THE EUROPEAN COMMUNITY

(Article B 946/89 Contract No: 8912)

A Preliminary Study of the Mangroves of Guyana

by

C. M. R. Pastakia

Final Report

AQUATIC BIOLOGICAL CONSULTANCY SERVICES LIMITED

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The views expressed herein are those of the authors and the European Community does not necessarily support the opions and the conclusions expressed in this report.

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A PRELIMINARY STUDY OF THE MANGROVE OF GUYANA

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1 INTRODUCTION

1.1 Introduction

This report is presented by Aquatic Biological Consultancy Services Limited (ABCS) to the European Community, documenting the work and conclusions of a study, funded through the European Fund for Ecology in Developing Countries, to determine the environmental value of the mangrove courida of Guyana. The study was supported locally by the Department of Hydraulics, Ministry of Agriculture, Guyana; and was directed and executed by ABCS Director Mr. C.M.R. Pastakia.

This report presents an outline of the environment of the mangrove coast of Guyana; reviews the problems of sea defences in respect of the use of mangrove; the problems relating to the loss and preservation of mangrove areas; and presents recommendations for future actions. Accompanying this report are 75 outline maps of the Guyana coast, which represent a baseline for the mangrove of the country. The descriptive narrative for these maps is found in Appendix I of this report.

2.1 Terms of reference

The terms of reference for the study are reproduced in Appendix II. The study was started in July 1989, field work being scheduled to be carried out later that year. However, loss of equipment and administrative delays, set the progress back by nearly a year, the field work being completed in November 1990. In view of these delays, together with lack of a programme for monitoring and managing new mangrove plantations by the Guyana Forestry Commission, the terms of reference relating to the requirement to the establishment of plantations of new mangrove areas were modified to require ABCS to define which areas, and methods, might be used to undertake such planting work in the future.

1.3 Execution of the project

The project was executed in accordance with the two phases as set out in the Terms of Reference (App.II:2.1), though some overlap occurred in the production and photo-interpretation of the maps and the field work, to update the mapping to establish the present baseline for the Guyana coastline.

The photo-interpretation of aerial photo-mosaics was undertaken by Mr. C.M.R. Pastakia, using the facilities provided by the Department of Lands & Surveys, Ministry of Agriculture, Government of Guyana. Outline maps were firstly drawn by Eddele Associates, Georgetown, Guyana, and the coastal features were drafted onto these maps by Mr. Pastakia, and the maps finished by Eddele Associates.

The photography available in Guyana covered the coastal area from the Corentyne to Pomeroon Rivers, in a scale of 1:10,000. From the Pomeroon to Waini Rivers no aerial photography was available, but 1:250,000 scale forestry maps were used as a baseline for this area. The accompanying maps were drawn to their respective scales. The aerial photography and the forestry maps covered the period 1973 to 1975, and the details recorded represent an historic situation. Once the field work was completed, the baseline maps were revised in accordance with the field observations, allowing for the changes over 15 - 17 years to be shown.

The 1990 baseline is partly subjective, as distances and small features could not be determined in all areas without further extensive ground surveys or vertical aerial photography. However, the accompanying maps still provide a realistic record of the changes and the present baseline for the Guyana coast.

Field work was undertaken by aerial observations, observations on foot, and observations from boats; as well as cutting of transects in some areas, to determine the composition of the courida and train local counterparts in species and methods. Field work was hampered by the problems of transport and access to many parts of the coast, particularly within the compressed timescale of the project. Nevertheless all areas of the coast were observed, and relevant observations recorded on the maps. To improve the understanding of the Guyana mangrove areas, data from Venezuela, Trinidad & Tobago and Suriname have been used, and included where relevant, in this study.

The Guyana Forestry Commission was unable to provide technicians to work on this project. The main environmental agency in Guyana, the Guyana Agency for Health Sciences Education, Environment and Food Policy (GAHEF) provided an Environmental Officer to be trained and assist in some of the field work. To assist in this work, the Environmental Monitoring & Control Unit (EMCU) of the Mahaica-Mahaicony-Abary Agricultural Development Authority (MMA/ADA) was contracted to provide technicians to assist in the field work and to receive training in the appropriate techniques. The Unit Manager assisted in all areas of the country, and individual technicians from the Unit assisted in field work in different areas.

2 THE COASTAL ENVIRONMENT OF GUYANA

2.1 Introduction

Guyana is situated on the North-east Atlantic coast of South America. The country is about 214,970 Km^2, with a coastline of about 400 Km from the Waini River, the north-western boundary with Venezuela and the Corentyne River (Suriname boundary) in the south-east. This coast is dominated by the Guiana Current which is the continuation of the South Equatorial Current, and by the northward sediment transport from the Amazon River along this stretch of coast.

The population of Guyana is about 760,000, and 80% of whom live along a thin coastal strip, from the Pomeroon to Corentyne Rivers. The largest conurbation is the capital Georgetown (on the eastern mouth of the Demerara River) with a population of 190,000, Linden (about 45 Km up the Demerara River) with a population of 30,000, and New Amsterdam (eastern bank of the Berbice estuary) with a population of 20,000.

The country has a tropical climate, with two dry and two wet seasons a year. Hussain (1990) gives a rainfall range for the country of between 70 - 320 mm. There is a general drop in temperature towards the coast, which attracts the diurnal on- and off-shore breezes at dawn and dusk. Winds are generally Northeast or North-Northeast, and the country is outside the Caribbean hurricane belt.

2.2 The coastal plain of Guyana

The Guyana coast is a low lying coastal plain of marshes and ridges, and is below sea level in many areas (which has resulted in an extensive and elaborate system of sea defences). The coastal plain lies north of the Guiana shield, which is made up of residues of deeply weathered Precambrian rocks (estimated at 1,400 million years old). Within the coastal plain are four principal outcrops of sediments (Figure 1):

Berbice sediments of terrestrial origin deposited in the Pliocene epoch (>10 million years)

Coropina sediments of marine origin, deposited during the Pleistocene epoch (>1 million years)

Demerara sediments of marine origin, deposited during the Holocene epoch (>10,000 years)

Pegasse or peat sediments that have been deposited in the transitional zone between the Demerara and Coropina sediments (6,300 - 8,700 years).

The coastal plain has been described as a 'chenier plain' by Augustinus (1978), which he describes as "...shallow-based, perched sandy ridges, which rest on clay along a marshy or swampy, seaward facing tidal shore, with other beach ridges stranded in the marsh behind."

The shallow-based, perched, sand beach ridge ridges resting on clay are the 'cheniers'. These are distinguished from 'normal' beaches ridges in that they cheniers commonly rest on marshy clay with their bases near sea level, whereas 'normal' beach ridges have deep subsurfaces extending 5 - 15 metres below sea.

Augustinus (1978) describes three main forms of landscape for the coasts of Suriname, which are appropriate for Guyana. These landscapes are the result of the continuous transport of fine sediments along this South American coast. One feature of this transport is the development of fine sediments that form a thixotrophic mud ('sling-mud') that causes the development of the mud-shoals and mudflats along the coast. These landscapes are described as follows:

(a) Mud accretionary coast

Mudflats, generally broadening eastwardly, where they also increase in height. At the west side accumulation occur, with the eastern side being abraded. The west side is predominately a barren, smooth surface with a shallow, meandering drainage pattern. Mangroves may grow further to the east where the mudflat has silted up to above mean high water level. The mangroves increase in height towards the east and towards the land. An increase in erosion can be established by an increase in irregularity eastward from the 'smooth' western surface of the mudflat. If the supply of sand and shell clastics is greater than the westward transport, then a sand accretionary coast will form to the east of the mudflat. A lesser supply will result in an erosional coast.

(b) Sand accretionary coast

Characterized by voluminous and high cheniers, with numbers of ridges deposited against each other. Vegetation will mainly be of shrubs and herbs.

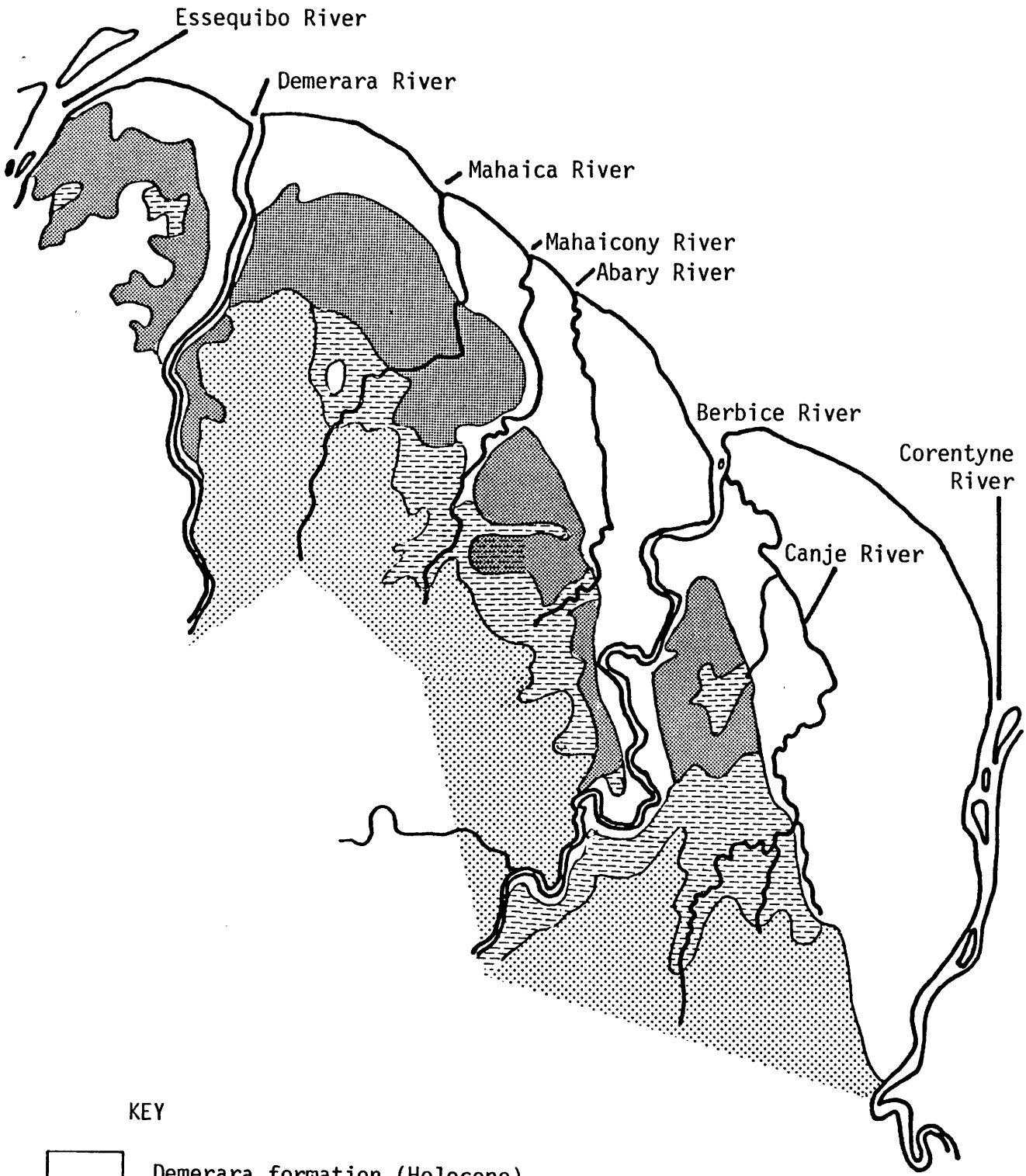

FIGURE 1 : Coastal plain of Guyana
adapted from Brinkman & Pons (1968)

(c) Erosional coast

Two types of sub-types can be distinguished: (i) a straight erosion coast and (ii) an indented erosion coast ('Happen-coast'). They have a number of common features: uprooted tree stumps piled up against the chenier or mangrove; wash-over fans and deltas on the landside of the chenier; a low cliff seaward of the chenier; and the more or less wholesale death of the mangrove to the landward of the chenier.

The mud accretionary coast and the erosional coast landscapes are common in Guyana. The sand accretionary coast is more rare, due to the need for sand and shell clastics, which are provided by the large rivers along this South American coast. Augustinus and Mees (1984) note that the Corentyne and Essequibo Rivers are the two main sources of such transported sediments in respect of Guyana.

2.3 The mangroves of the coast

Mangroves are the constituent plants of tropical intertidal forests. The mangrove plant community is now termed a 'mangal' to provide qualification to the historic confusion caused by the single term 'mangrove' (Tomlinson, 1986). Communities of these halophytic (salt tolerant) plants are dominated by some trees and shrubs within the families Avicenniaceae, Combretaceae, Rhizophoraceae, Sonneratiaceae. In South-East Asia the family Palmae has a single genus (Nypa) that is classed as a mangrove. In addition to the main mangrove species, there are a number of other halophytic plants that are 'mangrove associates', which help to make up the overall intertidal community, or are found in significant numbers in the 'back-mangal' (inland areas of the mangal).

In the Guianas of South America there are a limited number of mangrove species. Traditionally three species were noted, dominated by the Black mangrove (Avicennia germinans [=nitida]). This plant was known locally in Guyana as "courida", and this term has historically been used both for the species and for the overall mangrove fringe along the coasts.

There is some confusion in the earlier scientific literature on the exact identification of mangrove species. The traditional three species are: Avicennia germinans (Black mangrove), Rhizophora mangle (Red mangrove), and Laguncularia racemosa (White mangrove). Species of Avicennia were collectively grouped into a single species A. nitida, but this name is now discontinued, and the main species in

the region is accepted as A. germinans. Tomlinson (1986) notes that A. schaueriana has "...a more or less continuous distribution...from Guyana south to Uruguay.". However confusion between these two Avicennia species is common, as Stearn (1958) notes; and it has been difficult to distinguish between Avicennia spp. during this study, primarily because of the lack of suitable field keys, and because of the leaf variation that is found in single plants of this genus.

Rhizophora mangle is the most common species of this genus in the region, although both R. racemosa and R. harrisonii have been recorded from British Guiana. Stearn (1958) notes a record of R. harrisonii from the "...immediate neighbourhood of Georgetown...", and for R. racemosa "...at the estuary of the Essequibo River". Here again field keys were not available to adequately distinguish between these species.

As the field work of the project was very intensive, there was little opportunity to make an extensive country-wide collection; so Avicennia and Rhizophora species are referred to only by the genus. However it is accepted that the species observed would have possibly included all the recorded species of the three main genera, viz: Avicennia germinans, A. schaueriana, Rhizophora mangle, R. harrisonii, R. racemosa, and Laguncularia racemosa.

2.4 The distribution of the mangrove species

The mangrove species considered here are all halophytic and should be equally well adapted for survival on exposed coasts as well as in estuarine conditions. Aspects of salt balance in the various families have been discussed by Tomlinson (1986). Personal observation during the study (and in Suriname) indicates that the geographical distribution of the species is different along this coast of South America, when compared to the normal distribution in the Caribbean.

The development of mangal in the Caribbean follows a pattern of pioneering shore colonization by Rhizophora spp. With increasing stabilization Avicennia spp. invade, and dominate the Rhizophora with a higher, denser canopy; with Laguncularia spp. forming the main part of the higher, inward areas of the mangal (Campbell, 1978).

In Guyana large areas of the coast have become effective mono-culture stands of Avicennia (and hence the courida fringe). There is no evidence that pioneering Rhizophora spp. have been present along parts of the coast. This is the main pattern of mangrove development along the Atlantic coast from the Corentyne to the Essequibo rivers.

Laguncularia racemosa is also able to colonize these parts of the Guyana coast. In the large developing sand banks and mudflats that dominate the coast in the west Corentyne Region (Map 58), Laguncularia and Avicennia are both found as pioneering species within the mudflats. At Good Hope (Map 37) Laguncularia has colonized parts of the small developing copse.

Where a mono-culture has developed, it is to be expected that the single species would provide new embryos for regeneration. However, embryos of all species are viable for long periods, and it is usual for embryos to be washed ashore many miles from the parent tree. Although, for instance, there is a mixture of all three species in the Mon Chosi area of West Coast Berbice(Map 55), new growth is still primarily Avicennia. At Novar (Map 47), rooted hypocotyls of Rhizophora have been destroyed by insect attack, leaving Avicennia as the new colonizer.

From the Essequibo to the Pomeroon Rivers there is a change in the general pattern of the coastal mangrove. In the denser areas of mangrove forest in the Pomeroon (west of Anna Regina) the dominant intertidal species belong to the Rhizophoraceae. Avicennia and Laguncularia spp. are found, but as dominant species in the inland mangal. Along the Pomeroon - Waini coast, Avicennia is re-established as the dominant mangrove, behind the shifting shell beach of this area.

This pattern of coastal Avicennia dominance changes along the river banks and the coasts adjacent to the mouths of river and creeks, with Rhizophora mangle dominating in the estuary and mainly along the western coast. The length of Rhizophora spread along the coast is apparently dependent on the size of the river. Along the Corentyne and Essequibo rivers, the development of seawalls has diminished the mangrove, but Rhizophora is still evident in both river mouths, and along the western coast adjacent to the mouth of the Demerara (Map 36). This pattern of riverine distribution is also reported from the San Juan River estuary and its adjacant coast in Venezuela (Pannier & Ramcharan, 1983).

