Eco Vision
Environmental consultancy and management

The Ponds of Sint-Maarten
Sustainable Development and Management

Report prepared for the Department of VROM
Sint-Maarten

SUMMARY

The ponds of Sint-Maarten are attractive natural landscape elements providing quietness and variation on a fast developing island. These elements, along with other sites on Sint-Maarten, like the hills and the marine environment with the beaches form the very basis of the development potential of Sint-Maarten. Decay of these elements undermines the development possibilities. Sustainable management of the use of these areas is the only answer to the problem. For most of the ponds, sustainable management means sustainable integration of functions: ecological functions (habitat, nursery function for marine organisms), environmental functions (buffer for pollutants and sediments) and human supporting functions (tourism, recreation etc.).

Optimal functioning is possible when certain conditions are met and when threats are excluded. Important conditions for full ecological functioning are: the presence of mangroves, seawater flushing, a high waterquality (no effluents) and quietness. For an optimal environmental -buffer- function the main condition is (unlike ecological functioning) a limited flushing with seawater: Here the quality of the pond itself to cope with a moderate nutrient and sediment load is used. The important recreational function is supported by the presence of vegetation, birdlife and sufficient waterquality (no bad smell or colour).
Severe threats to the functioning of all the ponds are: development and pond filling, erosion, eutrophication (excess nutrients) and pollution.

Fieldwork has been carried out in Flamingo Pond, Little Bay Pond, Fresh Pond, Great Salt Pond and Red Pond. Some smaller ponds have been involved in the study. Based on this this field work, interviews with key informants and literature study the following recommendations can be given.

The Flamingo Pond is considered an important natural area, although human activities and the hurricane Luis led to a significant loss of mangrove stands. The anticipated development direction of Flamingo Pond is filling of the pond related to the expansion of the Princess Juliana International Airport. Management should be focussed on protection of natural values in the Lowlands: Protection of Cupecoy Pond, the Northeast section of Simpson Bay Lagoon and parts of Mullet Pond. Ecological development of Little Key and Southside of Simpson Bay Lagoon is recommended.

The ecological value of Little Bay Pond is considered low. Upgrading of the ecological function and quality to a high level is recommended as the development direction for Little Bay Pond. Low intensity recreation and ecotourism near the pond are compatible to this approach. The development strategy should include: initial ecological development, especially mangrove restoration combined with an optimal environmental bufferfunction. In a later stage -when effluents are brought back to almost zero and the pond is re-opened to the sea- the pond can be an important nursery area for an important marine nature area: the seagrass meadows from Little Bay to Lay Bay. Several seagrass and coral reef associated species (including economical valuable fish species) will come to maturity in the pond then.
Waterquality and quantity management are especially important in the first phase of the ecological development. Management of waterquality by VROM and Hygiene Department should be based on the early establishment of a basic waterquality[1], which should be defined for the purpose of pond management. Waterquantity management should be based

1 This is a waterquality in which a normal aquatic life (e.g. living fish) is possible. The water has no obvious signs of pollution (bad colour or smell).

on protection of beaches and sewaterquality in Little Bay and on mangrove development in the pond, When ecological upgrading and water-management lead to an "ecological" waterquality (which would closely approach the seawaterquality), actions can be undertaken to re-open the pond to the sea. Environmental impact assessment prior to the opening is one of the actions.
Area management should be carried out by the future Marine Park authority in cooperation with NGO's and civil organizations. This could be done on a partly or fully self-supporting basis (entrance to beach, shops, terrasses, educational projects etc.).

Fresh Pond is a beautiful mangrove area in the midst of an urban area. However the pond suffers from garbage, illegal filling, pollution and eutrophication (excess of nutrients). Because of the frequent overflows to sea, the environmental function of the pond is limited: the beaches of Great Bay suffer from poor waterquality for extended periods after rainfall. The recommended development direction is upgrading of the environmental bufferfunction and recreational function. Policy and management should be based on reduction of environmental load and on stimulation of the attractivity of the area (development of vegetation). Management of waterquality by VROM and Hygiene Department should be based on the early establishment of a basic waterquality. Management of waterquantity suitable for mangrove development and optimal bufferfunction should be carried out by DOW.

With a water surface of circa 220 ha the Great Salt Pond is the largest pond on Sint-Maarten. Although the colourful scenery related to the salt exploitation has been lost over the last few decades, many tourists are attracted by the beautiful panoramas of the town and the pond from the hills. The pond suffers from large scale filling (for residential purposes and waste-dump) and deterioration of waterquality. Because of the limited containing capacity, overflows via Fresh Pond take place regularly, which is threatening the quality of the beaches of Philipsburg.
The proposed development direction is improvement of the buffering capacity of the pond susainably integrated with upgrading of recreation and tourism on the banks of the pond. Reclamation for commercial activities is a secondary function, which can be allowed if sufficient separation takes place in space.
Management by VROM and Hygiene Department includes establishment and maintainance of a basic waterquality. Management of waterquantity by DOW should be focussed on limited exchange of pond-seawater (bufferfunction) and on waterlevels suitable for initial mangrove restoration. Management of recreational activities can be carried out by private enterprises under government control. Initiatives can be largely self supporting (terrasses, shops, museum, educational projects etc).

Red Pond is still a natural area where not much human disturbance occurs. The pond -which is extensively vegetated with mangroves- provides a breeding and feeding habitat for a significant local bird population and for migratory species. The pond is the most attractive of the ones studied.
Although the ecological function is the most pronounced function of the pond, ecological functioning is not optimal. The mangrove vegetation is drying out because of the low waterlevel in the pond. The proposed development direction for Red Pond is protection and development of ecological function and quality. Low intensity recreation and eco-tourism can be stimulated.
To protect the ecological values from external influences a natural bufferzone should be designated. To develop the ecological quality of the pond and the adjacent marine area, the pond should be re-opened to the sea.
Management should be focused on protection of ecological values and stimulation of low intensity recreation and ecotourism. Area management should be carried out under the authority of the future Marine Park Management, in cooperation with NGO's and civil

organizations. Management of the pond can be partly self supporting (eco-tours, snorkelling courses etc.).

Irrespective of the chosen development direction two important improvements are necessary for all of the ponds: improvement of waterquality and development of (mangrove) vegetation. Waterquality improvements include: increasing the number of connections to sewage treatment plants, optimizing functioning of sewage treatment plants and septic tanks and soakaways and stricter regulations for commercial effluents.
Conditions for replanting of mangroves are abundant; some important conditions are: the availability of a suitable substrate (mostly soft and moist mud, peat or sand), a saline environment with terrestrial fresh water influx and low wave action (which would uproot seedlings).
For some of the ponds dredging is necessary to improve the environmental or (in some cases) the ecological function. General guidelines for dredging in ponds to minimize environmental and ecological effects are discussed. The most important guidelines include: timing should be based on minimal disturbance of aquatic terrestrial and birdlife (e.g. no dredging during breeding periods); use of low resuspension (e.g. suction) techniques; the dredging should be kept to a minimal area and kept away from mangrove stands.

ADDENDUM

Sint Maarten's natural resources after 'Luis' and 'Marilyn'

an assessment of the environmental damage and related problems
caused by two hurricanes

In februari 1996 a report was made on request of the Department of Public Housing, Physical Planning and Environment (VROM) of Sint Maarten and is financed by KabNA. The study had two aims:

1. An update of the AIDEnvironment/EcoVision 1995 studies on respectively the Hillsides, the Ponds and the Marine Environment.
2. An input of information and recommendations to a two-member team of the Dutch 'Provincie Noord-Holland' that reinforced VROM for five weeks in February/March 1996, working at several urgent files in the environmental field.

This addendum contains the update of the study on the ponds of Sint-Maarten (underlying report).

Introduction and general observation

The state of the mangroves has been observed at all locations on the Netherlands Antilles' (N.A) part of Sint Maarten where they are found. Next a comparison was made with the state of the mangroves at the Fish pond (French part).

The general observation is that the damage of mangrove stands is severe. Complete stands have nearly died as a result of the hurricane which considerably changed the appearance of all the ponds. About 5 months after the hurricanes, recovery is still marginal. Only few trees show young shoots. The recovery of *Laguncularia racemosa* and *Conocarpus erectus* is more obvious and widespread than of *Avicennia germinans* and *Rhizophora mangle.* Especially the few *Rhizophora* stands on the N.A. part of the island have almost completely been destroyed.

Field observations at different locations

Dominant mangrove-species at the Cupecoy Pond is *Avicennia*, separated from the Simpson Bay Lagoon by a small fringe of *Rhizophora.* The mature *Avicennia* trees are dead. Only a few young trees show signs of regeneration. At the northern border of the pond, *Rhizophora* trees regenerate and even form new seedlings.

Rhizophora is the dominant species at the Flamingo Pond but the mature trees completely died and show no signs of recovery. The few *Laguncularia* trees show some new leaf development. On the other hand seed germination has increased significantly compared to the situation before the hurricane. Especially at the north side of the pond many seedlings were encountered, mainly *Laguncularia.* It is assumed that these seedlings survived the hurricane and found suitable conditions afterwards because no fruits or propagules are observed. This fast development of young plants may be ascribed to the competition for light. Normally a high percentage of the seedlings will die because of insufficient light. Due to the death of the older trees the seedlings receive more light to make fast growth possible.

At the Fresh Pond the mangrove stands, dominated by *Laguncularia*, associated with some *Conocarpus*, are heavily damaged as well. However, considerable recovery is noticed. Some fast growing species (*Stigmaphyllon periplocifolium* or Leatherleaf and *Ipomoea pes-caprae* or Sea vine) benefit from the increased light intensities caused by the loss of the mangrove-leaves. The recovering mangroves become partly overgrown by these species.
Many waterfowl were observed at the Fresh Pond: cattle egret ('koereiger'), snowy egret ('kleine zilverreiger'), common egret ('grote zilverreiger'), little blue heron ('kleine puperreiger'), moorhen, brown pelican, various ducks.

At Little Bay Pond and Salt Pond no abundant tree vegetation occurs. Mangroves are absent here.

At Red Pond most of the trees of the dominant *Avicennia* species were blown down during the hurricane. Most of the roots however are intact, so that recovery may take place. It can be observed that several species are recovering slowly; especially *Avicennia* and *Laguncularia* show young healthy branches. This is striking because before the hurricane (in May '95) the leaves of *Avicennia* showed obviuous signs of desiccation. The regeneration can be ascribed to the impacts of the actual rainy season that has increased the amount of fresh water in the pond coming from the surrounding hills. *Conocarpus* is less

abundant than *Avicennia* but recovers more rapidly. It is feared that the next dry period will stagnate the recovery of the mangrove stands at this pond.

A colony of avocets (waders, 'kluut') was seen at the Red Pond.

The *Laguncularia* and *Conocarpus* species at Oyster Pond recover whereas only a few *Rhizophora* branches show new leaves.

During the visit of the ponds it was noticed that the ponds and their banks, with the exception of Red Pond, are filled with either piles of garbage, car wrecks and debris of the hurricane. This will not support the regeneration capacity of the vegetation.

