 22,5 | 21,0 | 21,0 | 21,0 | 20,0 | 23,5 |
| Surface salinity (‰) | 17 | 13 | 11 | 10 | 11 | 8 | 18 |
| Dissolved oxygen (% saturation) | 88 | 57 | 70 | 72 | 71 | - | 90 |
| pH | 5,3 | 3,2 | 3,1 | 3,0 | 3,2 | - | 7,2 |
| Organic carbon (mg/l) | 8,6 | 9,6 | 7,8 | 8,0 | 7,9 | - | 12,7 |
| Secchi Disc Reading (cm) | - | - | 95 | 95 | 95 | - | - |
| Depth (cm) | 10 | 65 | 160 | 160 | 160 | - | 25 |

15 April 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 18,0 | 18,5 | 19,0 | 19,0 | 18,5 | 19,0 | 19,0 |
| Surface salinity (‰) | 4 | 2 | 2 | 2 | 3 | 2 | 0 |
| Bottom salinity (‰) | – | – | 17 | 19 | 17 | 11 | – |
| Dissolved oxygen (% saturation) | 88 | 92 | 100 | 103 | 67 | – | 78 |
| pH | 7,7 | 7,5 | 8,0 | 8,0 | 7,5 | – | 7,3 |
| Nitrate (μmol/l) | 41,8 | 133,3 | 2,5 | 6,5 | 4,3 | – | 10,4 |
| Phosphate (μmol/l) | 1,5 | 1,3 | 1,9 | 1,1 | 1,0 | – | 0,8 |
| Organic carbon (mg/l) | 5,7 | 6,1 | 8,2 | 6,2 | 4,8 | – | 5,5 |
| Secchi Disc Reading (cm) | – | – | 110 | 100 | 90 | – | – |
| Depth (cm) | 15 | 20 | 125 | 125 | 125 | – | 50 |

28 May 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 12,0 | 12,0 | 13,0 | 13,0 | 12,0 | 12,0 | 11,5 |
| Surface salinity (‰) | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Bottom salinity (‰) | – | – | 0 | 0 | 0 | 0 | – |
| Dissolved oxygen (% saturation) | 91 | 87 | 95 | 103 | 94 | – | 87 |
| pH | 7,0 | 7,1 | 6,9 | 7,0 | 7,0 | – | 7,1 |
| Nitrate (μmol/l) | 50,1 | 124,6 | 57,1 | 45,9 | 49,5 | – | 45,3 |
| Phosphate (μmol/l) | 2,0 | 2,8 | 1,7 | 1,7 | 2,5 | – | 1,0 |
| Organic carbon (mg/l) | 9,2 | 5,4 | 5,1 | 5,8 | 4,8 | – | 4,0 |
| Secchi Disc Reading (cm) | – | – | ⩾100 | ⩾95 | ⩾95 | – | – |
| Depth (cm) | 5 | 10 | 100 | 95 | 95 | – | 60 |

23 June 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 10,0 | 11,0 | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 |
| Surface salinity (‰) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bottom salinity (‰) | – | – | 0 | 0 | 0 | 0 | – |
| Dissolved oxygen (% saturation) | 17 | 88 | 88 | 87 | 74 | – | 97 |
| pH | 6,7 | 6,8 | 6,8 | 7,0 | 7,0 | – | 6,9 |
| Nitrate (μmol/l) | 49,1 | 49,2 | 1470,6 | 68,1 | 51,7 | – | 67,1 |
| Phosphate (μmol/l) | 1,1 | 1,6 | 1,7 | 1,1 | 1,1 | – | 1,1 |
| Organic carbon (mg/l) | 4,4 | 4,2 | 2,7 | 2,1 | 2,3 | – | 2,2 |
| Secchi Disc Reading (cm) | – | – | ⩾100 | ⩾100 | ⩾100 | – | – |
| Depth (cm) | 15 | 5 | 100 | 100 | 100 | – | 75 |

27 July 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 11,5 | 12,5 | 11,0 | 11,0 | 11,5 | 11,5 | 11,5 |
| Surface salinity (‰) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bottom salinity (‰) | - | - | 0 | 0 | 0 | 0 | - |
| Dissolved oxygen (% saturation) | 78 | 76 | 85 | 88 | 87 | - | 88 |
| pH | 4,5 | 3,5 | 7,0 | 7,0 | 7,0 | - | 7,2 |
| Secchi Disc Reading (cm) | - | - | ⩾100 | ⩾100 | ⩾100 | - | - |
| Depth (cm) | 50 | 5 | 100 | 100 | 100 | - | 75 |