This distribution in Guyana is similar to the entire coast of the Guianas, and a number of theories have been advanced to explain why Avicennia rather than Rhizophora is the pioneering species of the coast. Augustinus (1978) discusses these theories, and proposes his own: that the sling-mud conditions along the coast of the Guianas is so little consolidated that it can be fluidized by wave action to a certain depth, thus preventing the settlement of hypocotyls of Rhizophora. Avicennia embryos are able to become established in this regime, and so Avicennia spp. become the single pioneering species.

This hypothesis has much merit, but from observation of the natural distribution in the rivers and banks of Suriname and Guyana, it seems likely that other factors may also play a part in ensuring this unique distribution. Rhizophora spp. are more tolerant of longer periods of inundation, and also lower salinities, whilst Avicennia germinans is known to be tolerant of higher salinities and needs its aerial roots (pneumatophores) to be exposed above the water surface at regular intervals. Therefore, it would seem realistic to presume that the pattern of distribution of the mangrove in the Guianas is more likely to be related to an interaction between the stability hypothesis of Augustinus, the diurnal regime of salinity changes, and the flushing of various areas of the estuaries and the coasts.

2.5 The mangal community

In Guyana some distinction can be made between the environment of Rhizophora dominated mangal, and that dominated by Avicennia and Laguncularia. The large, dense crowns and high aerial roots (flying buttresses) of Rhizophora spp. provide for an open, clear woodland in its understorey, whilst Avicennia and Laguncularia dominated woodland has a more congested understorey. The overall plant community in the Guyana mangal is relatively constant in terms of species, but there are distribution changes at different areas of the coast.

The predominant mangrove species are Avicennia germinans, Rhizophora mangle and Laguncularia racemosa. These species dominate the trees cover of the foreshore and the immediate areas that are shown as mangrove forest or woodland on the maps. Conocarpus erectus (Buttonwood) is also common in areas where Avicennia and Laguncularia species dominate. Conocarpus erectus is usually considered to be a back-mangal constituent, and a mnagrove-associate rather than a true mangrove (Tomlinson, 1986).

In open mudflats that are beginning to show colonization, the initial pioneering species will be fine algae filaments and mats; whilst the first pioneering macrophyte is invariably the grass, Spartina brasiliensis. The development of Spartina as a foreshore stabilizing species in Guyana is documented by Martyn (1934), and by Pastakia & Persaud (1986). Along with Spartina, Philoxorus aggrigatus has been recorded (Pastakia & Persaud, 1986), although this plant is more commonly associated with the shrub Batis maritima (which is a dominate mangrove associate in the pans and the Avicennia understorey).

Martyn (1934) describes the vegetation of the sandy beach areas that develop from the cheniers and sand bars that are

found along the coast. These area are poor substrates for mangrove development and shows a more sparse plant cover. The surface of these beaches becomes covered with a mat of Fimbristylis spathacea together with Ipomoea bilboa. Sedges and grasses are represented by Stenotaphrum secundatum. Where depressions form, and rainwater can collect, Fimbristylis diphylla will take over from F. spathacea, and aquatic grasses such as Sporobolus virginicus and Paspalum distichum are found.

In the back-mangal, the dominant mangrove is often found to be Laguncularia racemosa. In many areas an understorey of Batis maritima is found. The fern Acrostichum danaeifolium is common as an understorey plant in the denser mangrove forests, and the back mangal. Other species recorded include Achyranthes aspera, Belchnum brownei, Corida macrostachya, Ruellia tuberosa, Cynodondactylon and Lactylarpheta species. In more open areas Sesiuium portulacastum and Brachypteris ovata can be found.

The open pan areas and the areas of mangrove scrub have a wide variety of terrestrial and semi-halophytic species. Plant communities are often dominated by migrant species from the back-mangal. These areas show vegetation patterns dependent on whether there has been human use (either historic or recent), the effect of clearance, and the effect of drainage (where deliberate or by outlet channels cut through the area).

2.6 The fauna of the mangal

The mangal provides an environment for a number of different species, from the open areas of the pan/lagoon complexes, to the foreshore areas and mudflats. Many of the species found are either vulnerable/endangered species, or have a high commercial value.

In the immediate offshore, there is a high primary production zone. The phytoplankton in this area is dominated by diatoms (Skeletonema spp), and also includes Chaetoceros spp., Rhizosolenia delicatula, Coscinodiscus spp., Hemiaulus sinensis, Thallassiothrix frauenfeldii, Navicula membranacea, and Nitzschia spp. (Cadee, 1975).

The sand banks and shoals areas, especially at the mouth of the major estuaries is a major spawning area for the shrimp Xyphopaenus kroyeri, and the mangrove area is a spawning area for the high value, commercial species Paeneus subtilis and P. braziliensis.

Within the mudflats a number of crabs are found, particularly fiddler crabs, Uca rapax, U. vocator and

Uca maraconai (Spaans & Baal, 1990. These provide food for the crab-eating raccoon Procyon cancrivorus. Other reptiles and mammals found within the Guyana mangrove are few, mainly due to the high impact of human activities close to the coastal belt. There is no information on the fauna in the Waini region, which is the major 'natural' area of the mangrove in the country. The shell beach that migrates along this part of the Guyana coast is known to be the nesting areas for a number of turtles species, which include the green turtle Chelonia mydas, the leatherback Dermochelys coriacea, and possible a few individuals of the Olive-Ridley turtle Lepidochelys olivacea and the hawksbill Eretmochelys imbricata.

The larger animals that will be found within the estuary zone (although not necessarily dependent on the mangrove areas) are the manatee Trichechus manatus and the spectacled caiman Caiman crocodylus.

The avifauna is rich within the mangal and the inland pans/lagoons. The water-fowl include various herons and egrets, including the great blue heron Butorides virescens, the white-necked heron Ardea cocoi, the night herons Nycticorax spp., the scarlet ibis Eudocimus ruber, the common egret Egretta alba, the snowy egret Egretta thula, and the glossy ibis Plegadis falcinellus. Carnivorous birds include the snail kite Rostrhamus sociabilis, and the turkey vulture Cathartes aura (which feeds mainly within the scrub lands and pans). Although not identified, woodpeckers and owls have been seen within the mangal in the Pomeroon.

The pans and lagoons are possibly areas for wintering migratory birds, although the effect of human impact so close to the shore in most areas of Guyana reduces the number of places where such over-wintering may occur. Species that have been recorded in the Nickerie District of Suriname (east coast of the Corentyne River) are given by Spaans & Baal (1990). Within the scrub/pan areas there will be a number of terrestrial birds, taking up all available niches, and these species have been recorded (in part) by Balram Singh (1986) and King (1987).

2.7 Human impact on the mangal

The Guyanese coast has historically undergone considerable human development by the clearance and empoldering of coastal areas for agriculture; and the settling in these areas of the majority of the population. With much of the coastal plain of Guyana lying below high spring tide level, the country has developed an extensive system of sea defenses, by means of seawalls and groynes.

This historic clearance has meant that the mangrove areas of the coast are generally thin. Only along the Waini - Pomeroon coast are mangrove forests of any size found today, together with isolated areas such as Crab Island in the Berbice estuary.

The result of clearance has led to the development of the pans and mangrove scrub lands that form the immediate seaward coast in most areas between Anna Regina in the Essequibo, to the Corentyne River. This land may be used for cultivation, grazing or now lie abandoned as saline conditions have built up after sea defence works have broken down. In many areas housing will be found up to the sea defense.

The most important effect on the mangrove fringe at present is the practice of cutting for fuel wood. This occurs in all areas, and is carried out both on an artisanal, family scale and commercially. During the survey wood cutters, were encountered using chains saws and tractor/trailer combinations to haul away the lumber. More common were bands of children and women with cutlasses, taking cut branches back for fuel.

The need for fuel is accepted, and the mangrove provides and easy source of fuelwood, given the proximity of human dwellings to the shore. However the practice is not supervised, and trees are badly damaged in the processes, so sustainable forestry is not possible.

Artisanal fishermen may also cause localized damage. In some areas, fishermen (many part-time) pull boasts up on mudflats and beaches, and create paths through the courida. As coastal changes occur, the fishermen may cut back into the foreshore to ensure the safety of their craft, whilst at the same time causing damming to the mangal.

Where new mangrove is developing, and beach or shore pans are being colonized, another hazard to the development of new mangrove is grazing by goats. There is no overall system of rangers to ensure that sea defences and foreshore areas are protected, and livestock is allowed to roam freely along earthen sea dams and graze the foreshore.

3 THE GUYANA COASTAL ZONE

3.1 Physical coastal change

The natural accretion/erosion cycle along this coast has been well documented (Augustinus 1978, 1984). Augustinus has

indicated that the coast of Guyana is has a number of shifting mudflats, moving from east to west. His work indicates that not only are these mudflats moving along the coast, but there in an inward movement. This (as stated in Section 2.2) means that there will be accretion as well erosion at the extreme ends of these mudflats. If the mudflats are adjacant to the shore, erosion will affect the present Guyana coast.

With human development so close to the shore in most areas, reliance on sea defence works is considerable. The Guyana coast is protected by a number of sea defences: about 70 Km are protected by masonry seawalls, a further 170 Km by earthen embankments (or the bunds of facade drains). The Department of Hydraulics consider that about another 80 Km may be protected by natural sand banks.

The Guyanese situation is thus different from that in Suriname, where human development has tended to be more inland, along the major and minor rivers (although the empoldering and drainage systems are similar). Suriname, by contrast to Guyana, has relatively few seawalls, and allows a strip of land (seaward of development) to be considered as 'sacrificial' land for natural erosion.

To reduce the cost of sea defence maintenance, consideration is being given to mangrove management in Guyana. Mangroves have traditionally been considered as suitable for coastal protection in certain areas, and form the main vegetation of the Surinamese 'sacrificial' strip. Mangrove forests are known to be effective barriers to coastal erosion by cyclonic storms. The Sundarbans of Bangladesh have been re-planted to assist in flood prevention, and recent anecdotal reports from Monserrat show that boats sheltering within the mangroves survived hurricane Hugo in 1989 (whilst boats in harbour and open water were destroyed).

However the erosional nature of the coasts of the Guianas is one where there is considerable undercutting of the foreshore. This results in a rapid loss of foreshore area, and the species of mangrove along eroding coasts provide no protection to this form of erosion. Tomlinson (1986) notes that the general accepted conclusion of the role of mangroves in coastal protection is that they do so only in regions that "...would undergo sedimentation even in the absence of shoreline vegetation.". This view has been supported by Hussain (1990).

Neither does the species of mangrove appear to affect the consequences of erosion along the Guyana coast. Rhizophora has been undercut on the Pomeroon coast, as has Avicennia in most other coasts of the country. The only natural stabilization is the development of beaches and sand bars,

and the formation of these could provide some form of natural coastal protection.

Mangroves will also be affected by external factors, both natural and man-made, in inshore areas. Chenier formation can isolate mangrove areas and prevent the normal tidal flushing necessary for the health of the plants. Some inland areas may be well drained, but evaporation will lead to hyper-salinity in the soils and the subsequent death of the plants. Where a chenier isolates a depression, or encloses an area between two drainage bunds, a lagoon may develop. This will fill through rain water, and without any means of drainage will rapidly become stagnant. Such lagoons will destroy Avicennia and Laguncularia species by inundation of the pneumatophores by the build up of brackish water.

The mangroves do have a potential role in coastal protection in Guyana, by raising foreshore areas through increased sedimentation. However, it will be necessary to consider other means to ensure such new coastal areas are stabilized. This may mean the establishment of groynes and breakwaters to stabilize areas of mangrove or new plantations (Pastakia, 1986).

3.2 Institutional management of the coast

For the sea defences of Guyana to be effective it is important that all aspects of coastal zone management are addressed, not merely the maintenance of the sea defence works. This would involve the inspection and management of foreshore areas; the management of mnagrove by sustainable forestry practices; and the monitoring of the coastal and offshore changes.

Responsibility for sea defences rests with the Department of Hydraulics, Ministry of Agriculture, who have control of the development of the foreshore. It is proposed that the Hydro-meteorology department should, in future, be under the Department of Hydraulics. There is no forestry control of the mangroves by the Guyana Forestry Commission (now part of the Guyana Natural Resources Agency [GNRA]).

Coastal monitoring should fall under GAHEF, together with the Department of Fisheries, Ministry of Agriculture. GAHEF has convened a sub-committee, as part of its Advisory Environmental Council, to consider coastal zone management. GAHEF is still undergoing a period of institutional strengthening, and its role will increase towards the end of this period. At present, practical coastal monitoring can only be undertaken by the EMCU (MMA/ADA).

Management of the foreshore is the province of the Regional Council. For local government purposes, Guyana is divided into 10 Regions. Regions 1 - 6 lie along the coast from the borders with Venezuela to Suriname.

These institutional responsibilities will need to be co-ordinated for effective management in the future. To assist in this processes it is important that future practices are related to the actual conditions within the country, and the alternative courses of action offered by these conditions.

To assist local decision making, and more easily consider the present status of the mangrove coastline, the baseline will now be discussed by Region. The maps provide a quantitative baseline for Regions 2 to 6, and the following sections summarize, on a Regional basis, the major features of the areas covered by the maps.

3.3 Region 1 : Waini/Pomeroon

This area is covered by MAP AA. The coast in this Region represents the most 'natural' coastal area in the country. There has been no useful aerial photography, as the population is widely dispersed and there is no ground infrastructure in this area. Access is by plane into Mabaruma, and by boast along the coast and the rivers.

The coast is dominated by a thin strip of shell beach, behind which is a dense coastal forest. The shell beach migrates as part of the continuous chenier/mudflat process along this coast. The actual composition of the coastal forest is unknown, although it seems that the coastal fringe is made up mainly of tall trees of Avicennia. There is evidence from (from aerial observation) that the ground is extremely swampy, although with the high shell beach this may be flooding from the Waini River. Along the coastal fringe there are a few areas of clearance on which coconut has been planted.

There are isolated areas along this forested coast where erosion has occurred, as evidenced by fallen trees. Some coconut has fallen, and it may been that these plantations are moved as natural conditions destroy old sites. What such cultivation may do to future coastal vegetation is unknown.

Further to the south, within the catchment of the Moruka River, there is an extensive coastal swamp. This is very low lying and is afforded no coastal protection. The interior of the swamp is typical of the coastal swamp savannahs of Guyana, made up of grasses and reeds with small copses of Aete palm (Mauritia flexuosa).

3.4 Region 2: Pomeroon/Essequibo

This Region is covered by MAPS 1 - 23. The area is very interesting, as it demonstrates a number of features of the Guyana coastal situation , and is the main area of Rhizophora dominance.

The coastal road turns west at Better Hope, and so the coast running north-east from here is increasing removed from the main access artery. Access is available at Marias Delight, where there has been considerably erosion. There is no evidence of regeneration as yet, and erosion is active to the north-east. It is possible to access the mangrove up to the drains by Somerset & Berks, and this area has been studied as a representative site (Maps 9 & 10).

The mangal is dominated by Rhizophora on the extreme seaward edge, with Avicennia developing as a belt inland to the sea dam. The impression of the forest in this area is that the Rhizophora species provide the dominant cover to the seaward mangal; whilst Avicennia species are found, both as isolated large trees in the seaward zone, but mainly as an inland belt, together with Laguncularia racemosa. This impression is supported by transects made at Somerset & Berks show the reduced depth of the mangal, and the increase in the numbers of Rhizophora on the seaward fringe, though with Avicennia being found over most of the mangal.

Evidence of coastal erosion appears in the area of Somerset & Berks. Rhizophora spp. form full, rounded crowns, and it difficult to see the degree of erosion of this species from the air. It may be that erosion is continuing northward along this coast, but access was only by land, and no boat work was undertaken along this coast to check on the northward fringe.

From Marias Delight southward the sea defence works are generally masonry walls. The coast is under severe erosion at certain points, specifically Marias Delight and Land of Plenty/Three Friends. From Dartmouth, southward, the sea defences mark the shoreline, and there is little mangrove evidence, until the thin line at Three Friends. This is an isolated, eroding stand of trees. The mangrove along this southern coast has practically completely disappeared, presumably from the close proximity of human development to the shore.

At Three Friends erosion has now resulted in a shore chenier developing, and inland (between the chenier and the facade drain) there is a small isolated lagoon. There is evidence that this lagoon developed from a depression that became isolated from the sea by the chenier, and the consequent lack of flushing has caused the death of Avicennia species

around this water body. The variation in salinity in this lagoon ranged between 4000 - 7100 mg/l NaCl, which is a very dilute brackish-water situation. The Avicennia has died presumably from inundation by rain water accumulation. This is similar to the observations made on Avicennia death at Trafalgar, West Coast Berbice (Pastakia, 1986).

Along the coast near Suddie, a groyne field has been established. This has caused a sound beach development which acts as the sea defence. However, sand is an unsuitable substrate for mangrove, and there is no tree cover along this foreshore.

The thin fringe reappears opposite Tiger Island, and continue southward towards the mouth of the Supernaam River. At the river mouth there has been some accretion, and new mangrove growth. The cause of this is unknown.

The general impression is that in the southern part of the coast of the Region, human activity (including sea defence works) has removed all mangrove cover. Although there are substantial mangrove forest areas in the north, these are still under pressure from coastal erosion and human cutting for fuelwood. Woodcutters in this area were using chain saws and tractor/trailers to remove the timber. On questioning they accepted that they should not cut courida, but it was easily accessible, and fetched a good market price. There was no monitoring or management system in force in this Region.