Recovery perspective

It is known that vigorous stripping of young branches of *Rhizophora* due to an hurricane causes internal damage and leads to the death of whole trees. In wide and dense stands the inner vegetation rows are quite protected against hurricane forces. However, the border vegetation of the ponds on Sint Maarten had already been destroyed bit by bit due to filling and garbage and rubble dumping activities. Small fringes were left which made the stands very vulnerable. All trees of these small fringes were exposed to the hurricanes, explaining much of the heavy damage observed on both the French and the N.A. side.

Avicennia stands fall over easily due to the shallow rootsystem which doesn't provide for enough stability during hurricanes. This is observed at Red Pond. It is known further that when the pneumatophora ('luchtwortels') are inundated for a longer period of time (several days to a week), the trees will die, which may be the case at Cupecoy pond. Here the impact of the hurricane might have been reinforced by the drainage of waste water by a private water purification plant, located here.

Considering the young shoots and new leaves here and there, recovery of the mangroves is possible but needs time. *Laguncularia* and *Conocarpus* apparently recover more easily than *Avicennia* and *Rhizophora*. The general guideline is to conserve and monitor present stands and off-shoots. The conservation measures should focus on the preservation/creation of the ecological conditions for mangrove development:

- availability of suitable, muddy substrate.
- occurrence of flat slopes in the tidal zones, allowing broad mangrove stands.
- adequate waterquality (water refreshment, no hypersaline conditions, no accumulation of metals and oil).

Specific recommendations[1] are the following:

- At Cupecoy Pond the small dam that separates the pond from the Simpson Bay Lagoon can be removed in order to restore better water exchange and tidal effect. The effluents of the private water purification plant should be sampled, analyzed and evaluated on their effects on the water quality.
- Red Pond and its colony of waders should effectively be protected. The salt content should be regularly monitored. In case the salt content reaches hypersaline values, opening up of the link with the sea should be considered in order to let seawater in.
- The Fresh Pond should be cleaned up (banks and bottom). Small natural elements (e.g. fields of water plants, mangrove stands of *Laguncularia*) can be developed to create

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1 Additional to the recommendations made in the EcoVision report on the ponds from January 1996.

more diversity (and thus better habitat) for fish and the abundant bird-life. With the intention to create more interesting places for tourists ('eco-tourism'), the bird watching place near the Zagersgut's bridge could be restored. A footpath with green provisions around the pond and some fishing locations could be constructed.

- Little Bay Pond has a large potential to serve the need felt on the island for green zones. The pond area can be developed into a recreational park with trees, grass strips, a beach, a pond and possibly a restaurant/outdoor café. The pond itself can be reserved for aquaculture (e.g. shrimps) which however demands a high water quality and open access with the sea.
- At the Salt Pond a potential exists to restore the link salt factory-dikes-zoo and develop it into a nice footwalk (birdwatching); situate the salt factory in the water, rebuild some dikes and develop a small park next to the zoo.
- The Flamingo pond will be filled up to create space for the extension of the airport. Compensating measures should be integrated in the airport extension plan like for instance pilot projects to replant mangroves. Potential locations: Fresh pond (see above), Simpson Bay lagoon (southeast of Mont Fortune) and Little Bay pond (along old inundated road). As many healthy seedlings are available in the Flamingo pond, they should be gathered and used for the pilot replantings.

Another compensation can be the funding of a master plan for the Simpson Bay lagoon from the perspective of the Ramsar wetland convention.

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Figures and maps

Appendix

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1 INTRODUCTION

1.1 Sint-Maarten and its ponds

Sint-Maarten (63°06'W and 18°30'N) is the largest island of the Windward Islands of the Netherlands Antilles. The island is divided into a French and a Dutch part and covers a total of 86 km². The southern part is Dutch and covers 34 km². Tourism is the main source of income for the 35.000 inhabitants of the island.
On the Dutch side of Sint-Maarten there are several relatively isolated, enclosed water bodies called ponds. Formerly, all the ponds were permanently connected to the sea, which explains the development of mangroves around them. However, natural process es and human intervention in time caused the enclosure of the lagoons. In some cases, the mangroves have disappeared completely.
The ponds are relatively shallow, the depth varying from 0.5 m near the banks to a maximum of 5 m in the middle of some of the ponds. They contain water varying from almost fresh to almost brine depending on the season and flushing processes.
The ponds are unique natural areas determining the landscape of Sint Maarten. As such, the ponds are also of touristic value.

1.2 Problem definition

In almost all coastal countries and islands, conflicting interests among the development activities that compete for the occupation of coastal environments and resources are most intense around enclosed bays and coastal lagoons. The island of Sint-Maarten is no exception. The natural protection afforded by lagoons and enclosed bays stimulated the development of ports for shipping and recreational boating. Tourism is the main economic activity on the island of Sint-Maarten, with more than 600,000 tourists and 300 cruise ships visiting the island every year. The lack of regulation of development, along with a lack of zoning and coastal planning under a rational policy, has produced an accelerated environmental degradation and loss of resources.

Port and urban development, amongst which land fill of ponds, has modified the natural coastal environment of Sint-Maarten and has polluted the waters of coastal lagoons and enclosed bays. By definition, ponds and lagoons have a restricted connection with ocean waters. The significance of pollution impacts in the ponds is closely correlated with the degree of flushing by ocean and fresh water systems. Pollution from urban areas and clearing of the surrounding mangroves are the main factors causing the decay of the bays and ponds. This loss is a severe problem, not only for the flora and fauna depending on the mangroves but also for the maintenance of the buffer function for pollution and the role of mangroves in limiting the erosion processes of the entire pond (see chapter 2).
Without clear development plans for the ponds, it is feared that more of these valuable areas have to be given up in the near future.

1.3 Objective

The objective of the underlying study is to establish a framework for the sustainable development of the ponds of Dutch Sint Maarten. This is done for each of the studied ponds by determining the desired direction of development, followed by drafting management concepts and tentative implementation plans. The development direction of any one pond may be chosen in relation to the development of other ponds, resulting in a coherent planning for the pond systems of Sint-Maarten.

The rationale for this study is the importance of well-functioning ponds for ecological, environmental and human supporting reasons.

1.4 Object definition

The study was restricted to the larger ponds because of their relevance for the environmental and biological diversity. Map 1.1 shows the ponds that have been studied. The largest of these, Flamingo Pond, Little Bay Pond, Fresh Pond, Great Salt Pond and Red Pond were studied with respect to ecological quality (flora, fauna) and environmental quality of water and top soil layer[1]. Two ponds, one near Cupecoy and one near Flamingo Pond were visited in order to get a more rough impression of the quality of the pond system by observation of the flora, fauna and possible threats.
A very small pond near Guana Bay, which is exposed during most of the year was not visited but its presence is involved in the underlying study.
Mullet Pond and Oyster Pond are not included in this study; these ponds are part of the study " The Marine Environment of Sint-Maarten" (AIDEnvironment and EcoVision, 1995).

1.5 Approach to the problem

In order to set a framework for physical planning and management of the ponds, it is necessary to determine both current and possible future functions of the ponds. These functions comprise ecological, environmental and human supporting values.

Secondly, an evaluation of the presence of conditions for optimal functioning has to be carried out. This evaluation gives information about the possibility of combining different functions of the pond.
Guidelines and recommendations for pond development, physical planning and a tentative action plan are based on this evaluation.

Depending on the existing situation different approaches can be followed to give direction to the pond development. For the underlying study, in which the approach is from an ecological viewpoint, the first of the following approaches is most favoured, the last is least favoured:

1. By setting ecological conditions to the development of an area, future plans will be elaborated in such a way that these plans fit in the ecological functioning of the water area. With respect to conservation of natural values, this method is the most effective.

2. For several situations this approach is no longer possible because of far advanced decision making. In those cases maximum conservation of natural values is aimed at within the framework of a proposed development direction.

3. Possibilities for compensation can be considered whenever conservation of natural values is not/ or no longer possible at the location involved. In the first place, possibilities for compensation are considered near the area under study. If this is not possible, compensation possibilities are considered outside the area.

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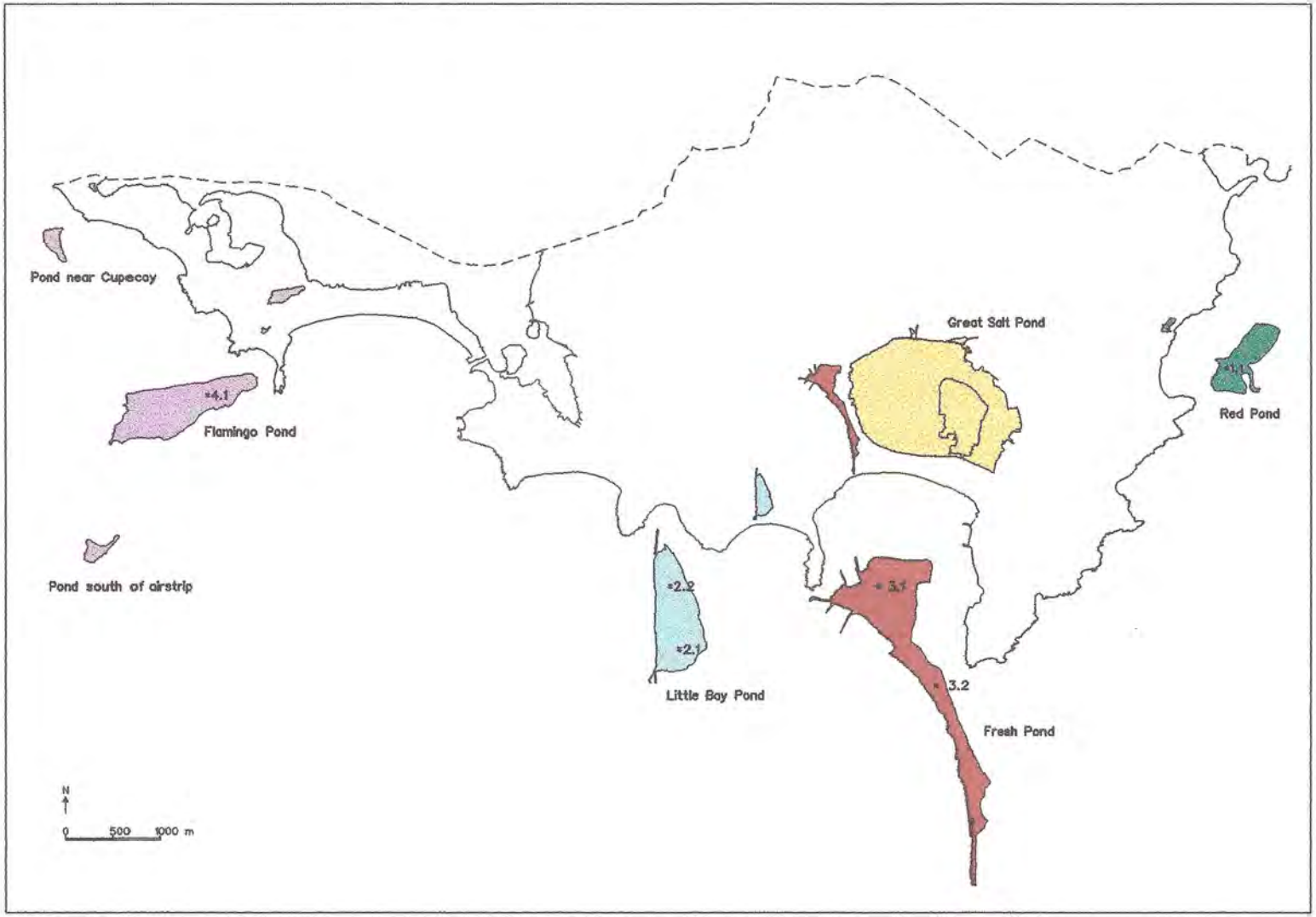
1 This was not done for the Great Salt Pond, which is subject of a more elaborate study on environmental quality related to the future of the landfill.