13 August 1982

| SAMPLING STATION | A | B | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| State of mouth | | | | OPEN | | | |
| Temperature (°C) | 11,0 | 13,0 | 11,0 | 12,0 | 11,0 | 11,5 | 12,0 |
| Surface salinity (‰) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bottom salinity (‰) | - | - | 0 | 0 | 0 | 0 | - |
| Dissolved oxygen (% saturation) | 92 | 74 | 88 | 85 | 83 | - | 83 |
| pH | 2,9 | 2,4 | 6,7 | 7,1 | 7,1 | - | 7,0 |
| Secchi Disc Reading (cm) | - | - | ⩾100 | ⩾100 | ⩾100 | - | - |
| Depth (cm) | 75 | 5 | 100 | 100 | 100 | 100 | 75 |

APPENDIX III. Physico-chemical data obtained from the overflow pond (station C), AECI main drain (station D) and Heldersig stream (station $G_1$) from December 1981 to August 1982, during neap tides.

Sampling Station C

| PARAMETER | DEC | JAN | FEB+ | MAR+ | APR | MAY | JUN | JUL+ | AUG+ |
|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 27,0 | 26,0 | 26,0 | 18,0 | 18,0 | 12,0 | 10,0 | 12,0 | 12,5 |
| Salinity (‰) | 22 | 17 | 1 | 2 | 9 | 0 | 0 | 0 | 0 |
| Dissolved oxygen (% saturation) | 143 | 99 | 64 | 64 | 92 | 91 | 50 | 78 | 77 |
| pH | 8,3 | 7,5 | 3,6 | 3,3 | 7,5 | 7,0 | 7,1 | 3,5 | 2,3 |
| Nitrate (µmol/l) | 1,5 | 28,2 | 959,2 | - | 9,4 | 300,0 | 2813,4 | - | - |
| Phosphate (µmol/l) | 10,8 | 11,1 | 0,2 | - | 3,1 | 8,4 | 36,5 | - | - |
| Organic carbon (mg/l) | 9,1 | 0,1 | 9,4 | 15,5 | 7,5 | 5,9 | 9,8 | - | - |

+ AECI main drain flowing into the estuary via the overflow pond.

Sampling Station D

| PARAMETER | DEC | JAN | FEB+ | MAR+ | APR | MAY | JUN | JUL+ | AUG+ |
|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 29,0 | 29,0 | 26,0 | 22,5 | 19,0 | 18,0 | 13,0 | 12,0 | 12,5 |
| Salinity (‰) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dissolved oxygen (% saturation) | 74 | 80 | 74 | 67 | 58 | 69 | 77 | 74 | 76 |
| pH | 2,0 | 3,9 | 4,4 | 3,3 | 2,7 | 2,9 | 3,1 | 3,6 | 2,3 |
| Nitrate (μmol/l) | 1468,9 | 3212,4 | 1002,6 | - | 5890,5 | 13167,0 | 1058,3 | - | - |
| Phosphate (μmol/l) | 143,8 | 2,9 | 0,2 | - | 32,1 | 20,0 | 187,6 | - | - |
| Organic carbon (mg/l) | 11,5 | 16,6 | 11,5 | 14,5 | 21,2 | 16,7 | 4,4 | - | - |

\+ AECI main drain flowing into the estuary via the overflow pond.

Sampling Station $G_1$ +

| PARAMETER | MAY | JUN | JUL | AUG |
|---|---|---|---|---|
| Temperature (°C) | 12,0 | 10,0 | 11,0 | 11,0 |
| Salinity (‰) | 0 | 0 | 0 | 0 |
| Dissolved oxygen (% saturation) | 91 | 74 | 80 | 83 |
| pH | 7,0 | 7,0 | 7,6 | 7,6 |
| Nitrate (µmol/l) | 10,5 | 13,4 | - | - |
| Phosphate (µmol/l) | 1,2 | 1,3 | - | - |
| Organic carbon (mg/l) | 4,4 | 7,5 | - | - |

+ Stream only flowing between May and August.

APPENDIX IV. A checklist of amphibians and reptiles recorded for the area covered by the South Africa 1:50 000 Sheet, Somerset West (1981).

Frogs (according to Poynton (1964) and Cape Department of Nature and Environmental Conservation (unpublished records)).

| Species | Common Name |
|---|---|
| *Heleophryne purcelli* | Cape Ghost Frog |
| *Bufo angusticeps* | Sand Toad |
| *Bufo rangeri* | Raucous Toad |
| * *Breviceps gibbosus* | Cape Rain Frog |
| *Breviceps acutirostris* | Strawberry Rain Frog |
| *Rana montana* | Banded Stream Frog |
| *Rana grayii* | Clicking Stream Frog |
| *Arthroleptella lightfooti* | Cape Chirping Frog |
| * *Cacosternum capense* | Cape Caco |
| *Tomopterna delalandii* | Cape Sand Frog |
| *Xenopus laevis* | Common Platanna |
| *Capensebufo rosei* | Cape Mountain Toad |
| *Breviceps montanus* | Cape Mountain Rain Frog |
| *Rana fuscigula* | Cape River Frog |

* Indicates endangered species (McLachlan, 1978).