3.5 Region 3 : Essequibo Island & East Coast Demerara

This Region is covered by MAPS 19 - 36. The two main Essequibo islands are Wakenaam and Leguan Islands. These have traditionally be heavily cultivated, and in some areas have been provided with masonry sea walls.

The northern, Atlantic Ocean facing, coasts of both Wakenaam and Leguan islands are dominated by large stands of mangrove, with Avicennia on the fringe. These coasts are undergoing continuous erosion at present, and the tress in on the shore are being continuous under-cut and brought down. There has been notable sedimentation on the north-east of both isalnds, with beach and pan formations, occurring, however, at the expense of the old mangrove. Mudflats are forming offshore, and these are extending and may join to form a single large bank to the north of these islands.

The banks upstream are dominated by Rhizophora mangle This is the typical situation of the rivers of north-eastern South America. Hog Island, further upstream, has a total Rhizophora fringe, except where cut by human activities.

However human impact has reduced the mangrove fringe in many places, mainly in the centre of the islands, and close to the areas of housing.

There has also been a replacement of the Rhizophora by riverine species, such as Thespesia populnea and Montrichardia arborescens. Such species provide no protection from any flooding, neither are they useful as plants to encourage sedimentation. Many parts of the islands have suffered from destruction of their river defences, and in the southern parts of Wakenaam this is due to the invasion of riverine species, at the expense of the mangrove fringe. The southern tip of Wakenaam shows this clearly. It is interesting to note that the north-eastern shores of both islands are the most heavily eroded. On the western side of the islands, the mangrove shows signs of new expanding growth in some areas.

West Coast Demerara is another area where the proximity of human development has reduced any mangrove fringe. This is not a recent phenomenum; the 1970 baseline shows clearly that mangrove was scarce. The only notable area is that formed along the west coast of the Demerara River. Here the groyne at the river mouth has been extended, and there is considerable deposition of sediment in this area. Rhizophora is found at the seaward edge of the mangrove, but the dominant inland species is Avicennia. Much of the growth is recent, with Avicennia saplings growing from the fringe up to the old sea dam.

Human impact is lessened in this area, although there is some felling (mainly for posts) within the more mature Avicennia areas. It may be that the proximity to Georgetown, and the small size of saplings, has reduced the need and desire to cut for fuelwood.

3.6 Region 4 : Demerara/Mahaica

This Region is covered by MAPS 37 - 41. The photography for Georgetown was not available, and so this Region is covered only from Brothers to the Mahaica River.

There have been some changes in Georgetown itself, mainly in the area of Kitty, where a large groyne has allowed a substantial bank to be formed seaward of the seawalls. Most of the area is taken over by terrestrial species, although there are young Avicennia and Laguncularia saplings on the extreme edge of the mudflat. The whole of the Georgetown coast is defended by masonry walls, and there is an extensive mudflat to sea.

Small copses of mangrove, primarily Laguncularia exist at odd pints along the shore. There is a substantial beach formation between Mon Repos and Lusignan, with a large copse of mangrove, seaward of the seawall. This area has a large mudflat to sea, and the exposed old sluices demonstrate the degree to which this area of coast has been eroded. Erosion is still continuing in the area of Good Friends.

The mangrove copse lies behind a small raised beach, and is primarily of Avicennia at the seaward fringe. Inland Laguncularia dominates. All trees are small, and represent relatively young growth. Further inland there is a marsh, with various grasses, but large areas of bare ground, which lagoon by tidal flooding.

This copse represents the general pattern of the isolated outcrops that occur along this stretch of the coast. This Region is the most densely populated and human housing and plots are found up to the sea wall. Anecdotal evidence suggests that, within living memory, mangrove stands existed for some distances out to sea, but all evidence of mangrove forest has disappeared.

3.7 Region 5 : Mahaica/Berbice

This Region is covered by MAPS 41 - 56. The area is of considerable agricultural importance, but unlike the Essequibo, is reliant on earthen sea defences for most of its coastline. Human impacts on the coast are important in this Region.

The mouth of the Mahaica River shows a dramatic change, with the establishment of a sand bar and mudflat. This is already showing areas of colonization by Avicennia, and the mangrove forest inland from this shore is extensive. Between Mahaica and Mahaicony human settlement is not dense, and is generally situated away from the sea (along the public road), with the coastal areas being used for cultivation or grazing (if at all).

The short coast between the Mahaicony and Abary Rivers shows signs of accretion, particularly in the area between Dundee and Calcutta. This may be due to the accumulation of sediment due to the flood control system now operation on the Abary River, which (by flow reduction) will have little effect on coastal transport.

The foreshore at Novar is illustrative of the form of mangal along this coast. Dominance by Avicennia is complete, but there are patches of Rhizophora, Laguncularia, and Conocarpus. The new beach area is being colonized solely by

Avicennia. On the beach there are numbers of implanted Rhizophora hypocotyls, which are dying after being subject to insect attack. Boaden & Seed (1985) indicate that beetle larvae (eg: Chrysobothus spp.) can cause extensive damage by leaf grazing on Rhizophora mangle. The Rhizophora is found in a copse towards the inland pans. This area has been subjected to considerable cutting, perhaps for access but also for timber (axe marks are seen on the stumps). Here, as elsewhere in the Region, many trees throughout the mangal show cutlass and axe marks, where branches have been taken for fuelwood.

There are a series on long thin pans that make up the land inland from the mangrove fringe. These have been used for kitchen gardens, or are seen as bare, salt covered areas. It may be that these are old cheniers that have been isolated by new coastline development. Further inland the pans have various grasses, and are used for grazing. Some abandoned areas are dominated by Batis maritima.

Coastal accretion continues immediately east of the Abary River mouth. The area of Profit has held a large mangrove forest, but this has been much reduced by commercial cutting, and land clearance close to the side of the public road. This Avicennia dominated forest houses a large commercial apiary, producing Avicennia honey.

The accreting coast continues towards Belladrum, but there has been a serious, localized erosion opposite the Profit/Foulis drain. Here the mudflat has intruded into the coast, and the facade drain bund is at risk of being breached. Avicennia seedlings in this immediate area are less vigourous than elsewhere in the area. There is a drainage channel through the mudflat (probably assisting in tidal flushing of the coastal lagoon), and fishermen use this channel for bringing their boats close inshore. This practice may assist in preventing re-colonization of this mudflat.

From Golden Fleece east to the Berbice River the coast is actively eroding. This is in keeping with the locations of the mudflats (migrating over time) described by Augustinus (1984), and would fit in with his description of the accretion/erosion process (1978). The cycle of erosion here has been very rapid, with particular destruction at Lichfield where the facade drain is breached.

The mangrove destruction at Trafalgar has been historically studied (Pastakia, 1986). Here the chenier lagooned an area between the old Onverwagt drain, and the new outfall from the Trafalgar Pump Station. The lagooning was a result of rain water accumulation, and this inundation destroyed the Avicennia copse in this area. The data supporting this

sequence of events has been well documented, and although Hussain (1990) report anecdotal suppositions that hypersalinity may have been the cause of death, no supporting data for such an alternative hypothesis has been published.

The erosion at Phoenix is particularly interesting, showing as it does a fine example of the indented erosion coast (Happen-coast). The old sea defence line is seen by the isolation of the old sluice out to sea.

Large mangrove stands in the east of the Region were found at Lovely Lass and Bath. These are being severely reduced by erosion. The mangrove belt at Waterloo Jib is also under attack. Although there has been erosion eastward from here, and the sea defences at Cotton Tree are presently at risk, evidence of regeneration is being seen at Mon Chosi. There are large Spartina brasiliensis beds, and Avicennia is growing on the shore. The high water mark is covered with timber waste from saw mills in the Berbice River. This material is too loose to allow seedlings to become established, and thus maintains the barrenness of this part of the shore. Towards Zee Zight some Rhizophora can be seen on the seaward fringe, although the species has a depth of only 1-2 trees, and the line of trees is short.

3.8 Region 6 : Berbice/Corentyne

The Region is covered by MAPS 55 - 74. In this area the most interesting shoreward accretion features are found, together with much evidence of erosion nearer to the Corentyne River.

Within the Berbice River, Crab Island, retains most of its mangrove cover. This area is therefore very interesting, and it would serve as a useful baseline area for determining natural growth along this estuary. The fringe is Rhizophora but inland Avicennia once again dominates. Access is only by boat, and the area is subject to tidal inundation.

The coastal fringe is totally dominated by Avicennia, and there is evidence of much erosion at the west point of the Berbice estuary. This area is the outfall for a number of natural channels, and there is a developing mudflat in the area of an old coastal lagoon. The features of this area (Map 57) are most likely influenced by coastal processes to the east.

The most significant accretion formation seen in the survey is the sand bar development between Cheswick and Courtland (Map 58). Given the size of the sand bar it is likely that the feature will remain for some time. This coastal area has become a natural laboratory for the study of accretion along the Guyana coast. Shoreward of the sand bar, the mudflats

are traversed by drain outlets from sluices and lagoons eastward along the coast. These are fished by hand nets, and are covered by high tides. The sand bar itself is covered at high water, but is now being colonized and raised. On the inland slopes of the sand bar/mudflat interface both Avicennia and Laguncularia are colonizing. The shore fringe is also made up of young trees of both species, and there are areas of salt mash within the mangal. Bird life is abundant, and the largest flocks of scarlet ibis (Eudocimus ruber) were seen in this area.

The coastal changes further to the east are affected by the complex drainage systems at Port Mourant, and between Tain and Alness. Eastward from Alness, the coast is generally accreting in thin strips running along the existing shoreline, and these strips are being colonized by mangrove. Human activity up to the shore is very pronounced in this Region, coastal areas are being used for kitchen gardens, and clearance is considerable.

Between Dingwall and No. 55, there is a large inland mangrove forest that has been reduced in size over the years. Its composition and the caused of reduction have not been investigated, but there is evidence of new growth along the shore. The coastal fringe from Carnarvon to No.77 is largely intact, but this area shows a further accretion with a large beach formation running along the coast. The earlier erosion has reduced the forward mangrove fringe in many areas, and isolated trees with exposed roots can be found. There is much human activity up to the mangrove, and evidence of cutting for fuelwood.

Further east from No. 77 the coast is now undergoing erosion with considerably damage to the seawalls in many places. The mangrove had traditionally disappeared except as a thin line of trees, and this stretch of coast is reliant on masonry seawalls.

4 MANAGEMENT OF THE COASTAL ZONE

4.1 Prediction and control of coastal erosion

Although the use of aerial photography, and the mapping of the coast has been able to show the changes that have occurred along the Guyana coast, this system does not provide for a suitable on-going method to predict coastal erosion. It is possible by field monitoring of the coast to give early warning of areas at risk from coastal erosion. However this only permit remedial work, and does not provide a technique for long-term planning of coastal development.

In Suriname, the monitoring of mudflats, in accordance to the theories and work of Augustinus (1978, 1984) has proved successful in determining the mobility of this shoals. On the assumption that the eastern edge will show erosionary tendencies (if sediment transport is insufficient) the future location of these edges can be predicted. This monitoring is executed by the use of 1 : 20,000 aerial photography, and is carried out on a regular basis by the Ministry of Public Works, Government of Suriname.

This system appears to be the most effective, practical method to provide some prediction for identifying areas at future risk. It is therefore recommended that the Department of Hydraulics, through the Government of Guyana, approach the Government of Suriname to see whether there is possibility for the two countries to execute (on a regular basis) aerial photography of their adjoining coasts and offshore areas, and to cooperate in the analysis and use of the data from this monitoring.

Control of erosion may be undertaken in Guyana by using mangrove to slow the rate of erosion. It is more likely however, given the proximity of human development to the Guyana coastline that traditional sea defence systems will continue to be the main control system. However, given the increasing cost of maintaining such defences, though should be given to the possible relocation of communities, in order that parts of the coastline could be set aside as 'sacrificial' belts, similar to the condition in Suriname.

4.2 Mangrove areas at risk

The mangrove coast of Guyana is generally a very thin fringe, dominated by Avicennia spp. and subject to periodic destruction by the natural erosion processes of coastal transport. The thinness of the mangrove fringe is almost certainly due to historic human clearance, mainly as a result of the coastal strip development of the country.

The cyclic erosion/accretion processes along this coast are reflected in the mangrove stands. In general it is safe to say that the mangrove will naturally regenerate once the erosion process has stopped. During the period of erosion all species of mangrove will be severely undercut, and the thinness of the stands renders the existing mangrove fringe in most areas unsuitable for any form of primary sea defence.

Human impact in reducing the mangrove is continuing. Two direct effects can be identified:

(a) the destruction of mangrove for sea defence works or for agricultural land (including drainage works)

(b) cutting of mangrove for artisanal and commercial fuelwood

Unless these impacts can be controlled and minimized, extending and managing mangrove for any form of sea defence is impossible. Consideration of the mangrove should not be restricted to its sea defence value. The mangrove areas have an important environmental value, both as a fisheries spawning/shelter area and in terms of natural productivity and wildlife conservation.

At present certain areas are suffering from erosion of the courida, and the rate of destruction should be monitored to gain some idea whether courida does have a significant slowing effect on the rate of coastal erosion. There are two important stretches of coast which should be monitored. These areas will provide future information for a sea defence policy, as well as immediately identifying areas that may be at risk. These stretches of coasts are:

(a) the stretch of coast lying northwest of Better Hope, until the outfall of the Crozier Canal (Essequibo)

(b) the stretch of coast between the Mahaicony and the Berbice Rivers.

Of these two the second is extremely important, as it covers the coast, behind which lies major agricultural areas of Guyana. This area is also subject to a number of human impacts on the coast (other than the two given above) which include changes in the discharge of freshwater, possible pesticide run-off, and houses a large fishing community.

A recommendation has been made to the Chief Hydraulics Officer and to the European Community, and is reinforced here. The recommendation is, that as the coast between the Berbice and Mahaicony rivers shows a situation of active and continuing erosion in many areas (with some evidence that stabilization and the natural re-establishment of mangrove is also occurring in some areas), and that the sea defenses in this area of Guyana are generally weak (and, if breached, considerable damage can, and has, occurred) it is recommended that monitoring of this coastal region be implemented as soon as possible; to determine the existing condition in detail, as well as noting the extent of areas of regeneration, and the estimating the rate of erosion. Without this data, planning for sea defenses and hence agricultural production will be on an 'ad hoc' basis; early,

economic preventive measures could not be undertaken.

It is further recommended that Environmental Monitoring & Control Unit (EMCU) of the MMA/ADA be employed to plan and execute the monitoring programme. The EMCU is experienced in the necessary monitoring techniques through its collaboration on this study.

It is also suggested that the EEC Representative in Guyana be approached to see whether the EEC could assist with funds to undertake this very necessary work.

4.3 Mangrove areas to be preserved

Preservation of mangrove areas will require management of the coastal area, both in terms of policy and field monitoring. Human activities will need to be controlled, and if this aspect of coastal zone management is to be considered, both funds and personnel will be needed.

Existing large mangrove areas that should be considered for preservation are:

(a) the coastal forest between the Waini and Pomeroon Rivers

(b) the stretch of coast lying northwest of Better Hope, until the outfall of the Crozier Canal (Essequibo)

(c) the Dauntless Bank (Leguan Island)

(d) the area fronting The Best, West Coast Demerara

(e) the mangrove forest at Profit, West Coast Berbice

(e) Crab Island, Berbice River

(f) the entire stretch of coast between the mouth the Berbice River, to Courtland (Corentyne)

It is recommended that a policy for the protection of these areas be developed, with responsibilities for the protection of mangrove from human activities being clearly defined.

4.4 Planting of mangroves to extend existing mangal

The main areas of mangrove cannot be extended along an eroding shoreline. However certain areas are regenerating, and some areas could be extended by the developing of a new mangal to the seaward of the existing shoreline. This latter

form of development will require replanting and protection of the seedlings by some physical means of breakwaters or groynes.

The need to provide some protection for the seedlings is important. This will necessarily increase the costs of the planting exercise, but should ensure the success of any replanting. It should be possible to use timber to make temporary groynes and breakwaters, and this should be given serious consideration. It may even be possible to use fallen Avicennia for breakwater purposes. The wood is very hard, water resistant, and many large trees have fallen naturally. These will litter the adjacant shores in many areas suitable for replantation.

The planting of viable embryos is a possibility to ensure that the mangal is extended. Such an exercise in Guyana has been well detailed by Hussain (1984) and his general methodology can be followed. This would entail the planting of viable embryos in a grid pattern, with 1.5 - 3 m spaces. Viable mangrove embryos can be stored at cool (not freezing) temperatures for about 3/4 days prior to planting. This will allow for collection and transportation of a suitable number.

Hussain indicates that whilst there will be a labour cost, supervision of planting will be necessary. What is most important is that areas are planted in a planned sequence, to ensure that the exercise is both practical and successful. Work may well have to be executed from boasts, and these rowed in shoal waters. Thus the area covered per unit of time will be relatively small, and restricted to tidal regimes. The success of the implementation of Hussain's recommendations will be in the planning of the operation, and a sequence is suggested here:

(i) Choice of suitable sites: this will be dependent on whether the sites show accretion or non-eroding conditions, and whether the substrate would be suitable for planting (sandy beaches are not suitable; sand/mud and clay substrates are suitable)

(ii) Determination of embryo numbers: the site chosen will determine the species to be used. Although Avicennia is the dominant species for reasons suggested earlier, if offshore banks are being planted, it may be possible to use a species mix (Avicennia/Laguncularia, Avicennia/Rhizophora)

(iii) Collection of embryos: this will be a question of finding trees of the correct species, and with sufficient numbers of embryos available. Avicennia is a seasonal seeding plant, with flowering between

September - May. Rhizophora will bloom all the year round. It will be important to ensure that a suitable number of trees, probably form various sites, can be found to supply the required number of embryos. The embryos can be cool-stored prior to use.