Map 1.1 Studied ponds and sampling locations



Eco/Nelon N.V.

1.6 Information collection

To collect data for this study, fieldwork was carried out in a period of ten days in the months of March and April 1995. In this period, the five ponds were visited several times to study the mangrove vegetation and the overall ecological condition of the ponds.
Samples were taken of the water and top soil layer (excl. Great Salt Pond). The samples were analyzed for the contents of oxygen, oil, metals, nutrients and basic parameters. The environmental study includes data on the hydrology of the ponds as well as on the water and sediment quality.
In addition, literature was studied and interviews were held with several key-informants concerning previous studies and activities regarding the ponds.

1.7 Subdivision chapters

The study and results discussed in the above, are described in the following chapters:

Chapter 2 describes the general aspects of the ponds, starting with the functions and values a pond may have. These functions are subdivided into ecological, environmental and human supporting functions. Subsequently the conditions that have to be met for optimal functioning are specified, as well as possible ways to meet these conditions. Furthermore, aspects that threaten the conditions are discussed. Finally, legal aspects such as property situations, are reviewed.

Chapters 3 to 7 describe each of the following ponds in detail: the Flamingo Pond, the Little Bay Pond, the Fresh Pond, the Great Salt Pond and the Red Pond. Each of these chapters starts with a general description of the pond and a detailed ecological portrait (because of the character of the study!). Subsequently, the present function(s) of the pond is (are) reviewed. Thereafter, the presence and quality of the conditions for each of the functions are given.
On the basis of these items, conceivable directions of development are discussed, along with their possible consequences. Each chapter concludes with a recommendation for a certain direction of development, including a tentative action plan to initiate this development.

Chapter 8 concludes the study and gives general recommendations. The chapter commences with an integrated advice relevant to all the ponds. It is explained that certain conditions need to be improved regardless of the function of the ponds. Guidelines are presented how to improve these conditions and how to prevent damage to the natural values of the ponds.

2 GENERAL ASPECTS OF THE PONDS

2.1 Functions of the ponds

Roughly three categories of functions can be recognized: ecological functions, environmental functions and human supporting functions.

2.1.1 Ecological functions

By nature, the ponds of Sint-Maarten function as a habitat for a diverse flora and fauna. The unique environmental circumstances provide suitable conditions for exceptional plant and animal species of international importance (see appendix 3).
The presence of mangroves is one of the characteristics of the ponds. Mangrove vegetation comprises species of the intertidal zone that are dependent on saline influences, the so-called obligate halophytes. These species have special adaptations which enable them to grow under the harsh conditions of the intertidal zone, such as viviparity, high salt tolerance, ability to withstand tidal submersion, pneumatophore or aerating roots, succulence and salt excreting glands. They are also major producers of detritus that contributes to offshore productivity.
In the Caribbean, the mangroves typically have a zonation of trees with the red mangrove (*Rhizophora mangle*) forming the outer fringe in the shallow subtidal zone. Behind these red mangroves are the black mangroves (*Avicennia germinans*), which are found from the lower to the mid or upper intertidal zones. The white mangroves (*Laguncularia racemosa*) then occur from the middle intertidal to the upper intertidal zone. Buttonwood (*Conocarpus erecta L.*) may occur in the upper intertidal region, but more typically it is found behind the white mangrove trees, in areas of sand plants, e.g. in Red Pond (see appendix 1: taxonomy of mangroves).

The pond and its mangrove vegetation are an ideal sanctuary for avifauna, among which a number of migratory birds, indicating the international importance of the ponds. The most abundant birds are waders, herons and egrets. Shallow parts of the ponds provide excellent bird feeding areas. This is one of the main reasons that an ecologically well developed pond-area contributes significantly to the aesthetical value and the recreative function of the ponds.

The development of soft clayish mud, trapped by the roots of the mangroves, forms a suitable habitat for crustaceans such as crabs, which make their burrows in the mud. Attached to the roots of Rhizophora live molluscs such as mussels and oysters. Furthermore, sponges, tube worms and barnacles can be found as well as -not attached to the roots- juvenile fish.

In earlier times, the ponds were connected to the sea. Nowadays, most ponds are separated from the sea by e.g. a sand bar on the beach. When a pond does have an opening to the sea, it can have an important nursery function. Juvenile fish as well as shrimp and Queen Conch grow up in nursery areas like the shallow water surrounding the mangrove roots. With regard to the nursery function, ponds are not only of ecological importance, but also of economical importance, since fisheries could benefit from the presence of breeding grounds for snappers, sea bass, shrimp etc. (see fig. 2.1 upper).

2.1.2 *Environmental functions*

An important function of the ponds is the filtering and buffering capacity, related to the collection of fresh water runoff from the surrounding hills. Fresh water run-off is often polluted by domestic and industrial waste-water which would otherwise flow into sea, causing poor waterquality and diminished clarity for days. The environmental function increases when water-exchange with the sea decreases (see § 2.2 and fig. 2.1 lower).

Occasionally, the enclosed ponds may receive sea water during storms and abnormal high tides (fig 2.2 upper) but normally no ocean flushing takes place on a daily basis. Ponds with a large watershed area and a pond bottom above sea level are likely to be fresh-brackish most of the year. Ponds with a relative small watershed area and a pond bottom below sea level are likely to be hypersaline most of the year (fig 2.2 lower). This is caused by a combination of underground influx of seawater and evaporation.

Rainfall and runoff are most likely the important flushing forces in the ponds. Because much of this water leaves the pond through evaporation, the average flushing time for the whole pond may take many months[1]. Wind, the major factor moving water in the shallow ponds, provides sluggish circulation. Because of the poor water exchange and the poor circulation, the pond systems are very sensitive to changes in water quality and quantity.

In contrast to "open" systems where nutrient exchange is provided for by circulation, in these stagnant pond-systems the nutrient balance is much more determined by primary production. Especially primary production by higher plants (mangroves), which are capable of fixing nutrients outside the watercolumn, is of utmost importance for the quality of the pond system. Mangroves also aid soil formation by trapping debris and land runoff as well as removing terrestrial organic matter. Mangroves are the vital part of the filtering system of the ponds.

The limited water-exchange prevents exposure of sensitive coral reefs and seagrass beds to nutrients, pollutants and sediments from the surrounding areas. Excess nutrients cause eutrophication facilitating algal blooms which adversely affect coral and seagrass growth and sustenance. Sediment suffocates both corals and seagrass beds.
The filtering and buffering capacity of the ponds is also of indirect importance to the quality of the marine environment. The reefs and seagrass beds are very important systems in maintaining the stability of the sea floor. This stability is considered very important in the prevention of beach erosion.

An environmentally well functioning pond can contribute to the attractivity of the pond area, including the adjacent marine area, stimulating the recreational potential of the whole area.

2.1.3 *Human supporting functions*

The ponds on Sint-Maarten contribute greatly to the beauty of the island. The coastal landscapes, the white beaches and the nearby mangrove areas attract many tourists each year. The recreational function that ponds have is most developed in Oyster Pond, where water-recreation and yaghting occur in large parts of the pond.

At the moment several of the ponds are used for landreclamation (carrier function), creating space for house building and other activities.

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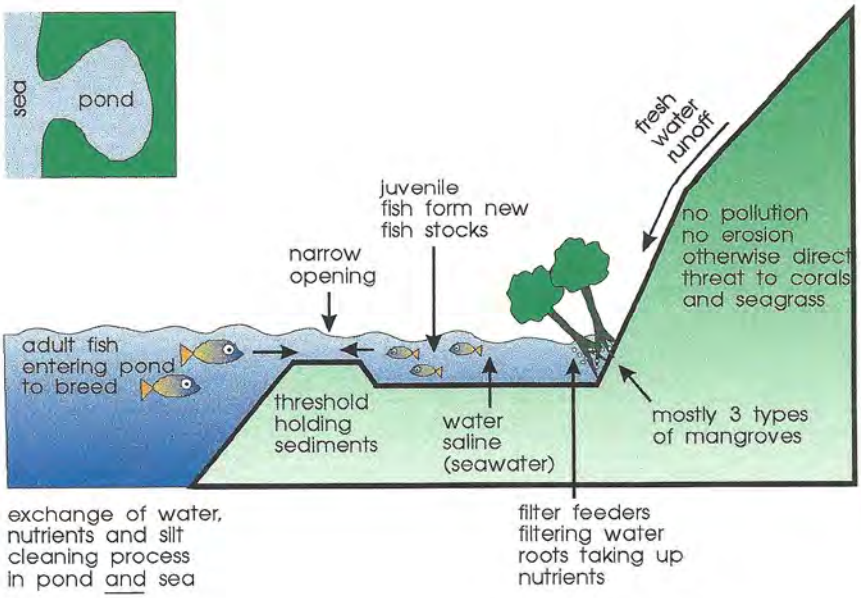
1 It has been documented (Sorenson et al, 1993) that open lagoons exhibit flushing times in the order of days or weeks.

Ecological function
(optimal)



(optimal)
Environmental function

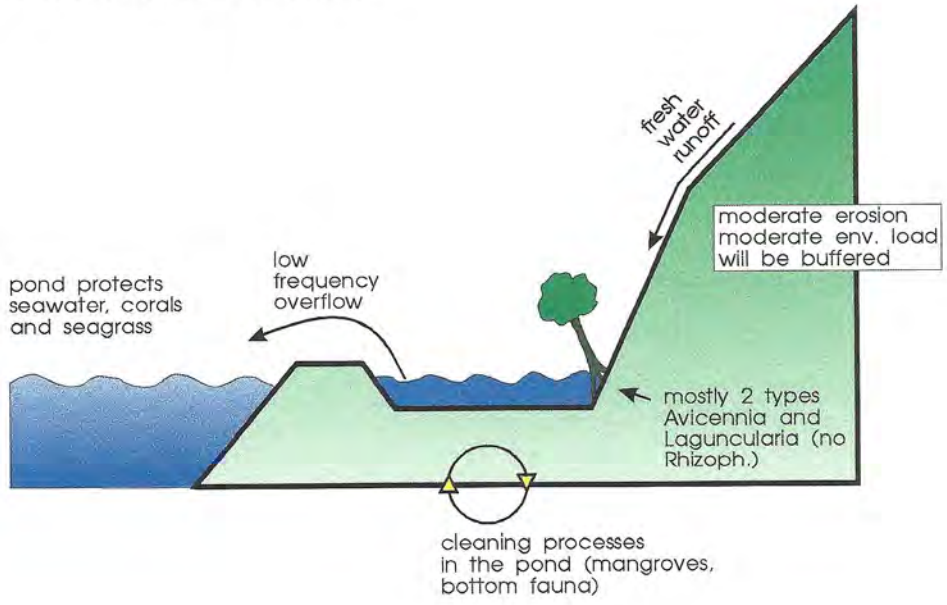
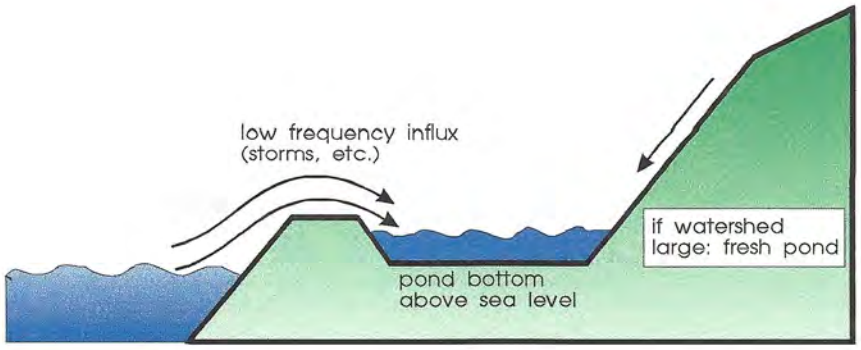