Tortoises and Terrapins (according to Greig & Burdett (1976) and Cape Department of Nature and Environmental Conservation (unpublished records)).

| Species | Common Name |
|---|---|
| * *Psammobotes geometricus* | Geometric Tortoise |
| *Chersina angulata* | Angulate Tortoise |
| *Homopus aureolatus* | Padloper Tortoise |
| *Pelomedusa subrufa* | Cape Terrapin |

Snakes (according to Fitzsimons (1962) and Cape Department of Nature and Environmental Conservation (unpublished records)).

| Species | Common Name |
|---|---|
| *Rhinotyphlops lalandii* | Pink Earth Snake |
| *Lamprophis aurora* | Aurora House Snake |
| *Pseudaspis cana* | Mole Snake |
| *Duberria lutrix* | Southern Slug Eater |
| *Crotaphopeltis hotamboeia* | Herald Snake |
| *Psammophylax rhombeatus* | Rhombic Skaapsteker |
| *Psammophis crucifer* | Cross-marked Grass Snake |
| *Elaps lacteus* | Southern Dwarf Garter Snake |
| *Hemachatus haemachatus* | Rinkals |
| *Naja nivea* | Cape Cobra |
| *Dispholidus typus* | Boomslang |
| *Lycodonomorphus rufulus* | Common Water Snake |

Lizards (according to Fitzsimons (1943) and Cape Department of Nature and Environmental Conservation (unpublished records)).

| Species | Common Name |
|---|---|
| *Cordylus cordylus* | Common Girdled Lizard |
| *Phyllodactylus porphyreus* | Marbled Gecko |
| *Agama atra* | Rock Agama |
| * *Bradypodion pumilum* | Cape Dwarf Chameleon |
| *Mabuyu capensis* | Common Skink |
| *Agama hispida* | Sand Agama |
| *Pseudocordylus microlepidotus* | Crag Lizard |
| *Puchydactylus geitje* | Oscillated Lizard |
| *Chaemaesaura anguina* | Cape Snake Lizard |

APPENDIX V. Mammals recorded by Stuart *et al.* (1980) for the area covered by the South Africa 1:50 000 Sheet, Somerset West (1981).

| Species | Common Name |
|---|---|
| *Eptesicus melckorum* | Melck's House Bat |
| *Rhinolophus clivosus* | Geoffrey's Horseshoe Bat |
| *Rousettus aegyptiacus* | Egyptian Fruit Bat |
| *Suncus etruscus* | Dwarf Shrew |
| *Papio ursinus* | Chacma Baboon |
| *Mirounga leonina* | Southern Elephant Seal |
| *Raphicerus melanotis* | Grysbok |
| * *Tatera afra* | Cape Greater Gerbil |
| * *Praomys verreauxi* | Verreauxs Rat |
| *Graphiurus ocularis* | Black and White Dormouse |
| *Bathyergus sucillus* | Cape Dune Molerat |
| *Aonyx capensis* | Cape Clawless Otter |
| *Felis libyca* | Cape Wild Cat |
| * *Felis serval* | Serval |
| * *Panthera pardus* | Leopard |

* Indicates rare, threatened species (Meester, 1976 and Skinner *et al.*, 1977).

APPENDIX VI. Saltmarsh and terrestrial vegetation recorded at the Lourens estuary on 30 March 1982.

Saltmarsh vegetation

*Juncus kraussii*

*Phragmites australis*

*Typha capensis*

*Cyperus textilis*

*Paspalum vaginatum*

Dune vegetation

*Erharta villosa*

*Senecio elegans*

*Tachyandra divaricata*

*Tetragonia decumbens*

*T. fruticosa*

*Carpobrotus edulis*

Elevated dune belt - AECI mouth area

*Pennisetum clandestinum*

*Geranium incanum*

*Pelargonium capitatum*

*Carpobrotus edulis*

*Stenotraphum secundatum*

*Acacia cyclops*

*A. saligna*

*Tetragonia fruticosa*

*T. decumbens*

*Zantedeschia aethiopica*

*Watsonia* sp.

Disturbed vegetation - Beach Road Bridge to pipe bridge

*Pennisetum clandestinum*

*Colpoon compressum*

*Rhus* spp.

*R. glauca*

*Cynodon dactylon*

*Conyza* cf. *ambigua*

*Sonchus oleraceous*

*Datura stramonium*

*Nasturtium* sp.

*Metrosideros excelsa*

*Myoporum serratum*

*Salix babylonica*

*Populus canescens*

*Acacia cyclops*

*A. saligna*

*A. mearnsii*

*Lantana camara*