(iv) Planting exercise: this may take some time and will require the logistics of the exercise to be carefully planned, to ensure that excess embryos/seedlings are not collected/transported until needs, and that a realistic area is planted at any time taking account of tidal conditions

(v) Monitoring the plantation: it will be necessary, once the planting has been completed, to set in place a monitoring programme to ensure that the plants are not damaged from human activities, and to take remedial measures if natural attacks (insects, waves effects) occur.

(vi) Nursery plantations: given the need to consider planting sea banks, it may be necessary to set aside protected areas of the coast, to act as nurseries to grow seedlings prior to planting. These areas will be relatively small, and seedling replanting should be done in rows rather than in a grid.

It will be seen that the replantation exercise will require considerable natural, human and financial resources. Approximately 2500 embryos will be needed to plant one hectare. This a major operation to coordinate collection, transport and planting. It is therefore considered that, given the nature of the mangrove fringe, it may be more practical in the short-term to consider only preservation of areas, and to undertake small scale planting exercise mainly to develop planting techniques for local conditions.

Certain areas will be suitable for early planting exercises. The main areas suitable for such exercises would be:

(a) the foreshore of Good Friends, Essequibo

(b) foreshore of The Best, West Coast Demerara

(c) foreshore of Mon Chosi, West Coast Berbice

(d) areas between the mouth of teh Berbice River and Courtland, Corentyne

4.5 Coastal Zone Management

A number of interests overlap when considering the value and management of the mangrove coast of Guyana. The institutional complexities have been summarized earlier, and it will be important (in the future) for the interests of forestry, conservation, fisheries and human heritage to be integrated into a policy for the management of the coastal zone.

Any preservation of mangrove or extension of mangrove forest will require some form of sustainable forestry management. The mangrove is not, at present, considered as a forest resource by the Guyana Forestry Commission (GFC). The National Forestry Action Plan for Guyana only suggests the development of multiple-use forest plantations to "... reduce destructive pressure on mangroves.". There is no plan to manage the mangroves themselves.

The first stage in any future management of the mangrove must be to determine the policy towards the foreshore. This is a complex problem, as it involves interests from many Government and private sector areas. It is not a matter of simply providing that the management aspects be passed over to any department, without consideration of the other impacts and uses of the coastal zone, and the availability of resources within the country.

The conservation of wildlife in the coastal zone is of importance. Archaeological studies are also focused on this zone, especially in the Waini area (Williams, personal communication), and fisheries (including the artisanal fishing community) also have considerable interest in this zone. These considerations, together with sea defences, social and agricultural planning, and the local government administration, should all be represented in any development for a management programme for the foreshore.

Accordingly, as a first stage to both forestry and wildlife management, it is considered that the Government of Guyana must develop a policy towards Coastal Zone Management. The present advisory sub-committee set up by GAHEF is an important step forward, but its capabilities are necessarily limited without a national policy and mandate under which it can act. It is therefore recommended that a new Coastal Zone Management Group be set up, made up of senior government officers and persons with experience in areas related to the coastal zone, and who are in a position to directly advise the decision makers in the country, and this Group should, in the first instance, develop a policy for the management and coordination of responsibilities for the coastal zone.

The technical aspects of Coastal Zone Management can only follow once the policy and mandates have been handed down to the various departments concerned.

4.6 Research

There are possible areas for future research into the mangrove courida of Guyana that would provide valuable information and increase the environmental database of the country. This study highlights two areas, and programmes for future research.

4.6.1 Waini study

The Waini area represents the most natural area of coastal forest in Guyana. Because of its remoteness from human activities, it has managed to preserve this unique character. Accordingly it represents the natural baseline for the courida of Guyana.

It is recommended that a multi-disciplinary study be mounted in the Waini area. This would have to operate either from a research vessel, or from fixed camps within the area.
The tasks of this project would be as follows:

(i) To determine the actual composition and extent of the mangrove forest between the Waini and Pomeroon Rivers, in order to provide a natural baseline for the Avicennia courida in Guyana,

(ii) To inventorize the flora and fauna of the coastal forest, and to estimate populations of any endangered species.

(iii) To study the ecology of the turtle communities on the shell beach.

(iv) To look into the archaeological evidence of migration and change in habit of the early Amerindian inhabitants of Guyana. Williams (personal communication) has indicated that the evidence of shell mounds within the Western Guiana Littoral are diagnostic of the changes in archaeological time.

4.6.2 Corentyne study

The sand bar and mudflats that lie between the Berbice River mouth and Courtland offer a major study area for a wide range of disciplines. This area can be used for the study of accretion by sand and shell clastics, and the stabilization

of mudflats. As the mouth of the Berbice River shows active erosion of the mangrove fringe, and Crab Island and West Coast Berbice are easily accessible by boat, this area is close of other interesting areas for comparative purposes.

It is important that this area is preserved without undue human development. In this instance any proposals to dam outlet channels, or develop fish ponds on the foreshore should be strongly opposed. Such development will only provide a short-term, and localized, economic return, whereas the area at the moment supports some artisanal fishing, and loss of the wildlife and data from this area will be irreplacable.

Unlike the Waini Study, studies in this area can be carried out as a series of individual projects or as a single project. Coordination between researchers of all disciplines will be essential.

Access to the area can be by boat and from the land. The proximity of the EMCU of the MMA/ADA means that there is a local base from which the research can be centered. The area is suitable for the monitoring of physical changes from aircraft. It is recommended that these studies be considered by the relevant departments in Guyana, together (where possible) with the University of Guyana, to devise programmes to execute these tasks.

The tasks that could be covered in this area are:

(i) The establishment of planted areas of mangrove and the comparison of these areas with naturally regenerating areas, to develop a local technology for replantation. At least two one-hectare plots could be marked out to compare naturally regenerating and planted areas.

(ii) The establishment of hides, and a survey of the migratory wildfowl that are likely to use this area. Data may show that this area may be a possible site within the Western Hemisphere Shorebird Reserve Network.

(iii) A study of the natural fishery within the area, to estimate the conditions and productivity of the mudflat/mangrove area in relation to fishery resources.

(iv) A study of the accretion/erosion process in the area, in particular the mechanism for beach formation, and its relation to the sand/shell clastic sediments carried by the major rivers and their transport properties along the coast.

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APPENDICES

APPENDIX I

DESCRIPTIVE NARRATIVE ON ACCOMPANYING MAPS

APPENDIX II

TERMS OF REFERENCE

APPENDIX I

DESCRIPTION OF THE GUYANA COAST RELATED TO BASELINE MAPS

KEY TO THE SYMBOLS AND LETTERING USED IN COASTAL OUTLINE MAPS

NOTE:

The details of the photo-interpretation of 1970's photo-mosaics are shown by simple black lettering in the appropriate areas. The same letters are used for the 1990 observations, and these are shown as white letters on a black background.

LETTERS

SB SAND BAR. Isolated sand strip developing along the foreshore.

MF MUDFLAT. Visible in the near-shore area, but complete outline uncertain in most cases.

B BEACH. Evidently firm beach. Complete outline not often clear.

L LAGOON. Clear area with water visible on photo-mosaic.

P PAN. Cleared area, probably natural, and showing dry on photo-mosaic.

MS MANGROVE SCRUB. Very light woodland, with many dispersed trees, which may be mangrove or mangrove-associates, usually in shoreward areas.

MW MANGROVE WOODLAND. Term employed by forestry maps (though not defined), probably intermediate form of woodland between scrub and mangrove forest.

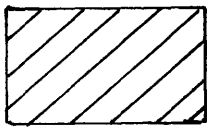
CF COASTAL FOREST. Term employed by forestry maps though not defined. Probably dense forest made up of coastal (non-mangrove species).

OS OPEN SWAMP. Open savannah swamps where there are seasonal water movements (shown on forestry map).

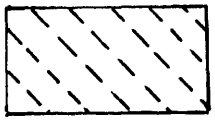
U UNCERTAIN. Human impact seems to have occurred, but details are not clear, and many trees are still intact.

H HUMAN IMPACT. These areas indicate that there has been tree removal or pan exploitation for human use, mainly agriculture and drainage.

SYMBOLS



Mangrove areas identified by photo-mosaics dating from the 1970's.



Mangrove areas identified by field-work and over-flying (1990).

— — — — — Line of single trees, or probable line of separation between two discrete areas (1970's).

—·—·—·—·— Probable line of separation between two discrete areas, or new coastline (1990).

==========

MAP AA

WAINI - POMEROON

SITUATION IN THE 1970's

The area shows a thick mangrove forest running along the coast up to the area seaward of the confluence of the Waini River/Luri Creek. At this point mangrove woodland takes over. It is uncertain as to the make up of this woodland, but it may be a less dense form of forest. Towards the Pomeroon River, large areas of open swamp (savannahs) are noted. The inland areas are also forested, but a distinction is made, and this forest is likely to be that common to lowland swamp forests.

SITUATION IN 1990

The shell beach shown along the coast is said to be transient feature, with no fixed location. At present it appears as a more or less continuous strip in front of the mangrove. The mangrove fringe appears to stretch from the Waini River mouth to about the mouth of the Moruka River. A little north of this point the mangrove fringe thins considerably, and there are open swamps with no obvious sea defence, stretching for considerable distances inland. There is no obvious distinction between this swamp and the earlier marked open swamps around the Pomeroon River.

MAP 1

SHEET NO: 0044 BOLTON ACRES

SITUATION IN THE 1970's

The seaward mangrove fringe is very thin, possibly as a result of the extensive clearance and cultivation that extends practically to the coast. In some areas the mangrove fringe appears as a series of small clumps, usually by landings.

SITUATION IN 1990

There has been little change to this area of coast, although the mangrove may be thinner in the north, and some clumps have now become small 'islands.

==========

MAP 2

SHEET NO: 0040 ESTUARY OF THE POMEROON RIVER

SITUATION IN THE 1970's

There is a thick forest on coastal mangrove to the east, but human activity has reduced the western coastal fringe considerably. Both banks of the river are mangrove lined, although human activity on the eastern bank has reduced this fringe.

SITUATION IN 1990

The overall picture has changed little. The large mangrove forest on the west bank of the Pomeroon River is marked uncertain, as the present boundaries of this forest have not been determined.

==========

MAP 3

SHEET NO: 0840 TUSCHEN - RELIEF

SITUATION IN THE 1970's

The foreshore shows a dense mangrove belt, in places over 2Km. wide, with variation in crown densities. It appears that the seaward half may be permanently inundated. Few small open water lagoons are found on the seaward edge, whilst on the sea edge before TUSCHEN a narrow fringe and lagoon is evident. Human impact is shown by pronounced clearance and cultivation, though there are small patches of re-colonization at NEW HOPE and RELIEF and a cleared pan remains at ENMORE.

SITUATION IN 1990

The mangrove forest seems to be largely intact, though the the existence of the coastal lagoons is now uncertain.

==========

MAP 4

SHEET NO: 0836 & PART OF 1636 ENMORE - PHOENIX PARK

SITUATION IN THE 1970's

There is a wide mangrove belt to seaward. This is cut by drainage channels surrounding DUNBARTON CASTLE to PHOENIX PARK, but mangrove extends either side of the drains, except where clearance for cultivation has occurred. Part of the human reclamation has taken place in the pans to the north of GREENFIELD to CALEDONIA. Seaward to the pan at BARIMA PROFIT and DIAMOND is an area of mangrove scrub; smaller scrub areas being found by the drain at PHOENIX PARK. There is a small seaward lagoon with scattered outlets to the north-west. In LIBERTY there is large uncleared mangrove area, reaching to the Pomeroon River. Some obvious riverine mangrove forest is shown, but many of the riverine forest areas are uncertain in respect of species. Most human impact shows continuing cultivation at the extremes of there lines, but some of the middle ground is heavily treed (though not in plantation patterns).

SITUATION IN 1990

The full extent of the mangrove forest has not been determined, and is not completely shown on this map. There is certainly a thick mangrove belt that continues along this section of the coast.

==========

MAP 5

SHEET NO: 0836 & PART OF 1636 MONKERS - PHOENIX PARK

SITUATION IN THE 1970's

Complete mangrove cover, except for small pan in corner of facade and main drain in PHOENIX PARK. There are some inlet lagoons to the sea.

SITUATION IN 1990

The mangrove belt is still very thick along the coast, although there is uncertainty as to whether the coastal lagoons shown are still there.

MAP 6/6A

SHEET NO: 1632 & PART OF 1636
PHOENIX PARK - FRIENDSHIP/PHOENIX PARK

SITUATION IN THE 1970'S

The mangrove forest is extensive, cut through towards the seaward edge by the facade drain. In the area of PHOENIX PARK and ENTERPRISE mangrove scrub is found adjacent to the human clearance, and between theses areas (KITTY) is the only major pan. Smaller pans are found near ENTERPRISE and LAND OF PROMISE. The latter area stretches completely to the facade drain. Cultivation appears to be recent in all areas except part of KITTY. To the seaward a mudflat build up continues, with isolated crescent beaches. The exact processes seaward of LAND OF PROMISE and ENTERPRISE are uncertain. It is possible that this is an areas fro future beach formation, or re-colonization by young mangrove.

The whole area is extensive mangrove forest. Seaward, especially to the lee of the spit (Bird Point) a mudflat is developing.

SITUATION IN 1990

The coastal mangrove belt remains thick, although the impression is that the mangrove has straightened the coastline, and the beaches and lagoons previously found are no longer there.

==========

MAP 7

SHEET NO: 1628 LAND OF PROMISE - JACKSON

SITUATION IN THE 1970's

From PLAYFAIR to JACKSON there is an extensive mangrove forest, showing new growth (possible new colonization) along this entire coast. There is evidence that the pan at PLAYFAIR has been developed by human activity. The picture at JACKSON is less clear: there is a drainage channel through the pan and mangrove, but whether the pan is natural or a result of human clearance is uncertain.

SITUATION IN 1990

The coast mangrove still exists in some considerable depth. The map does not show the shoreward boundary of the existing mangrove, and it may well extend to its earlier boundaries.

MAP 8/8A

SHEET NO: 2424 & PART OF 2428

SITUATION IN THE 1970's

The area shows as established forest with what appears to be a shoreline showing accretion. The seaward growth seems to lower, with less individual plants, and between this seaward belt and the main forest is a pan/scrub complex.

SITUATION IN 1990

The coast seems to have straightened considerably, losing the pan/scrub formations in the process. The shoreward boundary of the mangrove has not been determined, but the coastal belt is still relatively thick.

==========

MAP 9

SHEET NO: 2420 COZIER - ST. JOSEPH

SITUATION IN THE 1970's

The seaward mangrove forest is cut only by the main drainage channels. On the sea edge at ST. JOSEPH a small beach has developed, whilst along the coast to the south-east small inlets and headlands show the start of possible lagoon formation, and isolation of the seaward mangrove. The extensive drainage network passes through a large pan. Human activity in the area is generally in the form of small plots, but areas increase at ST. JOSEPH.

SITUATION IN 1990

The north-western mangrove belt appears to be thick and intact. However there is considerable erosion showing along the southern coasts at ST. JOSEPH, and the mangrove has been cut back, and replaced by an extensive mudflat.

==========

MAP 10

SHEET NO: 2416 SOMERSET & BERKS - BETTER HOPE

SITUATION IN THE 1970's

The seaward fringe of the mangrove is narrow. Scattered and isolated clumps are found in the mudflats seaward of OPPOSITE to BETTER HOPE. Human cultivation is extensive, especially shoreward of the sea dam. Only in OPPOSITE, and between MARIAS DELIGHT and BETTER HOPE, are patches of mangrove scrub found.

SITUATION IN 1990

The mangrove at the outlet of the canal of the Tapakuma empolder is eroding at the sea edge, but more severe erosion has occurred between MARIAS DELIGHT and BETTER HOPE. Here an extensive mudflat has developed and the mangrove has been totally destroyed. Some small re-generation is beginning at BETTER HOPE.

==========

MAP 11

SHEET NO: 3212 & PART OF 3616 BETTER HOPE - BETTER SUCCESS

SITUATION IN THE 1970's

A very thin mangrove fringe exists seaward of the facade drain by BETTER SUCCESS. Mudflats are developing to sea. Human impact is seen up to the facade dam, and seaward all mangrove has gone in front of BETTER HOPE.

SITUATION IN 1990

The mangrove has decreased at ANDREWS, but continues south from BETTER SUCCESS.

==========

MAP 12

SHEET NO: 3212 & PART OF 3216 BETTER SUCCESS - THE JIB

SITUATION IN THE 1970's

Only a small clump of mangrove can be found seaward of PHILIPS to WESTBURY. The facade dam forms the seaward defence and human cultivation is up to this drain. Mudflats persist seaward of the mangroves.

SITUATION IN 1990

The small mangrove clump has further reduced, and elsewhere the coast is free of all shore mangrove.