Figure 2.1 Ecological and environmental function of the ponds

Fresh type



Hypersaline type

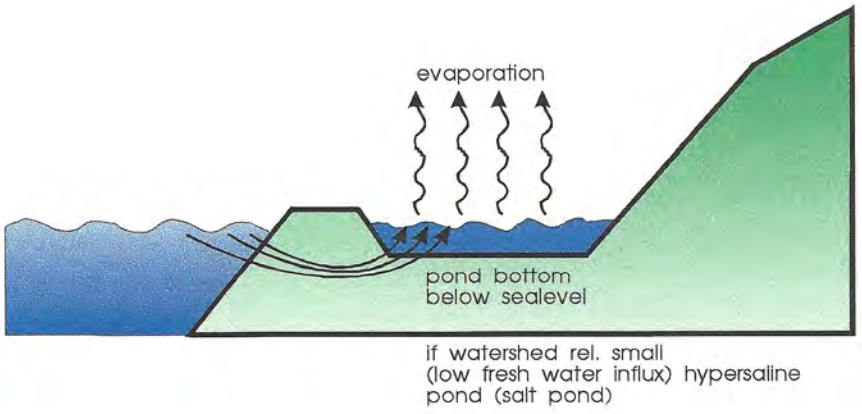


Figure 2.2 Freshwater and hypersaline ponds

Apart from the current human supporting functions, the ponds have potential for another type of human use, aqua-culture. Especially shrimp-farming and oyster-farming seem to have good potential in the larger ponds.

Salt-production, the main function of the Great Salt Pond for an extended period in history, has stopped in 1939.

2.2 Conditions for optimal functioning

Potential functions of the ponds have been described in the previous section. For each of the functions several conditions have to be met. The conditions are as follows:

Conditions for ecological functioning

Originally, mangroves were present in each pond, contributing to the ecological function. Disappearance has been caused by active removal and/or by deterioration of conditions. In conserving the ecological function of a pond, mangroves have to be protected. For restoring of the ecological function of the ponds, mangrove restoration, based on a natural dispersion of different mangrove and non-mangrove species, is a condition.

Restoration of mangrove vegetation cannot be reached by natural processes only. In some cases mangroves have to be replanted. For mangrove restoration availability of the proper soil types is an important condition, for extended growth and development of mangrove vegetation tidal movement is important.

To restore the original nursery function for the reefs, seagrass communities and fishery, the opening of the pond to the sea has to be restored. This opening however cannot be re-established immediately because of the resulting negative impact on the marine areas (pollution). If the quality of the water and sediment and the self cleaning capacity (mangroves!) is good, a pond could regain its potential for fisheries and as a nursery area. The presence of *Rhizophora* with its extended root system, providing a habitat for juvenile fish and filter feeders is important in restoring the ecological nursery function.

The mangrove vegetation provides a suitable habitat for birds. An important condition for conservation of birdlife is quietness. The presence of shallow waterparts is important for the presence of wading waterfowl.

Optimal ecological functioning requires good waterquality, this means under all circumstances sufficient oxygen and low concentrations of nutrients and pollutants. Oxygen depletion and algal blooms can contribute to fish kills and lead to significant loss of species.
Dredging disturbes the ecological functioning of the system severely. An important condition to optimal ecological functioning is a low degree of sedimentation, reducing the necessity for dredging.

In table 2.1 the conditions which should be met for a healthy (restoration of) mangrove vegetation and associated flora and fauna are summarized. Figure 2.1 (upper) shows the main characteristics of an ecologically optimal functioning pond.

Table 2.1 Conditions for optimal ecological functioning of the ponds

Type	Conditions
Biological conditions	- natural dispersion of mangroves and other higher plants - different mangrove species & associated flora and fauna
Physical conditions	- (for extended mangrove development) tidal movement - (for nursery function) waterexchange with the sea - shallow water area for mangroves and birds - availability of soil for mangrove development - no pond filling - no dredging except for support of ecological function - no road and housebuilding near the pond (quietness)
Environmental conditions	- high waterquality pond, no effluents - no excessive sedimentation - quietness (birdlife) - no garbage - for mangrove development and restoration see chapter 8

Conditions for environmental functioning

In some occasions, a certain environmental load (effluents) on the pond ecosystem can not be avoided. For an optimal environmental buffer function, the pond's carrying capacity for environmental load (self cleaning capacity) should never be exceeded. The pond should have a living ecosystem: no chemical pollution or oxygen depletion can be allowed, which would kill water- and bottomlife, such as worms and crustaceans, which are very important in the biological cleaning process. In addition, the presence of higher plants (especially mangroves) which are capable of fixing nutrients and trapping sediments is an important condition.

The emphasis is on self-cleaningness, meaning that the water is not directly carried off to sea, where natural cleaning processes occur, but that these processes take place in the pond itself. Incidental overflow to sea is less harmfull than a continuous load, which would lead to continuous algal blooms and pollution of beaches. To realize a sufficient self cleaning capacity the water containing capacity of the pond should be sufficient.
Erosion in the watershed area of the pond, which leads to sedimentation and land formation, has to be minimized. In some occasions, to prevent the pond to turn to dry land which would lead to the loss of the environmental function, active management like dredging is needed. Filling of parts of the pond should be avoided for the same reasons.

Figure 2.1 (lower) shows the main characteristics of an environmentally optimal functioning pond. In table 2.2 the conditions are summarized.

Table 2.2 Conditions for optimal bufferfunction (protection of sea and beaches)

Type	Conditions
Biological conditions	- presence of mangrove and other higher plants - healthy waterlife and bottom-life
Physical conditions	- restricted water exchange pond-sea - sufficient water containing capacity (occasionally: dredging) - no pond filling
Environmental conditions	- basic waterquality - no chemical pollution, no garbage - no excess of nutrients and sediments (basic quality) - no anoxia

Conditions for recreational and aesthetic function

Conditions for an optimal recreational function of the pond are related to the beauty of the pond. It is important that the pond contains water most of the year and that the (mangrove) vegetation is well developed. In addition the presence of many birds is experienced as an asset to the pond.

The water should be of reasonable (basic) quality and should not have a bad (anoxic) smell or colour.

Important is the presence of some basic facilities: footpaths, garbage collectors, jogging paths, benches and tourist information.

Table 2.3 Conditions for optimal recreational and aesthetic function

Type	Conditions
Biological conditions	- presence of mangrove and other higher plants - abundant bird life (bird-watching, photography)
Physical conditions	- presence of waterbody - no pond filling and unplanned development - sufficient space, otherwise other recreational facilities nearby
Environmental conditions	- no garbage - no bad colour or bad (anaerobic) water-smell - quietness
Facilities	- facilities like footpaths, jogging paths, garbage bins, information

Conditions for water recreation differ from conditions for recreation for aesthetical reasons (table 2.3). In case of water recreation, the water should be clear and of high quality. Practically this can only be reached by opening the pond to the sea. No effluents should be allowed. The waterdepth should be 1 to 2 meters making dredging necessary in most of the ponds.

For water recreation different facilities could be required. Depending on the type of recreation a beach or a marina.

Fish farming

For fish-farming the most important condition is the availability of a superior water quality, especially high oxygen contents are important. Therefore, the pond should be opened to the sea or seawater should be pumped into the growing-bassins.

The pond should be large and deep enough to accomodate the growing bassins. For a feasible setup an industrial scale (several ha) is necessary. The bassins should be protected for birds.

The conditions needed for stimulating fisheries are discussed in the section "Conditions for ecological functioning".

Table 2.4 Conditions for optimal fish farming function

Type	Conditions
Biological conditions	- dependent on method: restoration or clearing of mangrove
Physical conditions	- sufficient water exchange pond-sea - large surface, sufficient waterdepth (dredging) - no pond filling
Environmental conditions	- high waterquality (high oxygen), no effluents
Facilities	- infrastructure, growing cells - protection for fish eating egrets

Land reclamation (carrier function)

The function of land reclamation depends on the financial condition that the waterdepth is low, because of the high costs of filling material. In addition new watercourses have to be created for directing the fresh water run off from the hills.

2.3 Possible function combinations

Ecological-environmental

The ecological function is the most critical function and cannot easily be combined with other functions. Combining of the ecological function with the environmental function is not always possible, the functions are different in essence. In optimizing the ecological function no effluents are allowed to the system, whereas in an environmental function, the pond's quality of buffering run-off is used (see fig. 2.1).
In the phase of ecological restoration of a pond (when the pond is still closed) both functions can be integrated. In the progress of ecological development however, environmental pressure (effluents) has to be reduced to almost zero.

Ecological-recreation

Combination of the ecological function with a low intensity recreational function is possible, when the conditions for ecological functions are met. This means maintainance of the quietness, minimal infrastructure (footpaths) and installation of garbage collectors.

For water recreation deep water (and often dredging) is required. In addition, the required quietness for ecological functioning is not guaranteed. A combination of water recreation and ecological development can only be reached when these functions are sufficiently spacially separated. Both depend on high waterquality.

Ecological-fishfarming

A combination of ecological development and fish farming is not obvious because of the disturbances related to the fish farming process. Besides, birds have to be kept away which is not compatible with the ecological functioning.

Environmental-recreational

Both functions are the least critical. The combination of functions can be realized when the required quietness for recreation is taken into account. The environmental function is not compatible to water recreation, because the latter function requires more than a basic waterquality.

Environmental-fish farming

The environmental function is not compatible to fish farming, because of the (intrinsic) different water quality in both functions.

Recreational (aesthetic) and water-recreation

Both recreational functions are compatible when the criteria for water recreation are met and when a certain quietness for other types of recreation is guaranteed.

Recreational-fish farming

Both functions are incompatible because of the negative aesthetical impact of an industrial scale fish farming institute. Water recreation and fish farming could be compatible when spacially sufficiently separated.

Land reclamation

Land reclamation is not compatible to any of the described functions: stimulating of land reclamation leads to direct loss of any of the other functions types of the ponds. Only in large ponds this loss can be compensated.