==========

MAP 13

SHEET NO: 3208 PARADISE - WINDSOR CASTLE

SITUATION IN THE 1970's

This complete section has been cleared of all seaward vegetation. Sea defenses and human impact stretch to the sea edge. A small remnant of mangrove is left on the seaward shore of HAMPTON COURT.

SITUATION IN 1990

The mangrove has now completely disappeared from this section of the coast.

==========

MAP 14

SHEET NO: 3204 WINDSOR CASTLE TO HENRIETTA

SITUATION IN THE 1970's

There are two small, very diffuse clumps of mangrove on the shore at SPARTA to FEAR NOT, as well as at COFFEE GROVE. Some evidence of a mudflat developing offshore in this area. Human development is right up to the coast in this section.

SITUATION IN 1990

The mangrove has completely disappeared from this area.

==========

MAP 15

SHEET NO: 3220 HENRIETTA - THREE FRIENDS

SITUATION IN THE 1970's

A thin belt of mangrove extends from BUSH LOT to THREE FRIENDS. The line of existing and old facade drains forms the seaward edge of the belt, with small lagoons forming part of the shoreward edge of the mangrove at MAINSTAY and LAND OF PLENTY. Human impact is extensive, and up to the sea defence. The uncertain areas may be beach formations.

SITUATION IN 1990

The mangrove has disappeared as a belt throughout this section. There is now a thin, single line of trees stretching south from LAND OF PLENTY. A lagoon has developed in land of plenty, behind a small beach.

==========

MAP 16

SHEET NO: 3296 THREE FRIENDS - QUEENSTOWN (MOCHA)

SITUATION IN THE 1970's

Only a small clump of mangrove is found at THREE FRIENDS. The two uncertain areas (THREE FRIENDS and QUEENSTOWN) are possibly beach formations. Human impact extends to the shore.

SITUATION IN 1990

The mangrove at THREE FRIENDS has been reduced to a small line of trees. The rest of the coast is bare of mangrove.

==========

MAP 17

SHEET NO: 3292 QUEENSTOWN (MOCHA) - ABRAMS ZUIL

SITUATION IN THE 1970's

There are copses of shore mangrove at ABRAMS ZUIL, and L'UNION. The mangrove at L'UNION is bisected by an old drain, and further north in DAGERAAD there is mangrove scrub. Between ABRAMS ZUIL and L'UNION the shore is made up of a mangrove scrub/lagoon complex. The photography is unclear as to whether there is a seaward belt of young mangrove, or whether the lagoons forms a base for small scrub species. The long belt is classed as uncertain as there is no clear indication as to species type. Human cultivation starts shoreward of this uncertain area. At QUEENSTOWN (MOCHA) the human impact stretches to the shoreline.

SITUATION IN 1990

The mangrove has completely disappeared from this area, and human impact continues to up to the shore.

==========

MAP 18

SHEET NO: 3288 ABRAMS ZUIL - JOHANNA CECELIA

SITUATION IN THE 1970's

The mangrove between ABRAMS ZUIL to WASTE LANDS is reduced to series of clumps, within a pan/lagoon, with some mangrove scrub. The shoreward boundary is defined by an old road, and from there inland is human cultivation. Further south the human impact moves closer up to the shore, with only a small mangrove/lagoon complex at PERSEVERENCE, and a small mangrove clump at ZORG.

SITUATION IN 1990

The mangrove and lagoons complexes have disappeared. A beach formation starts further south.

MAP 19

SHEET NO: 3284 JOHANNA CECELIA - ADVENTURE & TIGER ISLAND

SITUATION IN THE 1970's

Along the coast is a thin strip of mangrove that is relatively continuous. The major clumps are at JOHANNA CECELIA, MARIA'S LODGE AND ADVENTURE, with a larger clump at ONDERNEEMING. In ADVENTURE the uncertain area may be old courida mangrove. Human impact is extensive, up to the shoreline in many places. The northern tip of TIGER ISLAND is fringed with mangrove, with a large pan inland.

SITUATION IN 1990

Most of the mangrove has been reduced, and where mangrove remains it is usually as a single, thin line. The shore has stabilized into beaches between JOHANNA CECELIA to ONDERNEEMING. There has been some reduction in the mangrove at the tip of TIGER ISLAND.

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MAP 20

SHEET NO: 3280 ADVENTURE - HUIST T'DIEREN AND TIGER ISLAND

SITUATION IN THE 1970's

Along the mainland coast there is a practically continuous fringe of mangrove, with a large gap at ADVENTURE. Human development extends up to the shoreline (or mangrove). On TIGER ISLAND the shore belt is considerably thinned in most areas, bur some large copse remain. The inland pan on the island shows signs of old, abandoned human cultivation. There is some regeneration of scrub in this area. This pattern continues further south, until working cultivated areas are reached.

SITUATION IN 1990

The mangrove fringe north of the Pomona River thins to a single line in ADVENTURE. At the river mouth the mangrove has extended, and in the old cultivated area inland from the fringe, there is an area of mangrove scrub. Human impact is still extensive. The pattern on TIGER ISLAND remains much as in the past, although the pan/mnagrove area on the eastern shore has been reduced.

MAP 21

SHEET NO: 3276 HUIST T'DIEREN - WAROUSIA AND TIGER ISLAND

SITUATION IN THE 1970's

There is a thin belt of fringing mangrove, largely intact on both sides of the separating channel. Seaward on TIGER ISLAND the fringe is more broken with small beach formations evident. To the south of the island some scrub is found. In all areas human impact as cultivated fields comes up to the mangrove belt.

SITUATION IN 1990

The mangrove fringes seem to be intact. Human impact occurs up to the fringe on the mainland, whilst TIGER ISLAND appears to keep its previous formations, although the beaches may be reduced.

==========

MAP 22

SHEET NO: 4072 & PART OF 4076 WAKENAAM ISLAND

SITUATION IN THE 1970's

The mangrove fringe on the Essequibo River shore is very small with a pan behind. On the shore of the Atlantic Ocean the fringe is thicker, with a pan at the tip, and a pan/beach formation.

SITUATION IN 1990

The mangrove facing the Atlantic Ocean has been much reduced by natural erosion. A mudflat is developing to the north of the island. The pan at the tip has been exposed, and a beach has now formed. The mangrove on the river shore has disappeared.

==========

MAP 23

SHEET NO: 3272 WAROUSIA - GOOD HOPE AND WAKENAAM ISLAND

SITUATION IN THE 1970's

The mangrove belt has been reduced by human impact to a line of scattered trees with clumps still standing at WAROSIA, MAKESHIFT and GARDEN. On WAKENAAM ISLAND the mangrove belt is narrow but continuous except for severe thinning in BANK HALL (probably by human impact).

SITUATION IN 1990

The mangrove on the mainland has been further reduced, with some clumps being cut off to form small 'islands. There has been some re-colonization of old cultivated ground in AURORA, and new growth on the shore is found between SPRING GARDEN AND GOOD HOPE. Human impact is extensive. The pattern on WAKENAAM ISLAND is similar to the past.

==========

MAP 24

SHEET NO: 3268
GOOD HOPE AND POTORARO, JOCKEY AND WAKENAAM ISLAND

SITUATION IN THE 1970's

The fringe on the GOOD HOPE shore is very thin and broken, but is thicker south of the mouth of the Supenaam River. The north-east shore of POTORARO ISLAND has a thin broken mangrove fringe, which thickens to the southern shores of the island. inland this island has an extensive pan with signs of abandoned cultivation. JOCKEY ISLAND has a full mangrove fringe all around, with inlets and beaches at the northern tip. Inland the island is cultivated. The mangrove on WAKENAAM ISLAND is also very broken, and human cultivation encroaches up to the mangrove and the shore.

SITUATION IN 1990

There has been regeneration of mangrove along the shore on the mainland at GOOD HOPE. There is no new information on POTORARO and JOCKEY ISLANDS. The fringe on WAKENAAM ISLAND are still very thin, however as the fringe progress upstream it is more infiltrated by terrestrial riverine shrubs, rather than mangrove species.

==========

MAP 25

SHEET NO: 3264 PART OF LEGUAN, WAKENAAM & GREAT TRULIE ISLAND

SITUATION IN THE 1970's

Human impact on WAKENAAM & LEGUAN ISLANDS is extensive. A solid fringe exists in LEGUAN, but the fringe in WAKENAAM is thinner and more broken. The large uncertain areas point to earlier cultivation, but it is not possible to determine whether re-colonization has occurred or whether these are abandoned plantations. GREAT TRULIE ISLAND has a continuous fringe of mangrove. To the north-west an area of mangrove scrub extends an uncertain area where human cultivation appears to be have been abandoned, with subsequent re-colonization.

SITUATION IN 1990

The riverine fringes of all the islands appear to be intact, although terrestrial species are still found as a fringe in parts of WAKENAAM ISLAND. There are few details on the inland areas of the islands, although WAKENAAM and LEGUAN ISLANDS show a considerable amount of human cultivation.

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MAP 26

SHEET NO: 3260
SOUTH PART OF WAKENAAM AND LEGUAN ISLANDS, AND NORTH HOG ISLAND

SITUATION IN THE 1970's

All islands have fringing mangrove belts, with human impact right up to this fringe. There is a uncertain pan/mangrove scrub area on WAKENAAM which may be the result of re-colonization of abandoned land; which may be the same situation with the mangrove scrub on the tip of HOG ISLAND.

SITUATION IN 1990

WAKENAAM ISLAND has some thinning to the mangrove and terrestrial fringe at its southern tip, and there is further destruction (mainly of terrestrial vegetation) on the eastern shore. The fringe of HOG ISLAND seems to be intact. LEGUAN ISLAND shows some reduction of the fringe on the eastern shore. Some of the mangrove have been reduced to pans, some areas showing further human cultivation.

==========

MAP 27

SHEET NO: 4060 LEGUAN ISLAND

SITUATION IN THE 1970's

There are thick fringes of mangroves opposite HENRIETTA and PHOENIX, and northward from SUCCESS. The uncertain areas are possibly old cultivation areas; and human impact comes down to the shore and the mangrove in most areas.

SITUATION IN 1990

The mangrove at HENRIETTA has been lost, but to the north of a groyne, the mangrove at PHOENIX remains. The shore is cut back between ANNA MARIA and SUCCESS. There is a small sand bar at OSTERBECK and a larger sand spit in front of the mangrove at VISSELVALLIGHEID. Here a pan has formed in an area where mangrove has been removed. Human impact is extensive.

MAP 28

SHEET NO: 4064 LEGUAN ISLAND (OSTERBECK - OKUM)

SITUATION IN THE 1970's

The northern shore of the island has a thick mangrove belt. The shoreward boundary is the public road, and areas of cultivated land. At VERTROUWEN there is a pan with mangrove scrub between the road and the shoreline mangrove. The uncertain areas between OSTERBECK and VISSELVALLIGEID are probably scrub re-colonizing old cultivated lands. To the south, human cultivation and housing has reduced the mangrove to small, isolated clumps; and a fringe from the south terminates at MARYVILLE.

SITUATION IN 1990

The northern belt is relatively intact. In the south the fringe at MARYVILLE has been reduced, though the shoreline changes indicate some new growth, surrounding small beaches. There is further reduction in the clumps at LA BAGATELLE and ENTERPRISE. Human impact has extended into part of the mangrove area at LA BAGATELLE. In front of BELFIELD mudflats are forming.

==========

MAP 29

SHEET NO: 4068 PART OF WAKENAAM AND LEGUAN ISLANDS

SITUATION IN 1970'S

On LEGUAN ISLAND there is a belt of mangrove scrub and pans to the seaward of beach formation showing new mangrove growth, all between DR. FLY and GRAND CANE. A thin seaward belt exists over the rest of the island, mainly with a mangrove scrub inland, bounded by human clearance and cultivation. On WAKENAAM the only mangrove of any depth is found on the MEERZORG shore, whilst the remaining mangrove is found as scattered, isolated clumps and trees. Between MARIONVILLE and AMERSFOOT the fringe is uncertain possibly dominated by palm escapes the adjacent plantations.

SITUATION IN 1990

The mangrove on WAKENAAM ISLAND has reduced. On LEGUAN ISLAND the mangrove on the south-west shore is still intact. Further north the mangrove has reduced, and beaches have been formed. The mangrove on the north-west tip of the island has been reduced to a beach/scrub complex, with the beach continuing to the east.

MAP 30

SHEET NO: 4072 & PART OF 4076 WAKENAAM ISLAND

SITUATION IN THE 1970's

Some fringing mangrove is seen by the West Channel in the Essequibo River. There is a large belt of mangrove stretching from the north-west, round to the south-east, where the mangrove is thickest. The uncertain areas may be mangrove forest, but the species composition is uncertain from the photography. Behind the northern fringe there is mangrove scrub and a pan/lagoon up to the cultivated areas inland. Human impact has cut significantly into the eastern tip.

SITUATION OF 1990

The mnagrove fringe facing the ocean has been considerably reduced, and mudflats are building up in the north. On the eastern tip a san bar has developed, cutting into the mangrove belt which has been much reduced. South of this sand bar, a beach/mudflat formation has developed.

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MAP 31/31A

SHEET NO: 4868 & PART OF 4864
LEGUAN ISLAND: DAUNTLESS BANK - CANEFIELD/DAUNTLESS BANK

SITUATION IN THE 1970's

The pan to the north of CORNELIA is very large, as is the mangrove cover on the DAUNTLESS BANK. The rest of the area is human settlement, up to the shoreline, with only a small mangrove clump remaining at OKUM and RETRIEVE.

The smaller map shows the continuing pan, and the fringing forest of the DAUNTLESS BANK.

SITUATION IN 1990

The mangrove at OKUM and RETRIEVE has increased in the lee of the seawall, and a beach has formed on its seaward shore. There has been a loss of mangrove in the DAUNTLESS BANK immediately north-east and east of the human cultivation at CORNELIA. Inland there has been a thinning into mangrove scrub, whilst the shore shows the development of a sand bar/beach, with the mangrove behind being cleared to form a pan. At the north-east tip of the DAUNTLESS BANK, and along the northern shore, there is some thinning of the mangrove shore. Otherwise this area still shows a major mangrove forest, which extends (though thinning) along the northern shore (MAP 31A). To the north an extensive mudflat is extending away from the island.

MAP 32

SHEET NO: 4056 SALEM - GREENWICH PARK

SITUATION IN THE 1970's

Although a thin mangrove fringe is found in all areas, it is very diffuse and broken, with single trees forming the line in many areas. The shoreward boundary is an old road/bund. At LOOKOUT a small, thin lagoon has formed, possibly as a result of beach formation at this pint. Mudflats and small beaches have developed between LE DESTIN and BUSHY PARK. Human impact is extensive, with development up to the shore. At ORANGESTEIN and SALEM some mangrove scrub is found, which appears to be re-colonization of abandoned clearings.

SITUATION IN 1990

There has been both reduction and regeneration of mangrove between HYDRONI and LE DESTIN. New beach formations are also found, and human impact in a mangrove scrub is found in the uncertain areas in HYDRONI and BUSHY PARK. Human impact is severe at PARIKA due to the ferry stelling, and there is a beach formation on this shore.

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MAP 33

SHEET NO: 4856 & PART OF 4860 UITVLUGT - GREENWICK PARK

SITUATION IN THE 1970'S

From UITVLUGT to DE KINDEREN mangrove is absent. There is an uncertain area in MET-EN-MEERZORG which may be low mangrove scrub. Seaward of DE KINDEREN and ZEELUGT there is a complex outfall with small islands. Some areas show mangrove scrub which may be re-colonization of old cultivated land. In these areas straight lines showing earlier clearances are evident. Small mangrove clumps are found along the coast to GREENWICK PARK, with some lagoon/scrub. The uncertain areas along this section to GREENWICK PARK are possibly old pans, or deliberately cleared areas.

SITUATION IN 1990

There has been small, new mangrove growth at VERGENOGEN and TUSCHEN DE VRIENDEN. In the latter case the shore has eroded into a small bay, with a small beach and lagoon. Behind this the scrub/lagoon complex has dried into mangrove scrub. Beach formations are found in the lee of the seawall at VERGENOGEN and BARNWELL. Human impact has increased in most areas, stretching up to the seawall. Mudflats have developed between ZEELUGT and MET-EN-MEERZORG.

MAP 34

SHEET NO: 5656 & PART OF 5660 UITVLUGT - RUIMZIGHT

SITUATION IN THE 1970's

The whole area shows considerable human impact up to the shore, with cultivation and housing. No mangrove is visible. Three uncertain areas are shown which may be old pans. Mudflats are found along the coast.

SITUATION IN 1990

The lack of mangrove remains, due mainly to the existence of the seawall. Shoreline processes are manifested by beach and mudflat formations which are found along this stretch of coast. Beaches are small and have developed at EDINBURG, HAGUE and BLANKENBURG.

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MAP 35

SHEET NO: 6452 & PART OF 6456 RUIMZIGHT - MARY AND HARLEM

SITUATION IN THE 1970's

There is a thick fringe of mangrove on the shore of WALLERS DELIGHT and MARY AND HARLEM.

SITUATION IN 1990

The mangrove fringe has been reduced to a thin line only 1-5 trees thick. The foreshore has developed a mudflat, and the shore at RUIMZIGHT has eroded.

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MAP 36

SHEET NO: 6452 & PART OF 6456 RUIMZIGHT - THE BEST & GEORGETOWN

SITUATION IN THE 1970's

Extensive northern belt of mangrove bounded shoreward by an old bund, and from WALLERS DELIGHT by the new sea wall. By THE BEST there is a shoreward area which is a pan/scrub that may lagoon through poor drainage. The bend in the public road at NOUVELLE FLANDERS marks the position of a seaward pan with scrub, where shore mangroves thins considerably. GEORGETOWN is bare.

SITUATION IN 1990

The mangrove from MARY AND HARLEM to THE BEST has been removed, and mudflats are developing off the shore. Human impact has moved towards the shore at MARY AND HARLEM. There has been regeneration of the mangrove in the pan area of THE BEST, and this regeneration joins into the foreshore mangrove of this area. The new groyne at the west bank of the Demerara River has caused some change to the area, and although there is some new mangrove, much is still mangrove scrub.

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MAP 37

SHEET NO: 8052 BROTHERS - BUXTON

SITUATION IN THE 1970's

The seawall extends along this part of the coast, and is generally bare of features to the sea. However, between MON REPOS and LUSIGNAN, there are sand bars forming either side of the DE ENDRAGT/GOOD HOPE outfall, and these sand bars enclose areas of mudflat.

SITUATION IN 1990

This sand bar/mudflat area has been colonized by mangrove, with a pan/lagoon formation on the eastern end. The shore has eroded in front of ANNANDALE to BUXTON and the foreshore is pan/lagoon complex, with mudflats to sea.

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MAP 38

SHEET NO: 8048 BUXTON - COLDINGEN

SITUATION IN THE 1970's

The seawall provides the shoreline for this short part of the coast.

SITUATION IN 1990

Inland from the seawall there is complex of drains, and between these are found areas of scrub and pan. There is an uncertain area which may be either pan or abandoned human development.

MAP 39

SHEET NO: 8848 COLDINGEN - GOLDEN GROVE

SITUATION IN THE 1970's

Seaward of the seawall between ELIZABETH HALL and HOPE is a small area of mangrove, with pans and pan/lagoon formations. Small beaches are found at GOLDEN GROVE.

SITUATION IN 1990

The main mangrove area has been significantly reduced, and there is a lagoon formation at FOULIS. Mangrove scrub is found at HOPE, and at GOLDEN GROVE The beach/pan formation has changed to a beach/mudflat formation. Immediately inland of the seawall is an extensive pan, but this shows areas of human development between BACHELORS ADVENTURE and PARADISE.

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MAP 40

SHEET NO: 8844 GOLDEN GROVE - BEE HIVE

SITUATION IN THE 1970's

The seawall forms the shoreline for most of this section of the coast. At GOLDEN GROVE, NABACLIS AND JOHN, a beach/pan formation is found to the seaward side, and there is a pan/mangrove scrub complex between HOPE and ANN'S GROVE. Human impact comes up to the seawall in all areas.

SITUATION IN 1990

The pan/beach to the north of this section has become a beach, with mudflats to the sea. Inland of the seawall the land has become abandoned, and reduced to a pan/lagoon between the seawall and the public road. The mangrove scrub between HOPE and ANN'S GROVE has developed into a small mangrove copse, with a pan/mangrove scrub complex developing inland of the seawall. Seaward of the mangrove a new beach has formed.

MAP 41/41A

SHEET NO: 9640 & PART OF 9644
BEE HIVE - CONCORD/BEE HIVE - ORANGE NASSAU

SITUATION IN THE 1970's

The seawall forms the shoreline up to the west bank of the mouth of the Mahaica River. Human impact is considerable up to the seawall, but there is a large pan/scrub complex between UNITY and LANCASTER. East of the Mahaica River There is a coastal fringe of mangrove along the whole of this coastal section, with a large forest area long the estuary eastern bank. Human impact has cleared much mangrove scrub between KENSINGTON and CONCORD, immediately inland of the mangrove fringe. In WOODLANDS There is a small pan/lagoon isolated within the mangrove.

Between BEE HIVE and ORANGE NASSAU the seawall forms the shoreline, with human development immediately inland.

SITUATION IN 1990

There have been complex changes in at the mouth of the Mahaica River. A series of mudflats have developed, together with a large sand bar on the eastern side of the river mouth. This area shows some colonization by new mangrove, and there has been re-colonization of the human impact/scrub lands inland of the continuing coastal mangrove fringe. Seaward of the seawall between GROVE and the western bank of the river mouth, a substantial mudflat has formed, which may (in time) stabilize further into a beach. No changes are seen in the shoreline (seawall) between BEE HIVE and GROVE.

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MAP 42

SHEET NO: 9636 CONCORD - COLUMBIA

SITUATION IN THE 1970's

There is a continuous fringe of mangrove along this section of the coast, with human cultivation inland of this, up to the facade canal.

SITUATION IN 1990

The mangrove fringe is intact, and re-colonization of the inland lands up to the facade canal has occurred. There is single large pan/scrub formation in CONCORD. On the coast beaches are formed between BELVIDERE and DANTZIG.

MAP 43

SHEET NO: 0436 BROOMHALL - COLUMBIA

SITUATION IN THE 1970's

A thin mangrove fringe extends along this wedge of coast. Between this and the canal is a pan complex. By BROOMHALL and CARLTON HALL, lagoons occur by the canal; whilst the rest of the pan is a pan/scrub complex. It is evident in PROSPECT and GLACIERS LUST that the complex is partly a re-colonization of old agricultural land.

SITUATION IN 1990

The mangrove fringe is intact, and there is evidence of re-colonization of the pan between the fringe and the facade canal.

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MAP 44

SHEET NO: 0432 DRILL - GLACIERS LUST

SITUATION IN THE 1970'S

The pattern for FARM - PLANTERS HALL continues here. Young mangrove between NOW OR NEVER and PLANTERS HALL shows lagooning and thinning at the seaward edge which may indicate an onset of erosion (alternatively this could be new growth). The human impact uncertain area is similar to above. From DE KINDEREN to GLACIERS LUST the facade canal provides the seaward limit to human impact. The mangrove thins in this area, with a pan/lagoon complex developing along the canal.

SITUATION IN 1990

The area shows considerable new growth throughout. Re-colonization of the seaward pan is very evident, although the full extent of new growth is hard to determine, and there are significant areas of scrub.

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MAP 45

SHEET NO: 0428 FARM - PLANTERS HALL

SITUATION IN THE 1970's

The entire coast is covered by a deep mangrove belt. This is an area of apparently young growth. Behind this, to the sea dam, the picture is uncertain. Evidence of cultivation exists up to the

mangrove belt, with crop rows being very distinct. However field boundaries have become blurred, and throughout the area is an extensive forest. Lagoons are frequent in this area. Whether the pattern is of re-colonization of abandoned land is hard to say. From the size of the trees, such re-colonization is reasonably old.

SITUATION IN 1990

There is a thick coastal mangrove fringe up to the western mouth of the Mahaicony River, and the mangrove fringe extends into the estuary on both river banks. The lagoons at LA RAISONABLE and TAYMOUTH MANOR are still evident. Between the sea dam and the mangrove fringe there is re-colonization of the human activities by scrub. A new beach is forming seaward of the fringe between ORMSARY and LA RAISONABLE.

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MAP 46

SHEET NO: 1224 & PART OF 1228 PARK - HUNTLEY

SITUATION IN THE 1970's

The whole area is mangrove covered except for a large salient in PARK which is subject to human clearance and cultivation. Pans and lagoons are found on the west bank of the Mahaicony River, and small lagoons are seen in PARK.

SITUATION IN 1990

There has been re-growth across the area, although the coast has straightened, and the two large, coastal 'fingers' of mangrove have apparently gone. On the west bank of the Mahaicony River pans have increased in the old mangrove area.

==========

MAP 47

SHEET NO: 1224 & PART OF 1228 SANS SOUCI - PARK

SITUATION IN THE 1970's

The Abary River mouth has a mangrove covered sand bar, forcing the estuary northward. From SAN SOUCI to PARK human impact extends practically to the coast. Between SANS SOUCI and RECESS lines have been cut into the mangrove, resulting in a diffuse belt. To seaward a beach is forming. From GOOD HEALTH to GROVE a large coastal belt of mangrove has developed. The dashed line shows the probable line of separation between young and old mangrove. Beaches formed from sand bars are found between GOOD

HEALTH and NOVAR, and a sand bar is established on the DUNDEE coast. There is only a thin strip of mangrove on the east bank of the Mahaicony River, though the west (Mahaica) bank shows a thicker fringe.

SITUATION IN 1990

There is a continuous belt of mangrove across this section of the coast. The large sand bar on the foreshore between DUNDEE and GOOD FAITH has been colonized by mangrove, and there is evidence of some encroachment of new growth in the seaward edges of the areas of old human activity. The pan on the west bank of the Abary River mouth has also been colonized.

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MAP 48

SHEET 1220 PROFIT - NOVAR

SITUATION IN THE 1970's

There is extensive mangrove on the coast of PROFIT and ADVENTURE, with a pan/scrub complex between this mangrove and the sea dam at PROFIT. Both banks of the Abary River are mangrove lined, with lagoons and pans inland. Human occupancy is extensive on the north Mahaicony River bank.

SITUATION IN 1990

There is an increase in coastal mangrove at PROFIT, and further re-colonization further north. Some of the pan and lagoon areas on either side of the Abary River also show signs of new growth. However there is considerable evidence of logging of the mangrove in areas close to the public road in PROFIT.

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MAP 49

SHEET NO: 2020 BELLADRUM - PROFIT

SITUATION IN 1970's

BELLADRUM has a seaward pan/mangrove scrub formation. At ELDORADO a beach formation occurs which continues into PROFIT. Shoreward of this lies a pan, bounded to the shoreward by a sea dam. Between this dam and the public road the lands all show human impact, including occupancy. Small copses of mangrove are found in ELDORADO, and extensive mangrove has established along the PROFIT shore. In FOULIS there is a large lagoon, seaward of the sea dam, and a thin lagoon/drainage channel within the PROFIT mangrove.

SITUATION IN 1990

There has been much change along this area of coast. New mangrove has developed from BELLADRUM to FOULIS, but the mudflat in front of the FOULIS drain is eroding, and the sea dam appears at risk. The re-growth of mangrove continues north from FOULIS, and mangrove scrub is developing in the pan area of PROFIT. The lagoon area in FOULIS has dried somewhat and reduced, though this may be a result of increasing earthworks along the sea dam.

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MAP 50/50A

SHEET NO: 2016/2012 BELLE VUE - FOULIS/BELLE VUE - JACOBA

SITUATION IN THE 1970's

The mangrove belt ends in BELLE VUE. From here to SEAFIELD is a seaward lagoon and pan/lagoon complex, that has evidence of much human impact in terms of drains lines and field boundaries, up to the sea dam; after which there is an extensive pan, relatively unused until HOPE. On the coast of SEAFIELD is an extensive lagoon behind a beach, with some mangrove scrub still remaining. Beach, or sand bar, formations go along the coast from a large coastal pan at RISING SUN to BELLADRUM. There is a thin mangrove strip left behind this beach between WASHINGTON and WELDAAD. Human occupancy of the land between the sea dam and public road starts at HOPE up to FOULIS.

There is a small mangrove copse in the pan behind the sea dam at COTTAGE. At LICHFIELD and BELLE VUE there is a thick seaward mangrove band,up to the sea dam. Behind this is a pan, which in LICHFIELD shows signs of being developed as a plantation. Further inland the pan is open, with signs of past works and boundaries.

SITUATION IN 1990

The new mangrove tapers and ends at PARADISE. The beaches that formed the shore between PARADISE and HOPE have consolidated into a single, thin continuous beach, and a mudflat is found at HOPE/WASHINGTON. The pans inland of the old shore line remain. At RISING SUN there is a slight area of accretion, stretching eastward to NO.40. This are has been colonized by new mangrove, and there is a small beach at RISING SUN.

The smaller map shows that the entire mangrove fringe of the past has been eroded, and the shoreline now lies at the foot of the facade drain. This area is undergoing active, and rapid coastal erosion.

MAP 51

SHEET NO: 2812 UNION - JACOBA

SITUATION IN THE 1970's

There is a thin strip of mangrove seaward of a lagoon/pan in UNION, with beach formation on the coast. Shoreward of the sea dam the pan has mangrove scrub. The seaward edge of the pan complex are the old agriculture dams, up to KINGELLY, behind which are occupied workings. At PHOENIX there is an extensive plantation. The nature of the seaward fringe is uncertain. The coastal pan complexes have been delineated by various drainage works. Beach/pan complexes occur in the centre of the isolated mangrove patch between YEOVIL and BRAHAN; with pan/lagoon and beaches forming on the coast of BRAHAN and KINGELLY.

SITUATION IN 1990

The coast between JACOBA/MOORPARK is actively eroding up to the facade dam. Just to the seaward of the present dam, is an old lagoon (formed by earlier sea defences) which has now drained, and this area is now undergoing re-colonization. This new colonization continues on the beach between PHOENIX and KINGELLY. The old pan/lagoon complexes and the mangrove is being eroded between BRAHAN and YEOVIL, and the erosion has removed the pan/lagoon to the seaward between YEOVIL and TEMPE. the mangrove fringe between TEMPE and UNION has disappeared, though there is some new growth on the present eroding coast. Between CHESTER and TEMPE, the old sea defense lines have broken down, and the old pan has become lagooned.

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MAP 52

SHEET NO: 2808 NØ.21 HOPETOWN - BRITANNIA

SITUATION IN THE 1970's

The HOPETOWN foreshore is a lagoon/pan, which extends to NO.23 ARMADALE. Behind is a pan extending to the sea dam. At NO.22 BEL AIR to ARMADALE a small seaward mangrove strip is found. At the ARMADALE/ NO.24 BUSH LOT dam, mudflats are found in front of a pan. In BUSH LOT a large mangrove outcropping begins, stretching to LOVELY LASS. A pan is found shoreward, with a large lagoon between GOLDEN GROVE and LOVELY LASS at the pan/mangrove interface. The mangrove extends as a strip to the ONVERWAGT/TRAFALGAR drain. At TRAFALGAR a pan/lagoon is found at the drain outlet, and the mangrove is severely cut into by pans and a large pan/lagoon. There is evidence of human impact, with clearings and crop lines between the sea dam and public road, with a belt of mangrove scrub starting by the dam at TRAFALGAR.

SITUATION IN 1990

The pan/lagoon and coastal mangrove at TRAFALGAR has been completely eroded, and the shoreline lies along the facade drain. The outcropping of mangrove that is found between ONVERWAGT and BUSH LOT has disappeared, although there is some new growth in the old uncertain area by the LOVELY LASS/GOLDEN FLEECE drain. In BUSH LOT a new beach has formed, and a beach/pan lies to the seaward of ARMADALE and BEL AIR. Between ONVERWAGT and BEL AIR are extensive mudflats. There is new mangrove growth over the beach/mudflat at HOPETOWN.

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MAP 53

SHEET NO: 2804 & PART OF 3604
WATERLOO JIB - NO. 25 GOLDEN GROVE

SITUATION IN THE 1970s

Beach and mudflat development continues along the coast from NO.13 WATERLOO JIB to NO.15 HOPE. The mangrove here extends practically to the public road with isolated pans. There is an isolated seaward mangrove copse at NO.15 HOPE, which marks the start of a thin seaward mangrove belt with a lagoon/pan complex on its shoreward side. This feature continues to NO.20 ONDERNEEMING. Between NO.15 HOPE and NO.16 EXPERIMENT, between the lagoon and the public road mangrove is found. At EXPERIMENT there is a seaward spit of mangrove, which extends to NO.17 BATH. Human impact (berms) have isolated a pan/scrub complex at NO.16 EXPERIMENT. In BATH pan formation has isolated a shoreward island of mangrove, extending into NO18. NAARSTIGHEID; the coastal mangrove between here and NO.20 ONDERNEEMING is very thin.

SITUATION IN 1990

The coast has eroded between HOPETOWN and NO.14, and all the coastal mangrove has been destroyed. The area now has a pan/scrub complex to seaward. Between EXPERIMENT and WATERLOO JIB the mangrove has been cut back, but a fringe remains on the shore of this area. The inland mangrove has degenerated to mangrove scrub, with pan/lagoons. The shore between BATH and WATERLOO is a thin pan, where old mangrove had been./ Human impact has cleared the mangrove inland of the facade drain at WATERLOO JIB.

MAP 54

SHEET NO: 3600 NO.7 WILLEMSTAD - NO.13 WATERLOO JIB

SITUATION IN THE 1970's

NO.8 INVERNESS to NO.9 EXPECTATION shows beach formation with isolated copses of mangroves; together with a series of pan/scrub, pan/lagoon and pan, up to the old sea dam alignment. Behind this human clearance has occurred up to the public road, and this continues to NO.11 WOODLEY PARK. At FRIENDS RETREAT and WOODLANDS the beach process continues with only mangrove scrub remaining. The seaward mangrove belt re-emerges at NO.11 WOODLEY PARK, increasing in depth up to NO.13 WATERLOO JIB, where the mangrove is bounded to seaward by a new beach formation.

SITUATION IN 1990

The beach at WATERLOO JIB has given way to mudflats, and the mangrove is still intact although now under active erosion. Inland of the facade drain the mangrove has been reduced to a pan, and a pan/lagoon complex has also developed. Further south the coastal erosion has reduced much of the old coastline, and lagoons, mangrove scrub and pans are now found on the shore, on the seaward edge of the facade drain.