Conclusions

By comparison of the conditions for each of the possible functions, the following conclusions can be drawn:

1. Functions that are compatible are:
- initial ecolocical development and environmental function
- ecological development and low-intensity recreation
- environmental function and recreation-function
- water recreation and other types of recreation

2. Functions that are compatible when sufficiently separated in space are:
- ecological development, water recreation and fish farming (high waterquality)

3. Functions that are incompatible are:
- ecological development to a high level and environmental functions
- fish farming and environmental function (waterquality)
- land reclaiming is not compatible to any one of the other functions (except in large ponds)

2.4 Threats

Development, pond filling

The mangrove vegetation on the island is marginal and on the verge of disappearing. They are under severe threats caused by rapid urbanisation, coastal development and pond filling. These activities cannot yet be sufficiently regulated, because of the lack of (zoning) regulations. If the present trend continues, the mangroves at Sint-Maarten will decline rapidly and eventually disappear.

Erosion

For the ponds which are surrounded by hills, erosion is an important issue in managing the quality of the ponds. Erosion is caused by rainfall washing down soil from the hills. Strong winds also cause erosion. Bare soil, where no trees or plants stabilize the ground are most sensitive to the process.
Erosion is enhanced by cutting out roads in the hills and by cutting trees and other vegetation, in most cases for building purposes or charcoal production. The soil which is washed down from the hills, follows the watersheds and ends up in one of the ponds. The ponds have a natural capacity to cope with (limited) sedimentation. However, human induced disturbances as mentioned above lead to oversedimentation. In map 2.3 the watersheds of four of the ponds are shown, as well as the main threats occurring in these areas.

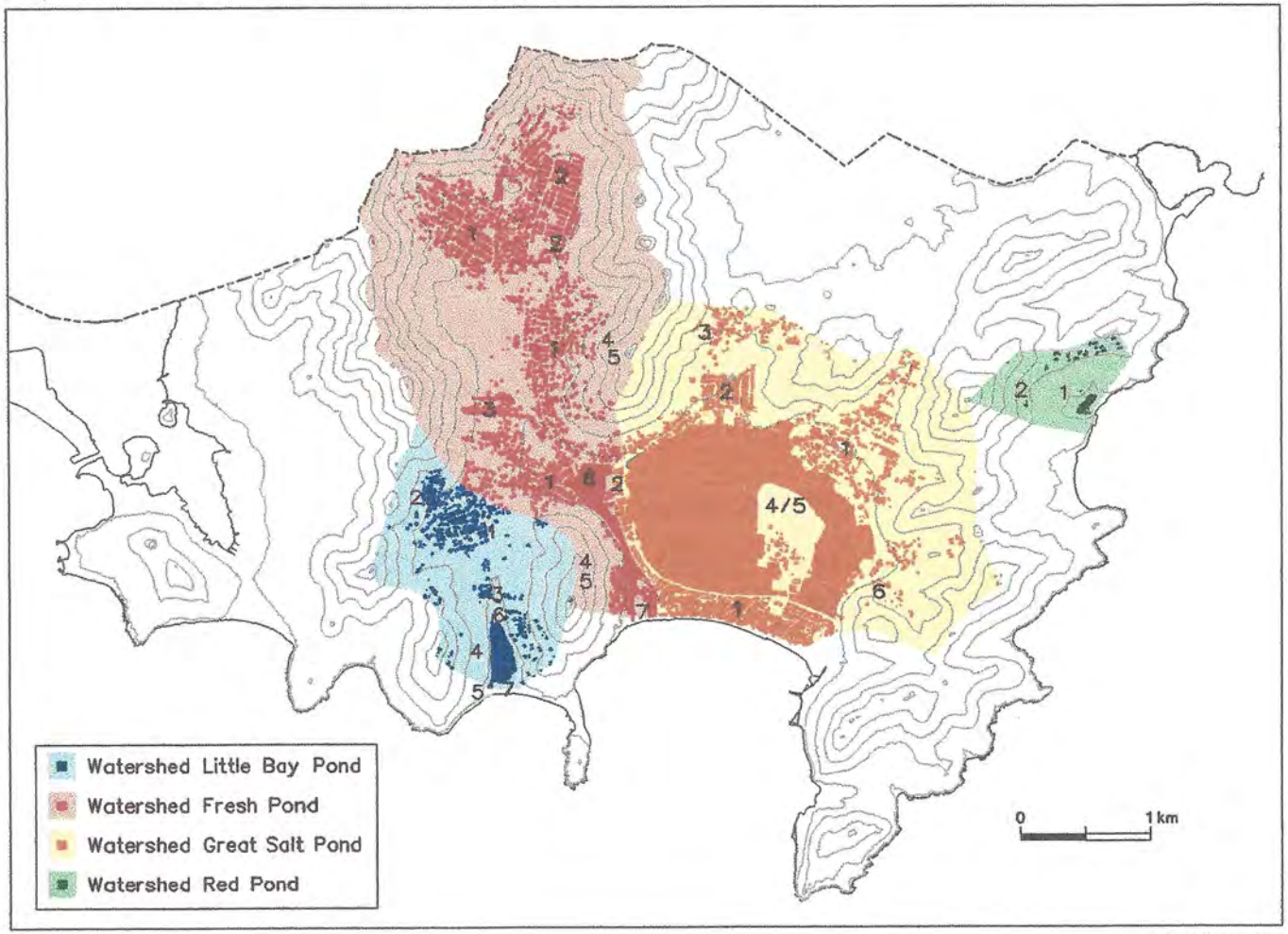
Apart from the effects of erosion on the ponds, the marine area is negatively affected by erosion (see also: "The Marine Envrironment of Sint-Maarten", 1995). The water containing capacity of the ponds decreases and overflows to sea lead to poor waterquality in the marine areas, which -dependent to the local circulation- can last for more than one week. The hillsides are also affected by the process of erosion (for more details see report "Zoning plan for the Hillside Area Sint-Maarten").

Eutrophication and pollution

Eutrophication or the accumulation of nutrients in the water (mainly phosphates, nitrates and ammonium) harms the environment in several ways. In the first place eutrophication leads to excessive growth of algae, which adversely affects the colour and the smell of the water. Secondly, in a eutrophicated pond the ecological functioning is poor because of the loss of characteristic flora and fauna (macro algae, shrimp, fishes and filter feeders).
Related to the process of eutrophication, bacterial growth poses a threat to public health and leads to oxygen depletion. Low oxygen levels and high temperatures can have a significant impact on the development of juvenile fish and may attribute to localized fish kills.
The continuous inflow of high levels of nutrients changes the quality of the sediments which triggers a long-lasting transformation of the entire ecosystem.

Eutrophication is partially caused by malfunctioning of sewage treatment plants. On Sint-Maarten three public sewage treatment plants are operational. The eastern part of Philipsburg and parts of the pondfill area are connected to the Philipbsburg Sewage Treatment Plant (PSTP). The southern part of the Ebenezer housing project is connected to the Old Sewage Treatment Plant (OSTP), the northern part the Ebenezer housing project is connected to the New Sewage Treatment Plant (NSTP). In addition there are 11 privately operated sewage treatment plants on the Dutch part of the island.

Map 2.3 Watersheds and threats ponds Sint Maarten



Threats Little Bay Pond

1. Functioning septic tanks/soakaways
2. Shack area Cake House
3. Hospital effluents
4. Development residential area
5. Development hotel area
6. Filling for road
7. Filling for hotel/marina

Threats Fresh Pond

1. Functioning septic tanks/soakaways
2. Effluents from STPs
3. Discharge shack areas
4. Cleared sites with erosion (Forthill/Saunders)
5. Future development
6. Dredging
7. Garages

Threats Great Salt Pond

1. Functions septic tanks/soakaways
2. Effluents from STPs
3. Discharge shack areas
4. Dump and oil pollution
5. Raw sewage
6. Erosion Hope Estate

Threats Red Pond

1. Plans for golfcourse
2. Plans for residential area

EcoVision N.V.

At the OSTP the overload of influent causes problems to the purifying-process. The effluents of the OSTP and the NSTP are discharged in a watercourse running north-south and end up in the Fresh Pond. The problem with the PSTP is that is has no back up generator system. During the frequently occurring electrical blackouts the sewage is only partially treated (only separation of solids). The effluent of the PSTP is discharged into the Great Salt Pond.

In many cases effluents from residences enter the ponds untreated (pers. comm. mr. T Boyrard, Hygiene Dept). At higher elevations problems arise with soakaways related to the poor permeability of the soil. In situations that soakaways are constructed on a rocky underground, sewage can seep through socalled "preference channels". Drainage will take place at the surface down the hill into the ponds or the marine waters. Comparable situations exist in the shack areas where no containment facilities are present at all.
Near the ponds problems arise during periods with high waterlevels in the pond. In those situations the flow of water in the soakaway is not downward but horizontal, leading to surface runoff of sewage into the pond. Many septic tanks and holding tanks are not used properly. Observations by Hygiene Department indicate that tanks are not always emptied in time and in some occasions even are damaged in such a way that the sewage flushes away to the pond.

Pollution from commercial activities can take place in different ways. The biological functioning of soakaways is seriously disturbed when toxic wastewater is discharged. In cases of poorly functioning soakaways and septic tanks the toxic components can enter the ponds as described above.
Storage of oil products takes place in such a way that oil-containing percolation water can enter the ponds. In some cases oil is discharged into the ground near the pond.

Prevention and mitigation of these threats are poorly regulated and controlled because of insufficient manpower within the Hygiene and VROM departments (see chapter 3).

2.5 Legal aspects

Property

By decree of the Authority of the Netherlands Antilles of 1953 (ERNA) the real estate of the Netherlands Antilles was transferred to the Islands, with the exception of the beaches ("stranden der zee"). In 1967 a new decree of the Netherlands Antilles (Pb 1967-62) gave an interpretation of the notion "beach" of the former decree by stating that "beaches" include: inner waters and the islands within these inner waters. With this new decree the former transfer of 1953 is limited, the legitimacy of which has been subject of discussion. At present, the transfer of the property of the ponds to the Islands has been established for most of the ponds on Sint-Maarten, with the exception of the Great Salt Pond. This transfer will be completed in the near future. In the Zoning Ordinance of Sint-Maarten of 1993 the inner waters within the coastline are mentioned to be "lands" covered by the working sphere of the Ordinance.

The domain lands of Sint-Maarten are shown on map 2.4, together with the remaining properties of the Authority of the Netherlands Antilles and the properties of governmental foundations (Ebenezer Estate).
The importance of the property situation lies in the fact that for domainlands direct possibilities exist for the active implementation of developments of public importance, like nature development, even without the existence of a Zoning Plan.

International conventions and compliance

In a number of cases the Authority of the Netherlands Antilles has agreed to comply to obligation under a treaty. In other cases, admittance to the treaty is only possible after obligations have been fulfilled. In order to comply with these obligations, legislation is being prepared on a national level: the Draft Ordinance for Foundations for Nature Conservation and Protection.

In this ordinance the following treaties will be implemented:

- Ramsar Convention (protection of wetlands)
- CITES Convention (stopping trade in endangered species)
- Bonn Convention (protection of migrating species)
- Cartagena Convention/SPAW Protocol (protection and development Marine Environments in the Caribbean)
- Biodiversity Convention (conservation of biodiversity in general)

Obligations which are imposed by the treaties mentioned will be partly delegated to the Island Councils. One of these delegated obligations is the establishment of an Island Nature Ordinance and an Island Nature Plan within 2 years after the national ordinance came into effect. They will have to contain measures for the protection of plant and animal life and of natural areas in general.