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MAP 55

SHEET NO: 3696 EAST BANK OF THE BERBICE RIVER - WILLEMSTAD

SITUATION IN THE 1970's

On the East Bank of the Berbice River the coastal lagoon and pan end, and the mangrove extends fully into the river estuary, bounded shoreward by the FORT ORDNANCE LANDS. On West Coast Berbice the mangrove at WILLEMSTAD and BEL AIR extends to the public road, whilst from ZEE LUST to MON CHOSI there is a pan between the mangrove and the road. The sea dam passes through the mangrove belt, but without much damage to the mangrove. Between the sea dam and public road at ZEE ZIGHT and COTTON TREE the land is mangrove scrub with signs of clearance and old field boundaries. Beach formation is starting at ZEE LUST, and between MON CHOSI and ZEE ZIGHT.

SITUATION IN 1990

The mangrove has disappeared along the northern part of this section and only a thin wedge remains between MON CHOSI and COTTON TREE. The old mangrove areas have been reduced to pans, and to pan/scrub in BEL AIR. There are extensive mudflats along this coast, and a beach development between WILLEMSTAD and ZEE LUST.

MAP 56

SHEET NO: 3692 COTTON TREE - NO.7 AND CRAB ISLAND

SITUATION IN THE 1970's

CRAB ISLAND (East Bank Berbice) is entirely covered in mangrove with a few (visible) lagoons, particularly in the south by the Canjee Creek. The southern inlet of the Canjee Creek has a thin mangrove fringe, bounded shoreward by plantation dams. ROSIGNOL is bare of mangrove. From NO.3 to NO.5 there is a thin riverine strip of mangrove, bounded shoreward by the dam of a single estate.

SITUATION IN 1990

The reduction of mangrove continues, leaving a thin seaward fringe between COTTON TREE and D'EDWARD. The fringe on the seaward of the BLAIRMONT ESTATE has reduced, with a pan/scrub complex inland of the fringe. A small pan is found in the mangrove between D'EDWARD and ROSIGNOL. Human impact continues up to the mangrove. CRAB ISLAND has been left largely intact.

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MAP 57

SHEET NO: 4496 NO.27 HAMMERSMITH - KINTYRE

SITUATION IN THE 1970's

From NO.27 HAMMERSMITH to NO.23 DUN ROBIN there is a narrow coastal mangrove fringe, bounded shoreward by a thin lagoon, followed by a pan which stops at the old bund. A large drain/sea wall has been laid between NO.23 DUN ROBIN and NO.15 SUSANNAH. This has lagooned the pan behind (shoreward). This pattern continues along the coast in this area. An isolated patch of mnagrove scrub is found in the pan at NO.21 WARREN. From NO.19 KENDALLS to NO.7, the coastal lagoon widens forming a lagoon/pan. The seaward mangrove belt also widens up to NO.11 TREUNIET. However the seaward edge of this mangrove shows considerable thinning (as shown by the dash line). At NO.19 LEWIS MANOR, the mouth of a small creek has been the area of considerable mangrove loss resulting in a lagoon (or bay) with a few isolated trees. From NO.15 SUSANNAH to KINTYRE a large forest of mangrove exists behind the coastal pan. Between NO.15 SUSANNAH to NO.9 LEWIS MANOR this forest is broken up (in part) into a lagoon/scrub complex. The bunds of agricultural land form the shoreward boundary. From NO.5 to KINTYRE a thin lagoon separates this mangrove from the coastal pan. The coastal mangrove strip may be due to colonization of an accreting coast, with evidence of an isolated sand bar between NO1. SEAWELL and KINTYRE.

SITUATION IN 1990

The coastal mangrove has been considerably reduced, and the central forest between KINTYRE and TREUNIET has disappeared. The pans inland of the coastal mangrove remain. The coastal area shows the largest change: a lagoons has developed at the seaward edge between NO.1. SEAWELL and NO.3. The large coastal lagoon between NO.5 and TREUNIET, has disappeared, being replaced by mudflats, and a small sand bar at NO.7. The mudflats extend eastwards along the coast.

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MAP 58

SHEET NO: 5296 NO.5 COURTLAND - NO.27 HAMMERSMITH

SITUATION IN THE 1970's

The foreshore at NO.5 COURTLAND is a pan with beach formation. Between NO.1 and NO.39 GIBRALTAR there is a pan with lagoons being formed in the shallows between sand and mud flats. There is a single small copse of mangrove in NO.1, and a seaward small copse of scrub in NO.Ø. From NO.37 MALROB to NO.27 HAMMERSMITH there has been heavy colonization of a sand bar. A single thin fringing line of mangroves is found shoreward of a long lagoon. The area behind, up to the old facade drain, is a pan.

SITUATION IN 1990

There is a continuing mangrove fringe between NO.27 HAMMERSMITH and the canal outlet between NO.37 BORLAM and NO.39 GIBRALTAR. Seaward of this fringe there are mudflats, and a mudflat/lagoon complex, which is shoreward of a massive sand bar that has developed between NO.31 CHESWICK and NO.Ø. New mangrove has developed along the new formed coastline between NO.37 BORLAM and NO.2 COURTLAND, with a new beach forming the shore between NO.Ø and NO.2 COURTLAND.

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MAP 59

SHEET NO: 5292 HAMSHIRE - NO.27 HAMMERSMITH

SITUATION IN THE 1970's

The coast is represented by the area in front of BELVIDERE to NO.3 FYRISH. A main drain complex, using existing creek outlets, is found between NO.6 NIGG to NO.5 ALBION. The BELVIDERE to NIGG foreshore is complex: the seaward edge has a mangrove belt extending up into the creek channel to the east; behind this mangrove is a lagoon/pan formation, followed by another mangrove

belt, and scrub/lagoon. A further pan has a thin series of mangrove scrub running through it, followed by a thinning mangrove belt. The shoreward edge is a bund, and the area in front of this is a pan with many small lagoons areas. The area of the triangle in front of ALBION is uncertain. There is a major copse (which should be mangrove based on its location) which appears to denser and more vigorous than other stands, with large defined crowns. The foreshore from ALBION to FYRISH is a pan with a thin beach, bounded shoreward by an old facade drain. The area immediately behind is a pan with large lagoons, in an area which shows signs of past human activated (possibly grazing based on the number of old trails).

SITUATION IN 1990

The new shoreline is determined by a beach from NO.3 FYRISH and the outfall of the ALBION drain, inland of which is a large pan with mangrove scrub at NO.3 FYRISH. New mangrove growth is found along the banks of the ALBION drain. The south-eastern part of the ALBION outfall has a small beach, but the mangrove has been reduced to s small wedge, with a large pan inland.

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MAP 60

SHEET NO: 6092 TAIN - BELVIDERE

SITUATION IN THE 1970's

The foreshore at TAIN is lagooned, part of the drowning further south. From RESOURCE to the PORT MOURANT/ROSE HALL drain there are foreshore lagoons with pans behind, with the estates' bunds forming the shoreward boundary. Evidence of channels, lined by mangroves, exists in the lagoon and sea areas of TAIN and RESOURCE. A mangrove copse is found either side of the ANKERVILLE/PORT MOURANT drain, with further copses nearer to the sea in PORT MOURANT by the ROSE HALL drain. There is a pan/lagoon/mangrove scrub complex from ROSE HALL to BELVIDERE, bounded shoreward by an old bund. The foreshore is a beach/lagoon complex. From WILLIAMSBURG a northward mangrove belt begins.

SITUATION IN 1990

From the sand bar in TAIN to the foreshore of RESOURCE there is a new line of mangrove. The shore north of this has been subject to erosion, which has removed the mangrove/lagoon complexes by the outfalls between PORT MOURANT AND ROSEHALL. On the ROSEHALL shore a new beach is being formed. Further north the mangrove at WILLIAMSBURG has disappeared. The foreshore mangrove at BELVIDERE has been replaced by a pan/beach.

MAP 61

SHEET NO: 6088 ALNESS - WILLIAMSBURG

SITUATION IN THE 1970's

A complex foreshore with large sand bars and lagoons, with pan and pan/lagoon formations shoreward up to the drains between ALNESS and WHIM. The foreshore is more broken north of the WHIM/AUCHLYNE drain; and from AUCHLYNE to CLIFTON there is evidence of erosion with the mangrove existing only as single lines of trees along old, drowned channels; or as isolated (and breaking don) lines of mangrove scrub. The lagooning of this area (AUCHLYNE to CLIFTON) is very extensive.

SITUATION IN 1990

New mangrove has developed into a new shoreline at ALNESS, with a seaward thin mangrove strip extending further north into ULVERSTON, where a beach is developing. Lagoons in this area have either dried out or drained, to form an extensive area of pans. The sand bars found northward of the AUCHLYNE/WHIM drain have stabilized into beaches, but the lagoon areas are still extensive.

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MAP 62

SHEET 6884 & PART OF 6888 HOGSTYE - ALNESS

SITUATION IN THE 1970's

The foreshore is a pan with a thin strip of mangrove scrub close to the shoreline.

SITUATION IN 1990

The development of a new foreshore, with new mangrove cover starts at HOGSTYE and continues northward to ALNESS. Behind there is an extensive pan, with lagoons in the north.

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MAP 63

SHEET NO: 6884 & PART OF 6888 NO.32 CROMARTY - ALNESS

SITUATION IN THE 1970's

The foreshore is a pan, with lines of mangrove scrub stretching from NO.32 CROMARTY and NO.28 BUSH LOT. A mangrove copse surrounds a small lagoon at NO.27 BUSH LOT. Human impact is significant with drains and roads evident up to the foreshore.

SITUATION IN 1990

Seaward new mangrove extends from the south into NO.32 CROMARTY. The pan further north between NO.31 PHILIPPI and NO.30 KILMARNOCK has eroded and there is a new beach evident, seaward of the old scrub. Sand bars are developing between NO.29 MAIDA and ADVENTURE, and fresh mangrove growth on one is found at KILDONAN to ADVENTURE. seaward of this the sand bar has formed a small beach. This new mangrove colonization continues in the north at HOGSTYE.

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MAP 64

SHEET NO: 6880 NO.37 BRIGHTON - HOGSTYE

SITUATION IN THE 1970's

The shore map ends at NO.31 PHILIPPI. From here, south to BRIGHTON, the foreshore is a cleared pan, with evidence of flooding but with no distinct lagoons. An old road marks the shoreward boundary, with evidence of old strip plantings and houses by the public road (which forms the shoreward boundary at NO.32 CROMARTY and NO.31 PHILIPPI). A thin line of mangrove is found at NO.36 NEVILLE, and two copses are found at NO.35 MACEDONIA, with a line of single trees to seaward. Mangrove scrub is found in clumps at NO.36 NEVILLE and NO.32 CROMARTY.

SITUATION IN 1990

The accretion of the coast continues from NO.37 BRIGHTON to NO.34 TARGOLIE. The shore is new mangrove in this area, except at NO.34 TARGOLIE, where on a thin line of trees is found. Human impact extends up to the shore in the open pan areas at NO.34 TARGOLIE and NO.33 WELLINGTON PARK. Old mangrove copses and scrub areas have disappeared, and are now cleared pans.

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MAP 65

SHEET NO: 7676 & PART OF 7680 NO.38 KILTAIRN - NO.37

SITUATION IN THE 1970's

The main part of this small area is a pan, with beaches forming on the shoreline. There are thin lines of mangrove, together with a small belt of mangrove between NO.38 KILTAIRN and BRIGHTON; and a larger copse between BRIGHTON and NO.37.

INDEX OF PLATES

SITUATION IN 1990

A new shoreline has developed with the colonization of a belt of young mangrove. Behind this the beaches have risen into pans, and seaward there are thin lines of mangrove defining new colonization areas. The old, inland mangrove areas have disappeared.

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MAP 66

SHEET NO: 7676 & PART OF 7680 NO.46 - NO.37

SITUATION IN THE 1970's

There is indication of a new foreshore due to beach and mudflat colonization. A large isolated mangrove copse is found between NO.45 and NO.44 GOOD HOPE. The pan/lagoon complex and the seaward edge seems to produce a mangrove 'island' from NO.44 GOOD HOPE to NO.40 DINGWALL. Around the outfall of NO.44 GOOD HOPE is a lagooned area with mangrove scrub. An extensive pan with mangrove scrub extends from NO.43. JOPPA to BRIGHTON, bounded shoreward by an old bund. Behind this bund line, up to the public road is an area of human impact, with evidence of planting and dwellings. A small area of mangrove is developing on a sand bar at NO.39 HAVERSHAM, with mangrove scrub inland.

SITUATION IN 1990

Between NO.46 and NO.45 a new shore fringe of mangrove is developing, with a pan to the shoreward. The old mnagrove 'finger' in NO.44 has extended. The mangrove 'island' between NO.44 GOOD HOPE and NO.40 DINGWALL has extended over the old mudflat, and new, thin lines of trees are visible on the seaward edge of beaches from NO.42 BENGAL to NO.40 DINGWALL. There has been further new mangrove and seaward accretion on the shore of a pan between NO.39 HAVERSHAM to NO.38 KILTAIRN.

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MAP 67

SHEET NO: 7672 NO.50 - NO.40 EPSOM DINGWALL

SITUATION IN THE 1970's

An extensive, large mangrove belt stretches along this section of the coast, with apparently younger, smaller trees towards the shore, and indications of continuing regeneration. The line between the age groups is indistinct, with numerous seaward incursions and lagoons. There is evidence of many beach/mudflat processes along the shore. Shoreward of the mangrove is a pan

with mangrove scrub, bounded shoreward by an old drainage line. Scrub is not evident between NO.50 - NO.49.

SITUATION IN 1990

The shore has raised and stabilized into an extensive, thin line of pans, with new mangrove strips developing to sea. This line of mangrove is broken by mudflats between NO.49 MARYS HOPE and NO.48 FLOYD WARD. Shoreward of the centre drainage line, the mangrove has been reduced forming mangrove scrub, and pans with mangrove scrub.

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MAP 68

SHEET NO: 7668 NO.52 - NO.44 GOOD HOPE

SITUATION IN THE 1970's

Beach formation processes and mudflats make up the foreshore at NO.52. Inland there is a belt of mangroves, followed by a complex of pans, lagoons and patchy mangrove scrub. The shoreward boundary is an old bund/drain. The human impact/scrub interface is unclear (especially at NO.50), although there is evidence of old plantings. The shore of NO.50 and NO.51 is a thin strip of raised beach, continuing northward before being obscured by the mangrove. The mangrove in the southern area appears to young growth (lower trees), and this belt is separated from the older, taller stands by a natural drain running north-south through the area. Shoreward of the mangrove is a pan/lagoon/scrub area with evidence of poor drainage. There is a patch of thinning mangrove to the north (hatched line).

SITUATION IN 1990

The beach/mudflats in NO.52, have stabilized as pans, with a new mudflat to sea. There is extensive new mangrove growth shoreward of the pain shore pan. This new growth extends northward, encompassing a new sandbar/mudflat that has developed off the old shore. Mudflats extend northward. The shoreward pan/lagoon/scrub complex has dried or become better drained, losing its lagoons and developing into a pan/scrub association.

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MAP 69

SHEET NO: 7664 NO.59 - NO.52

SITUATION IN THE 1970's

The thin strip of mangrove in the south breaks at NO.58 into lines 1-3 trees thick. The mangrove re-emerges from NO.55 northward, bounded shoreward by an old bund. This mangrove forms

a thick belt, with beaches and mudflats on its shore. Between NO.59 and NO.56 there is extensive human impact, showing evidence of past clearance and cultivation, but this area appears to be poorly drained.

SITUATION IN 1990

There has been accretion of the coast between NO.59 and NO.56, which has resulted in a new sand bar/beach strip. However, this new land has been colonized by local people and is heavily cultivated with kitchen gardens. This human impact continues to the north, where the mangrove has been reduced by clearance. The beaches/mudflats between NO.55 and NO.53 have stabilized into a large pan, which shows a new colonization by mangrove on its shore.

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MAP 70

SHEET NO: 7660 & PART OF 8460 NO.65 NEW MARKET - NO.59

SITUATION IN THE 1970's

A continuous belt from the south stops at the NO.66/NO.65 drain, with a thin fringe re-emerging at NO.60 to the north. Beaches are found along this coast between NO.65 and NO.61. Human activity is extensive, and includes housing, plantations and clearance for beach access. The large pan in NO.61 may lagoon at high tide and/or after rain. Fishponds are shown in NO.60.

SITUATION IN 1990

The mangrove has disappeared from this section of the coast, the southern mangrove area becoming an area of scrub. A lagoon has developed in NO.66 between the drain and the north bank of the creek. Human impact has increased all along the coast, and is found up to the shore. This is mainly in the form of small garden plots.

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MAP 71

SHEET NO: 7656 & PART OF 8456 HONG KONG - NEW MARKET

SITUATION IN THE 1970'S

A continuous mangrove belt stretches along this coast, with scattered areas of pans and lagoons throughout. A facade drain sets the shoreward boundary north of NO.70 MASSIAH; whilst an old bund is the boundary between NO.67 and NO.69 FRIENDSHIP. Small mangrove patches are isolated by the drain at MASSIAH. Mangroves

line both banks of the Anamoromise Creek at NO>66 (at least up to the public road).

SITUATION IN 1990

The mangrove belt is largely intact, and there is now a continuous ribbon of beach along this coast from HONG KONG to the Anamoromise Creek. The coastline has eroded into a small bay at the outfall of the creek. The mangrove has given way to mangrove scrub between NO.68 CARNARVON and NO.66 although there is still some fringing mangrove along the north bank of the Anamoromise Creek.

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MAP 72

SHEET NO: 7652 & PART OF 8452 SPRINGLANDS - HONG KONG

SITUATION IN THE 1970's

A mangrove belt extends (increasing in width) from NO.77 northward to HONG KONG. There is evidence of extensive pans and lagoons south of the SPRING GARDEN drain. From NO.77 to SPRING GARDEN the shoreward edge is bounded by an old bund, whilst a larger facade drain determines the shoreward boundary north of SPRING GARDEN.

SITUATION IN 1990

There are extensive mudflats along this coast, which are emergent at low water. Erosion is occurring to the south, and the mangrove has been destroyed and thinned by this process at NO.77. The mangrove north of SPRING GARDEN has remaining largely intact, but there is a new beach formation along this stretch of coast. In front of SPRING GARDEN the pan has extended, largely due to eradication of the mangrove, and the re-alignment of the drain outfall channel. Many of the old lagoons appear to have dried out.

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MAP 73

SHEET NO: 7648 & PART OF 8448 NEW CALCUTTA - SPRINGLANDS

SITUATION IN THE 1970's

A thin mangrove strip runs along the the seawall at NEW CALCUTTA and SKELDON. At SKELDON and GRANT human impact is shown by coconut plantations up to the shore, through at GRANT a small strip of mangrove has been left, but isolated from the river by shore works.

SITUATION IN 1990

All mangrove has been eradicated, possibly by natural erosion of the shore. There are extensive mudflats developing by SPRINGLANDS, still within the estuary of the Corentyne River. Human impact continues up to the seawall.

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MAP 74

SHEET NO: 7644 & PART OF 8444 CRABWOOD CREEK

SITUATION IN THE 1970's

South of the seawall the mangrove is largely intact. Along the seawall extensive clearance is evident, whilst opposite NEW CALCUTTA a thin strip of mangrove continues northward.

SITUATION IN 1990

Very little change is observed along the shore of CRABWOOD CREEK; though the fringing mangrove at NEW CALCUTTA has disappeared.

APPENDIX II

TERMS OF REFERENCE FOR THE STUDY

1. Objectives

To carry out a preliminary assessment of the environmental value of the mangrove courida of Guyana, along the whole length of the coastline, so as to identify:

1.1 Areas where environmental changes have reduced or destroyed the courida

1.2 Areas of courida which should be preserved or extended as a primary sea defence system for part of the coastline

1.3 Systems of replanting and protection to improve the environmental value of the courida

1.4 Areas that can otherwise be exploited or utilized for natural resources (in particular for their forestry value), wildlife conservation and fisheries.

2. Terms of reference

The Contractor (ABCS) shall:

2.1 Carry out the study in two phases as follows:

(a) make an initial assessment and simple mapping of the coast, based on photo-interpretation of existing aerial photography
(b) carry out field examination of key areas, both those showing representative mangrove vegetation, as well as those areas damaged by erosion or coastal works.

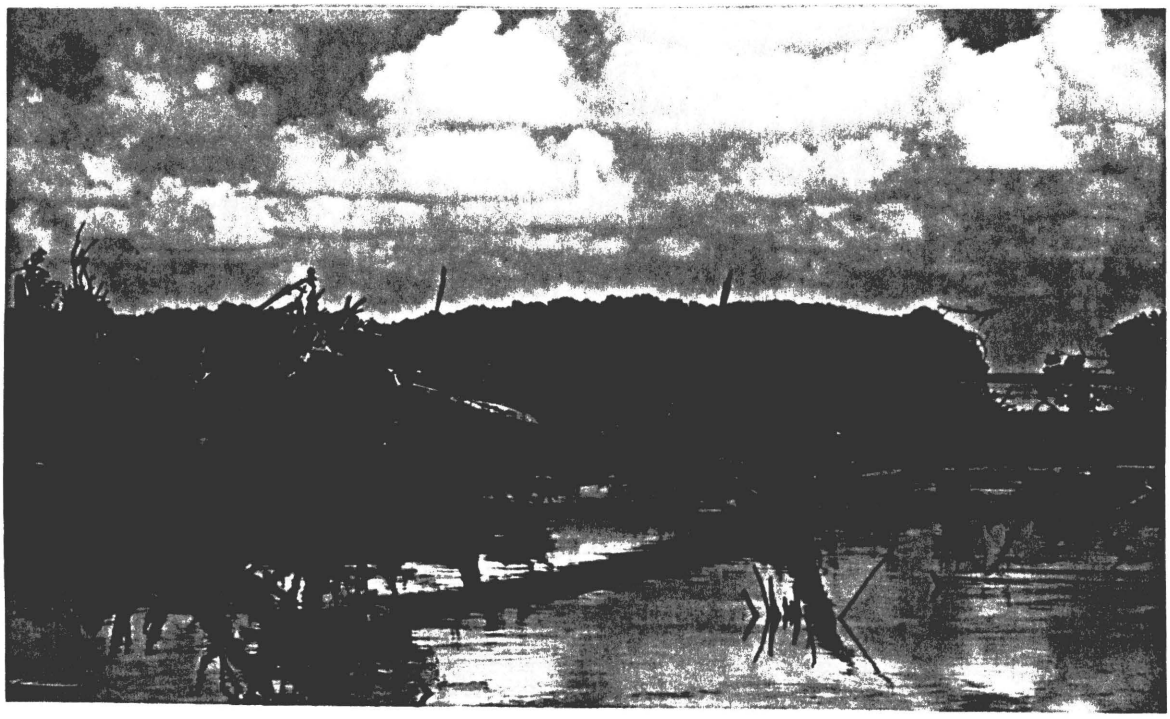
2.2 Assist in the field training of technicians from the Guyana Forestry Commission in the identification of mangrove and coastal botanical species, in the execution and interpretation of field transects and data therefrom and in the establishment of nursery areas for mangrove species.

2.3 Set out small trial nursery areas for planting of mangrove species, making every effort to ensure that the Guyana Forestry Commission shall continue these plantations as part of the future forestry management of the courida.

2.4 Provide the Guyana Forestry Commission with data on which future forestry management of the mangrove courida can be undertaken.

2.5 Highlight those coastal areas at risk from sea intrusion due to erosion or destruction, by some other means, of the courida, thus providing data to enable the Department of Hydraulics to plan and improve the sea defences of the country.

1



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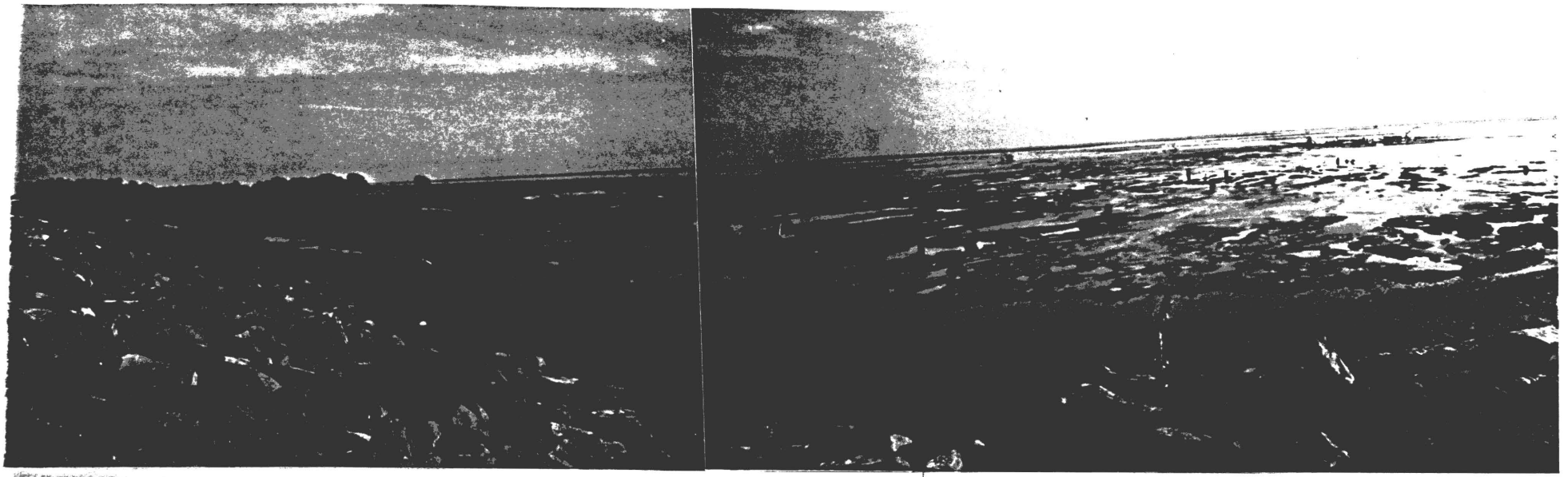

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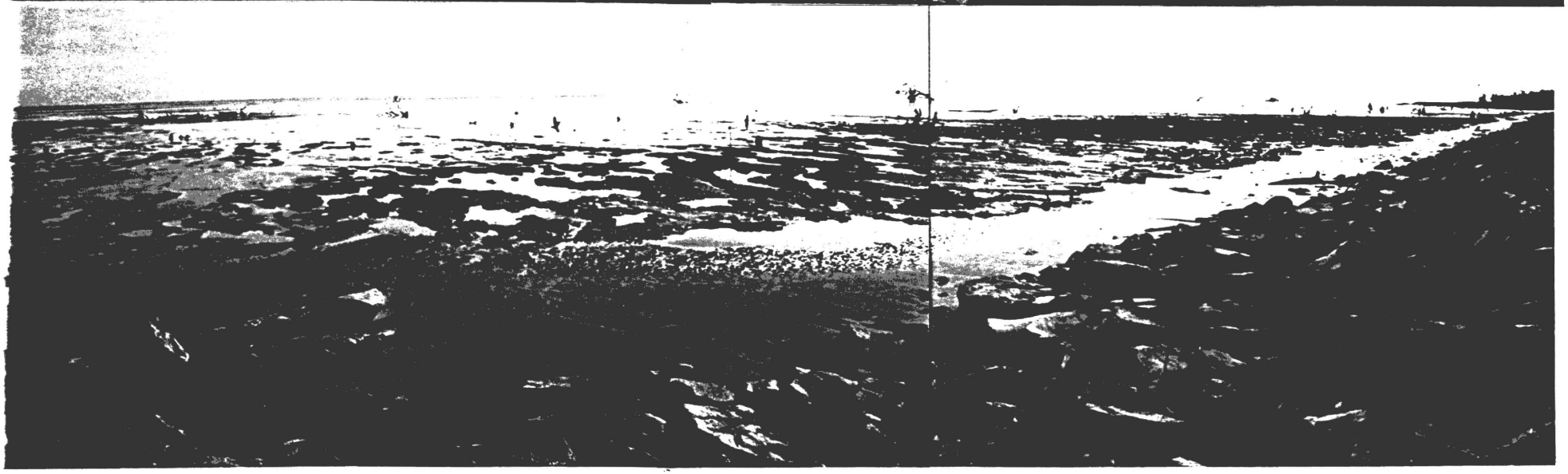

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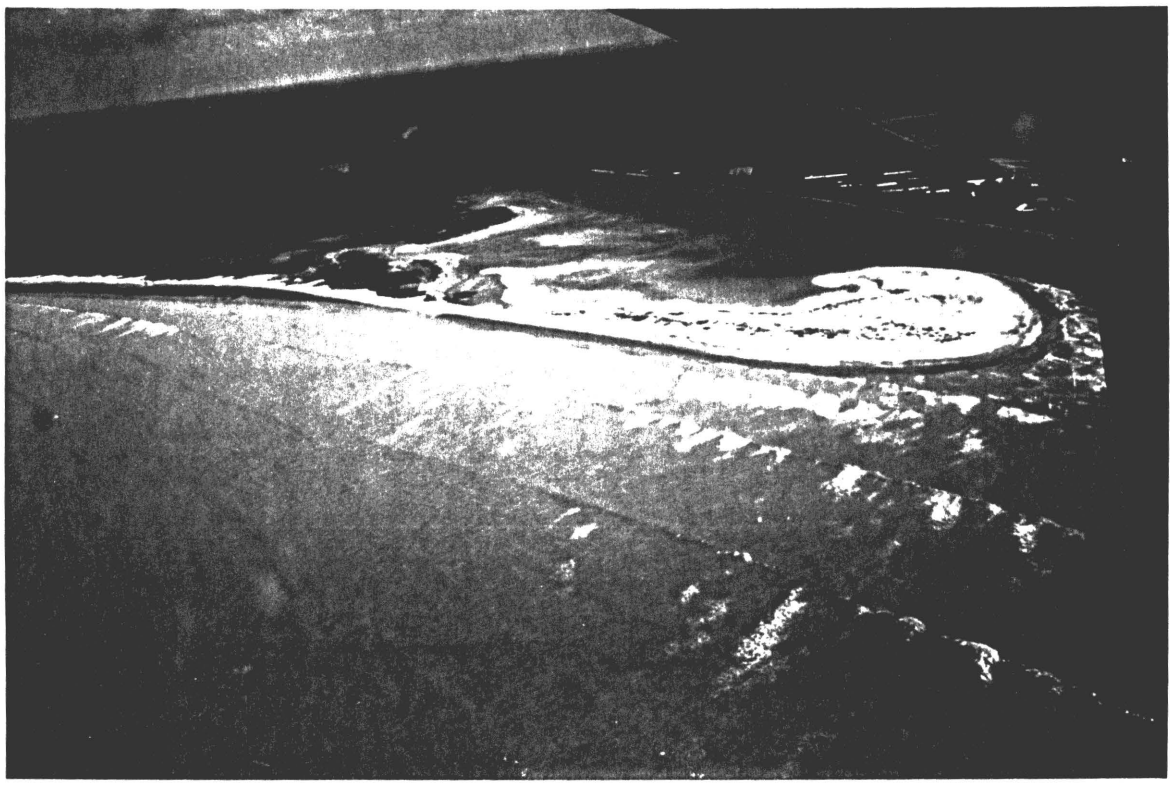

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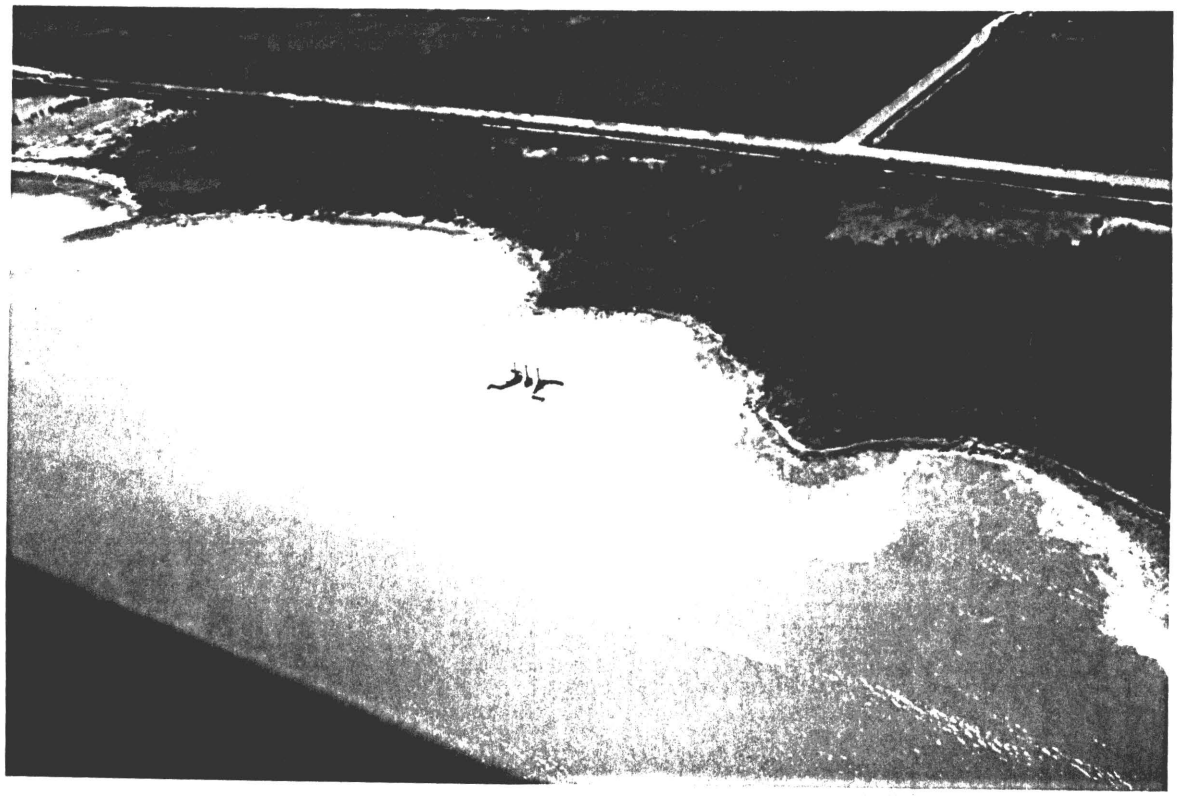

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