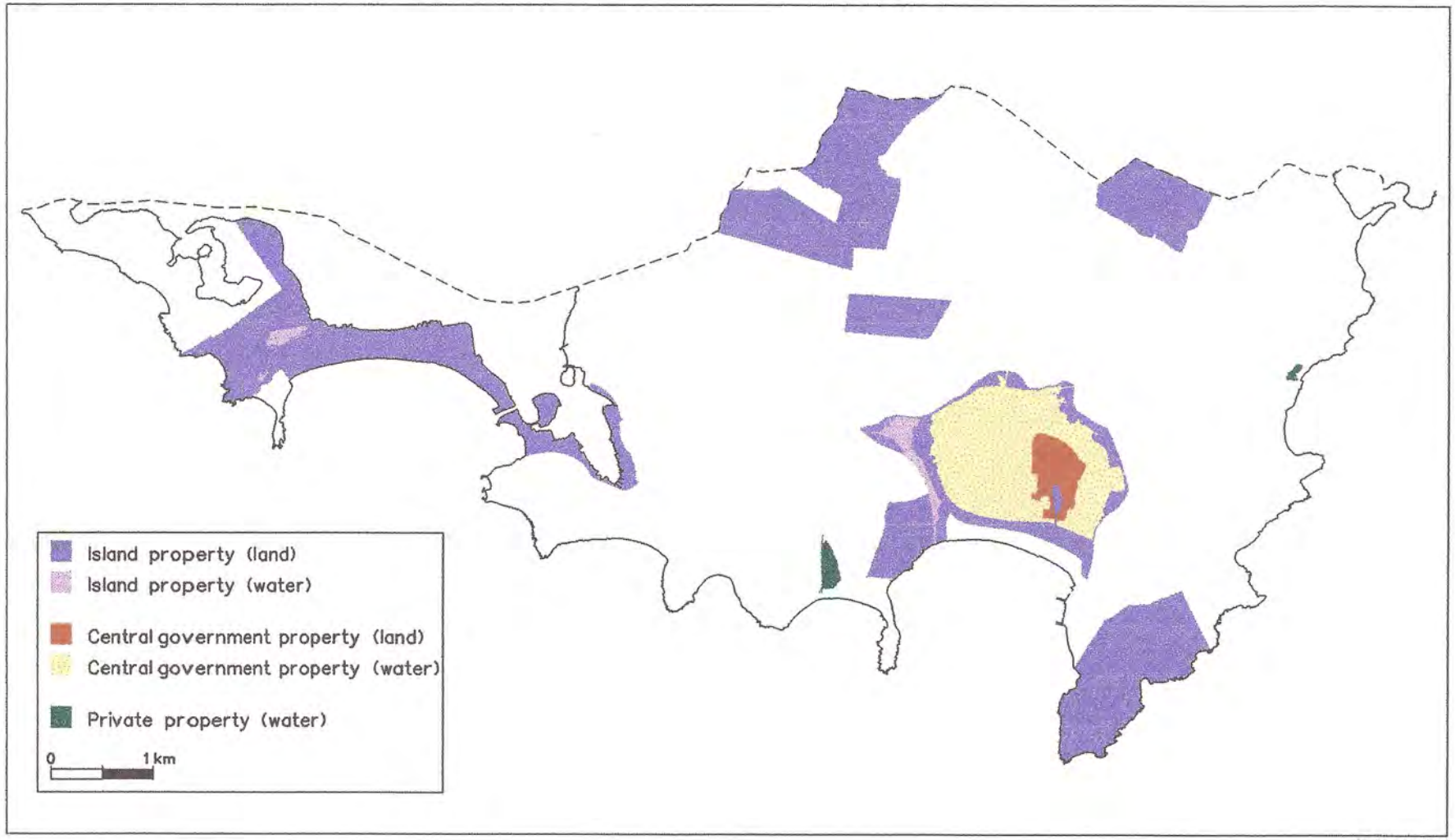
Island legislation

As compliance to the decree of the Authority of the Netherlands Antilles of 1967 (Landsverordening grondslagen ruimtelijke ontwikkelingsplanning), the Island Government has drafted the Zoning Ordinance of 1993. The Zoning Ordinance is the legal framework for the drafting of Zoning Plans, which provide the desired development on the long term. The ponds within the coastline are subject to the working sphere of the Zoning Ordinance.

Since January 1992 St. Martin has a Discharge Ordinance. This contains a general obligation for house owners and companies, to be linked up with the sewage system in the area of the sewage treatment plant. The Ordinance has special directions for companies and institutions. A special permit for discharging is needed when the effluent of an institution could contain dangerous chemicals. Other institutions have a limit on the content of waste materials in the water and/or prohibitions on the discharge of certain waste materials such as oil. All other institutions have a general obligation to report the discharged materials. Implementation of the Discharge Ordinance is not sufficient, mainly due to capacity.

In 1964 a Nuisance Act (an Island Ordinance) came into effect. This ordinance is the foundation for the regulation of danger, damage or hindrance caused by activities falling under the notion "institution". The Ordinance contains a general ban on institutions which can cause danger, damage or hindrance, except for specific exceptions to be made. On the island, 50-75 companies would need a permit. Of these, 30 actually have a permit (data from 1992). Implementation of the Nuisance Act is not sufficient, mainly due to capacity.

Map 2.4 Domainlands Sint Maarten and property situation ponds



3 FLAMINGO POND

3.1 Introduction and description

General description

The Flamingo Pond is located on the western side of Dutch Sint-Maarten and comprises a water surface of approximately 3.5 ha.
Vliegen (1994) described the history of the pond as follows: "Maps from 1886 (Molengraaff) show the Flamingo Pond as an integral part of the Simpson Bay Lagoon. A map from 1950 (Christman) shows clearly, that the pond has become an autonomous water body with small land ridges on the lagoon and on the seaside. At that time the pond extended further to the southwest. Earlier expansion of the landing strip of Juliana Airport has led to major land fill, decreasing the total surface of the pond to about one third of its original size, while the latest extensions in the 1980s again have modified the shape of what is called the Flamingo Pond".

The main traffic artery to the hotel accommodations of the Lowlands and the residential areas runs along the northern perimeter of the pond. An industrial site (concrete, building blocks) has been established at this side as well. To the west, surplus building material and general debris have accumulated.

The Flamingo Pond and the surrounding areas are property of the Island Government (see map 2.4). The area surrounding the pond is in use by the Princess Juliana Airport N.V. The main buildings (including the terminal) are located at the southeast side of the pond. Facilities such as fuel depots are located south of the pond. The Flamingo Pond is under severe pressure of the continuous expansion of the airport which needs more facilities, parking places and other infrastructure to meet the demands of more flights and tourists to the islands.

Ecological description

Though narrow, the fringe of mangrove vegetation surrounding the pond is of high quality. Three species of mangrove occur here, of which the red mangrove is especially worth mentioning, since it does not occur in the other studied ponds.
The Flamingo Pond provides a habitat for herons and egrets. Molluscs, small and juvenile fish are found among the mangrove roots. The pond provides a food source especially for smaller fish-eating birds; herons and coots were encountered during the survey. According to Vliegen (1994), Bone fish (*Alula vulpes*) are found in the deeper parts of the pond.

On the southside of the pond red and white mangroves occur in a narrow fringe of less than five meters (see map 3.1). A considerable surface of mangrove has been cleared for construction purposes for the airport. The fringe is an almost uninterrupted mangrove vegetation (see photograph Flamingo Pond next page). The proproots of the red mangrove are permanently inundated and provide a habitat for juvenile fish, oysters and barnacles. The other studied ponds are too dry to sustain a red mangrove stand. The Simpson Bay Lagoon also showed a dominance of Red mangrove; the Oyster Pond to a lesser extent.
There are many saplings, seedlings and propagules of the red mangrove along this shore. The stems of the trees are quite thick. The white mangrove showed a lot of flowers and fruit in this month of the year (April). A few black mangrove trees were reported with a height of circa 8 m. A lot of garbage was found in the trees mainly brought by the wind.

On the west side, there are white mangrove trees and a few red mangroves with a height between 5-7 m. On the east side, red and white mangroves were recorded in equal densities. A lot of debris was found near the vegetation strip which was less than 5 m in width. On the north side of the pond is a much denser mangrove stand which is not easily accessible. The red mangrove borders the pond which has a steep slope. The prop roots are covered by oysters and barnacles. Oysters were not observed in other mangrove areas in Simpson Bay Lagoon, Mullet Pond and Oyster Pond[1]. In the drier places, white mangrove trees occur with an abundance of flowers and fruits, and a few black mangrove. The girth of the trees is smaller compared to the south side and only a few seedlings were encountered of each species.

A comparison of the dominance and basal area of the different species in the plots taken at different sites of the ponds showed that the red mangrove was dominant on the south side of the pond and the white mangrove was more frequently recorded on the north and the west side (see appendix 2: data collection and map 3.1).
The Flamingo Pond is of considerable ecological value, although human activities and the Hurricane Luis lead to a significant loss of mangrove stands.

Quality of the environment

A limited waterflow between the Simpson Bay Lagoon and the Flamingo Pond is possible through an underground connection at the north-east side of the pond. This connection provides some tidal activity in the pond. Two outlets of raw sewage run into the pond, generating eutrophic algae. One drainage pipe provides the pond with fresh water, being runoff from the airport. No inlets of any other type have been detected. This has been confirmed by employees of Princess Juliana International Airport. Salinity of the water (table 3.1) is significantly lower than seawater (35 ‰) indicating poor flushing of the pond.

The clarity of the water was reasonable, between 1 and 2 metres. Analysis of the water and top-sediments of the pond has been carried out for a number of parameters (table 3.1). No significant elevation of the concentrations of oil and heavy metals could be detected. The values are near the Dutch "target" values for (ground)water and soil quality. There are no indications of severe eutrophication of the water.

Table 3.1 Quality of water and top sediment Flamingo Pond (sampling date 12-4-1995).

Site number	Analysis	Result	Remarks
W 4.1.	water temperature	30,2 °C	
W 4.1	water visibility	1-1,2 m	
W 4.1	water salinity	16,5 °/oo	seawater 32-36 °/oo
W 4.1	water oxygen	6,8 mg/l	normal value oxygen
W 4.1	water phosphate	0,088 mg P/l	app. 0,5 x limit value (*
W 4.1	water nitrate	0,1 mg NO_3/l	relatively low
W 4.1	water mineral oil (C_{10}-C_{40})	< 100 ug/l	no significant pollution
B 4.1	sediment mineral oil (C_{10}-C_{40})	170 ug/kg d.w.	no significant pollution
B 4.1	sediment heavy metals	Appendix 4	no significant pollution

*) Limit value for general ecological function of surface waters (The Netherlands): P total 0,15 mg P/l
N-total: 2,2 mg N/l.

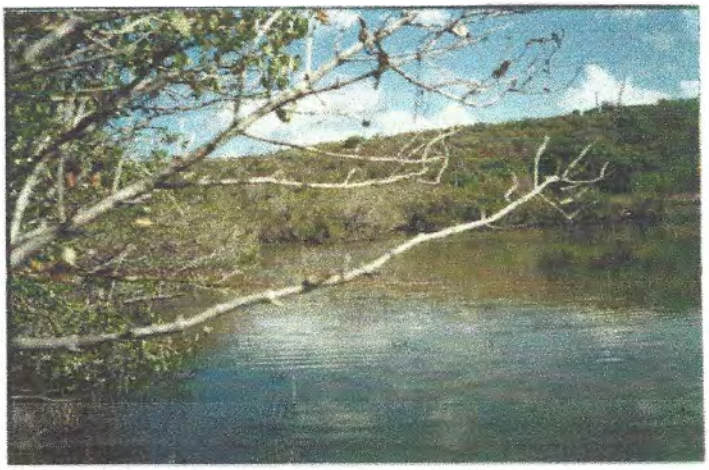
1 The marine environment of St-Maarten, AIDEnvironment/EcoVision, 1995

Flamingo Pond

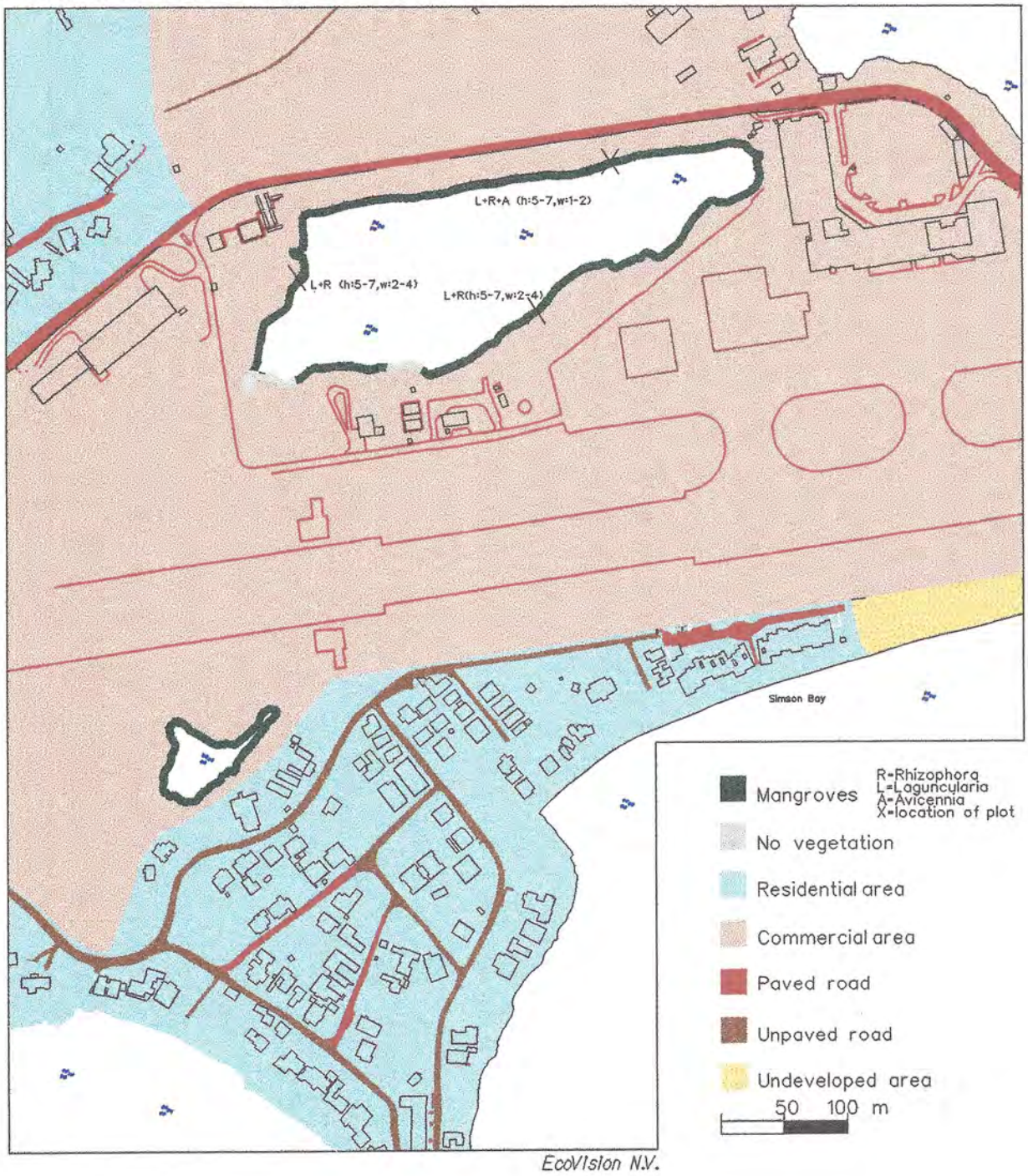
1. Flamingo Pond, a relatively large natural area near the airport will be given up for the purpose of the extension of the airport. Other areas will be designated to compensate for this loss.

2. A small, nearly dried up pond is located south of the airport and Flamingo Pond. The pond is threatened by the continuous need for expansion of the airport. A lot of building waste is discarded at the baks of the pond.

3. Close to Cupecoy, another small pond is situated. This pond is surrounded by a dense fringe of mangroves. Because of a surface connection with Simpson Bay Lagoon the pond has an important nursery function for marine waters.



Map 3.1 Flamingo Pond
Flora and fauna and use of area



3.2 Present functions

Flamingo Pond harbours a mangrove vegetation of high quality, found in only few places on the island. Biological diversity is high. In spite of this the ecological function is limited, mainly because of limited circulation (limited nursery function), and disturbance (see § 3.3).

The watershed area of Flamingo Pond is a Lowland area. This means that influx of sediments and nutrients is significantly lower than for the ponds in hillside areas. Despite of the relatively low influx, the pond has an important environmental function, because of the relatively low exchange of pond and seawater (see § 3.3).

Although the area is not open for public the pond contributes significantly to the quality of the area for tourism an recreation.

As can be concluded from the preceding paragraph, the pond has been used for reclaiming for a long time in history. The (former) pond therefore has a significant carrier function.

3.3 Evaluation of conditions for optimal functioning

Conditions for ecological function

The Flamingo Pond is a relatively disturbed pond. Besides the noise, the turbulence and gasses produced by landing and take-offs, the pond has been used for reclaiming over time. With the process of reclaiming dense stands of mangroves have been removed. The above mentioned situation indicates that three important conditions for optimal ecological functioning (quietness, mangrove- and pond protection) are not met.

Tidal movement is responsible for the presence of three species of mangroves, among which the red mangrove. The roots of the red mangrove provide a habitat for a rich fauna of fish and filter feeders (a.o. oysters). Environmental data suggest that flushing of the pond is poor. Consequently, this could be the case for fish migration and migration of planktonic larvae. Therefore the ecological function, more specific the nursery function is expected to be limited. Increasing the water exchange between pond and Lagoon would enhance this function, which would be favourable for fish stocks and fisheries as well.

The pond is relatively deep while sedimentation is expected to be minimal. Dredging is not necessary to maintain the ecological function. Shallow parts are absent which is the reason for the fringe type mangrove vegetation and the absence of wading birds (except egrets).

The current waterquality is sufficient to support the ecological function of the pond. The presence of oysters confirms this. Although some conditions are not met the ecological value of the pond is considered high.

Conditions for environmental function

The dense and healthy mangrove stands play an important role in fixing nutrients. Waterfauna especially filter feeders are in good condition and play an important role in the cleaning of the pond water. No anoxia is observed near the bottom. Bottom life (e.g.

worms and crustaceans) supports the degradation of organic matter and the cycle of nutrients.
Because of the small connection between the pond and the Lagoon, the exchange of pond water and water of Simson Bay Lagoon is limited. Limited flushing of the pond is also caused by the relatively small watershed area of the pond (no collection from hillsides). This contributes to the self cleaning capacity of the pond.
Although continuous filling of the pond has lead to a decrease of the environmental function of the pond, conditions to support this function are generally met.

Conditions for recreational function

The pond is an asset to the landscape. The high trees bordering the pond block the view on the Princess Juliana International Airport. Conditions for an optimal recreational function are met except the fact that the area is not open for the public and the disturbance related to the airport. The recreational function could be enhanced by opening the pond to the public. Especially for people waiting on the airport the pond could have a function as a resting place. Facilities, like a snackbar, tables and benches would be needed.
Conditions are suitable for small scale waterrecreation like pedal boating.

Conditions for fish farming

Important functions for fishfarming are met: the pond has a relatively large surface and is deep enough to harbour fish. Waterquality is good, but it is unknown whether the quality is good enough. Another unanswered question is whether the continuity of quality parameters is sufficient. For example the salinity can rise and fall in relation to rainfall. Different fish species react differently to these conditions. More waterexchange could be necessary.
Infrastructure would be needed and protecting measures would have to be taken.

Conditions for reclamation

The deepness of the pond makes filling a costly operation. After reclamation the pond looses its function as a collection reservoir of fresh water. Alternatives for the collection of runway-rainwater are present in the small pond south of the Flamingo Pond.

3.4 Potential developments

Ecological and recreational development

Developing the area as a recreational area would not be incompatible with the ecological function of the pond. The ecological function refers largely to the mangroves and the underwater situation which would be unaffected. The ecological function could even be enhanced by providing more watercirculation.
In this development direction the area would have to be opened to the public, e.g. people waiting at the airport. Exploitation of the area could be self supporting (snacks, some small shops, renting of pedal boats). It is expected -like the situation on Maho Beach- that the disturbance related to the airport would not keep the public away from the pond.

Fishfarming

In this development direction, the size of the pond allows the function of fish farming only. Because of many uncertainties this development direction would need further elaboration.

Filling

Filling of the Flamingo Pond is anticipated. In connection with the Short Term Extension Project of Princess Juliana Airport N.V., there has been a request for the filling of the pond for facilities, parking places and infrastructure. The extension has been obstructed for a long time because of the uncertainties about alternatives. Alternatives have been proposed, but can only be realized against very high costs. In balancing the ecological value against the economic value of the area, the choice has been made to fill the pond and look for compensating measures in other areas (type 3 approach, § 1.5). The filling has to take place in such a way that the filling means no threat to other marine areas.

3.5 Recommended direction of development

The recommended direction of development is the combination of recreational use and ecological upgrading. The pond has an important ecological and aesthetical function contributing to the attractivity of the area for tourism and recreation. Both the recreational and the ecological function can be further enhanced.

If the filling of Flamingo Pond cannot be avoided, sufficient compensation has to be offered. Recommendations refer to the choice of this development direction.

The loss of the Flamingo Pond means loss of a well developed mangrove community and associated flora and fauna and loss of an area with an aesthetical value. Because of the potential loss of functions in the Lowland area, compensating measures should be looked for in the Lowland area in the first place. For this purpose, two other ponds in the Lowlands were surveyed: one small pond to the south of the runway of PJIA and one small pond near Cupecoy (see map 1.1)[1]. The ecological value and the importance of protecting these objects are part of the integrated advice in this report, as well as some mangrove areas in Simpson Bay Lagoon, which were part of the study on the marine nature on Sint-Maarten.

Protection and compensating measures could be relevant in one of the other studied ponds: Little Bay Pond, Fresh Pond, Great Salt Pond and Red Pond (including a dried up pond near Guana Bay). These possibilities are discussed in chapters 4-8.

Pond south of runway

The small pond south of the runway which has been part of the entire Flamingo Pond at the end of the 19th century is very shallow and contains only little water most of the year. The pond can have a significant value in drainage of the runway. Mangrove vegetation (mainly white mangrove) is severely desiccated and only few birds were observed. The pond has no connection to open water and has little potential as a nursery area contrary to the Flamingo Pond. Clearly the ecological value of this small pond is small compared to the value of the

1 Possibilities of nature development at Mullet Pond are described in "The Marine Environment of St-Maarten" (in press).

Flamingo Pond. For this reason other areas have to be involved in finding adequate compensation.

Pond near Cupecoy

The small pond near Cupecoy is a relatively undisturbed pond. Mangrove fringes are ca. 5-10 m wide and 4 m. high. Part of the vegetation is threatened by desiccation. At several locations near the pond waste has been discarded. At one location at the shoreline building waste has been pushed into the water. At one location near the pond (south of the pond) oil has been discarded into the ground.
The pond has a good potential for recovery and should be protected against further damage and pollution. The pond has a connection with Simpson Bay Lagoon through a fringe of mangrove and is expected to be a valuable breeding area for marine organisms. The Lagoon part of the mangrove area is also considered valuable[1].
It is recommended to protect the pond including the Lagoon part of the mangrove area. Prevention of further damage by waste disposal or house building in the area should be given high priority. Protection of this pond could partially compensate for the loss of Flamingo Pond.

Other mangrove areas in Lowlands

The northeast side of Simpson Bay Lagoon harbours a dense fringe of mangrove (10*100 m). This area is the most intact mangrove area of Simpson Bay Lagoon, considering the height (up to 8 m) and the density of the trees[2]. This area is recommended to be protected as a refugee area for mangroves and a breeding and shelter area for birds and waterfauna. Protection and or extension of this area can partly compensate for the loss of Flamingo Pond.

Mullet Pond, especially the inlet is a valuable mangrove area. Protection and or extension of this mangrove area can partly compensate for the loss of Flamingo Pond.

A small island in Simpson Bay Lagoon, Little Key, is private property. Compared to the Flamingo Pond, no important mangrove vegetation exists. The island has a potential for mangrove recovery, however. Ecological development of this area could partly compensate for the loss of Flamingo Pond.

On the south shore of the Simson Bay Lagoon, from the Red Cross building to the east side of the runway, a scattered mangrove vegetation present. At some parts the vegetation comprises young trees. Planting has been carried out by D.O.W. on experimental basis. Large parts of the south side of Simpson Bay Lagoon could be used to grow small mangrove trees of different species with the purpose of re-planting them elsewhere. At some locations in the area a more dense permanent vegetation could be maintained to restore the heavily damaged shoreline. Ecological development could significantly compensate for the loss of Flamingo Pond.

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1 See also The marine environment of St-Maarten", AIDEnvironment/EcoVision, 1995
2 The marine environment of St-Maarten", AIDEnvironment/EcoVision, 1995

Summary

The loss of Flamingo Pond could be compensated in the Lowland area. Compensation should comprise a set of protection and devlopment measures:

- protection of pond near Cupecoy
- protection of mangrove area in northeast part of Simpson Bay Lagoon
- protection of mangrove areas in Mullet Pond
- ecological development of Little Key
- ecological development of southside of Simpson Bay Lagoon

3.6 Proposed actions

Protection measures

Designate the pond near Cupecoy, the mangrove area in the northeast part of Simpson Bay Lagoon and relevant areas in Mullet Pond (see "The Marine Environment of Sint-Maarten") as protected areas. Nature development in these areas should be considered as much as possible.

Development measures

At the south coast of the Simpson Bay Lagoon and Little Key habitat development for mangroves, birds and waterfauna should be emphasized. Both areas can serve as a suitable education and scientific training ground for specific target groups such as school children and students.

The areas have a high potential for mangrove recovery, but inventories of the soil-quality (grain size), the course of the slope and other environmental and ecological parameters should be carried out to estimate the viability of a newly planted mangrove fringe of different species. A wide horizontal tidal range is considered important because to reduce erosion and to provide a habitat for different species (including upland species).

An implementation- and management plan should be drafted. Consultation of the owners is recommended to find support for the approach.

Mitigation impacts filling

The negative impact of filling the pond should be minimized and mitigated as much as possible. Small trees, seedlings and propagules could be collected and planted to supply other areas such as the marginal fringes on the southcoast of the Simpson Lagoon and the banks of Little Bay Pond for mangrove restoration. Collection should start as early as possible. On an experimental basis older trees should be replanted as well. If succesful the result of the replacement would be the permanent presence of seeds and seedlings, which would possibly reduce the costs of revegetation.

The organisms in the water such as larvae and juvenile fish could be saved by pumping the water from the Flamingo Pond into the Simpson Bay Lagoon. The fish population is to be netted and put into the lagoon. Prior to the filling of the Pond, bottom fauna could be collected and transferred to the Simpson Lagoon which most likely provides similar habitat conditions. The Iguana individuals are to be caught and moved to a proper alternative location.

The required quantity of filling material is roughly estimated at 350.000 m^3. For more accurate estimates hydrographical surveys of the pond are needed.

The location for the collection of the filling material should be carefully selected and implemented. Preferably, a thin layer of coarse sandy material (less than 10% fines) should be applied first in order to achieve a well compacted subgrade to support the heavy loads. Dredging in lagoons such as the Simpson Bay Lagoon should be conducted under strict regulations. Although this lagoon is less susceptible to such activity considering its size compared to smaller water bodies, the creating of deep anoxic areas in the Lagoon should be avoided.

Dredging should take place as far as possible from the mangrove fringes to protect the bank slopes. A possible location could be the southcoast of the Lagoon along the side of the airstrip or at places where there is a need to dredge for boat channels and no impact on the mangroves is predicted. Collection of materials from bays is not recommended because of the impact on the sea bottom and seagrass beds reducing the natural coastline (hurricane) protection.

Although no significant oil pollution and heavy metals could be detected in water and bottom-soil, the filling proces should be carried out with the greatest precautions. The connection underground between the Flamingo Pond and the Simpson Bay Lagoon should be closed to avoid a water flow and the influx of fine floating materials from the pond to the Lagoon. Water of the Flamingo Pond should be pumped into the Simpson Bay Lagoon, without disturbing the top layer of the bottom.

4 LITTLE BAY POND

4.1 Introduction and description

General description

The pond is located behind Little Bay Beach and has an almost triangular shape. It has a water surface of approximately 7 ha. To the south, the Little Bay Pond is separated from the Caribbean Sea by a narrow sand ridge with a beach on the seaside. Natural elevated boundaries are the Cay Hill on the westside and the Fort Hill on the eastside. To the north the valley extends into the residential area of Welgelegen.
In the early days of the colony of Sint-Maarten the community centre (The Old Town) was located not far from the Little Bay Pond. The bay opposite of the pond (Little Bay) provided better shelter for sailing ships than the Great Bay. Traces of a 17th century road can still be found at the west side of the pond. The old road is permanently inundated.

The pond used to be rather inaccessible from the landside due to thick vegetation, amongst which probably mangroves. This, together with the waterbody of the pond furnished a good habitat for herons, egrets, migrating ducks and waders.

However, approximately fifteen years ago, large parts of the banks of Little Bay Pond were cleared for the purpose of a future development. Apart from the construction of the Bel Air Hotel close to the pond, these developments never took place.

The Little Bay Pond is the property of Caris Development N.V. However, there are uncertainties about the legal aspects associated with the transaction that took place in 1961. In this context the meaning of Pb 1967-62 is important, bringing forward the question whether the Island or the Federal Government was the competent authority carrying out the transfer (see § 2.5.1).

The inundated road is Island property. A parallel unpaved road more uphill (photograph 3 next page) belongs to the property of Dunnet Ltd.

Ecological description

No mangrove vegetation was encountered here although earlier reports indicate that the pond provided a rich wetland ecosystem hosting mangroves and many migratory bird species. Still, birds are found to rest and feed here such as waders, sand pipers, Bahama pintails and herons. The highest bird concentrations are found in the northern part of the pond. It was observed that birds migrated from the Little Bay Pond to the Fresh Pond in the early morning.

On the seaside, a plain stretches between the pond and the beach, consisting of grass land, Acacia and Tamarinds. On the westside a typical hill vegetation is encountered, which is intersected by an unpaved road parallel to the pond. On the eastside a lower Acacia vegetation can be found as well as sea purslane and grass land closer to the water. Grassland borders large parts of the banks of the entire pond (see photographs next page and map 4.2). Grasshoppers, several butterfly species, crickets, crabs, lizards and spiders were reported. Bush ducks were reported to visit the pond on their migration route from North to South America (information: Heritage Foundation).

Quality of the environment

The bottom of Little Bay Pond is above sea level (information: ICE 1995), indicating that circulation and flushing by the sea occurs during storms and extremely high tides only. Seawater flushing is insignificant compared to flushing by fresh water run off. This is in accordance with the low salinity detected in the pond (table 4.1).
From the shack area Cake House unpurified sewage enters the pond through waterguts along the public roads, contributing significantly to the eutrophication of the pond. From residential areas near Cay Hill and Welgelegen (map 2.3) rainwater and sewage are collected in a watercourse running north-south to the northern part of the pond. The sewage can be qualified as black water (overflow of septic tanks) and grey water (from kitchens, showers, information: Hygiene Department). To this watercourse the sewage water from the nearby hospital is added. Problems with the dimensioning of the septic tanks often lead to overflow of these tanks. The quality of the sewage water of the hospital is unknown.

Table 4.1. shows that the water of the pond is moderately-strongly polluted with oil. In the sediment, only a slight elevation of the concentrations of oil could be detected. Values for copper are very high. No information is available on background values for this element.

After inspection of the open drains in the watershed area of Little Bay Pond by the Hygiene Department several years ago no oil pollution could be detected in this system, indicating that the origin of the oil could be illegal discharges directly into the pond.

Clear indicators for the eutrophication of the water are the green colour (algae) and high phosphate values. Eutrophication is probably caused by the effluents of residential areas and the poor flushing of the pond.

The high oxygen concentrations can be partly attributed to the heavy rainfall at the moment of sampling. However, eutrophication of the water, causing growth of planctonic algae, can also be held responsible for the high oxygen values during day-time.

Table 4.1 Quality of water and top sediment Little Bay Pond (sampling date 11-4-1995)

Site number	Analysis	Result	Remarks
W 2.1-2.2	water temperature	30,2 °C	
W 2.1-2.2	water visibility	< 10 cm	green colour
W 2.1-2.2	water salinity	6,3 - 8,4 ‰	
W 2.1-2.2	water oxygen	14-12,2 mg/l	high value, after rain
W 2.1-2.2	water phosphate	0,50-0,54 mg P/l	app. 4 x limit value (*
W 2.1-2.2	water nitrate	0,5-1,3 mg NO_3/l	
W 2.1-2.2	water mineral oil (C_{10}-C_{40})	1100 µg/l	mod.-strongly polluted
B 2.1-2.2	sediment mineral oil (C_{10}-C_{40})	300-260 ug/kg	lightly polluted
B 2.1-2.2	sediment heavy metals	Appendix 4	high values copper

*) Limit value for general ecological function of surface waters (The Netherlands): P total 0,15 mg P/l N-total: 2,2 mg N/l.

4.2 Present functions

As a habitat for flora and fauna, the Little Bay Pond has a moderate function. The vegetation is rather poor in diversity, due to the fact that it mostly consists of secondary

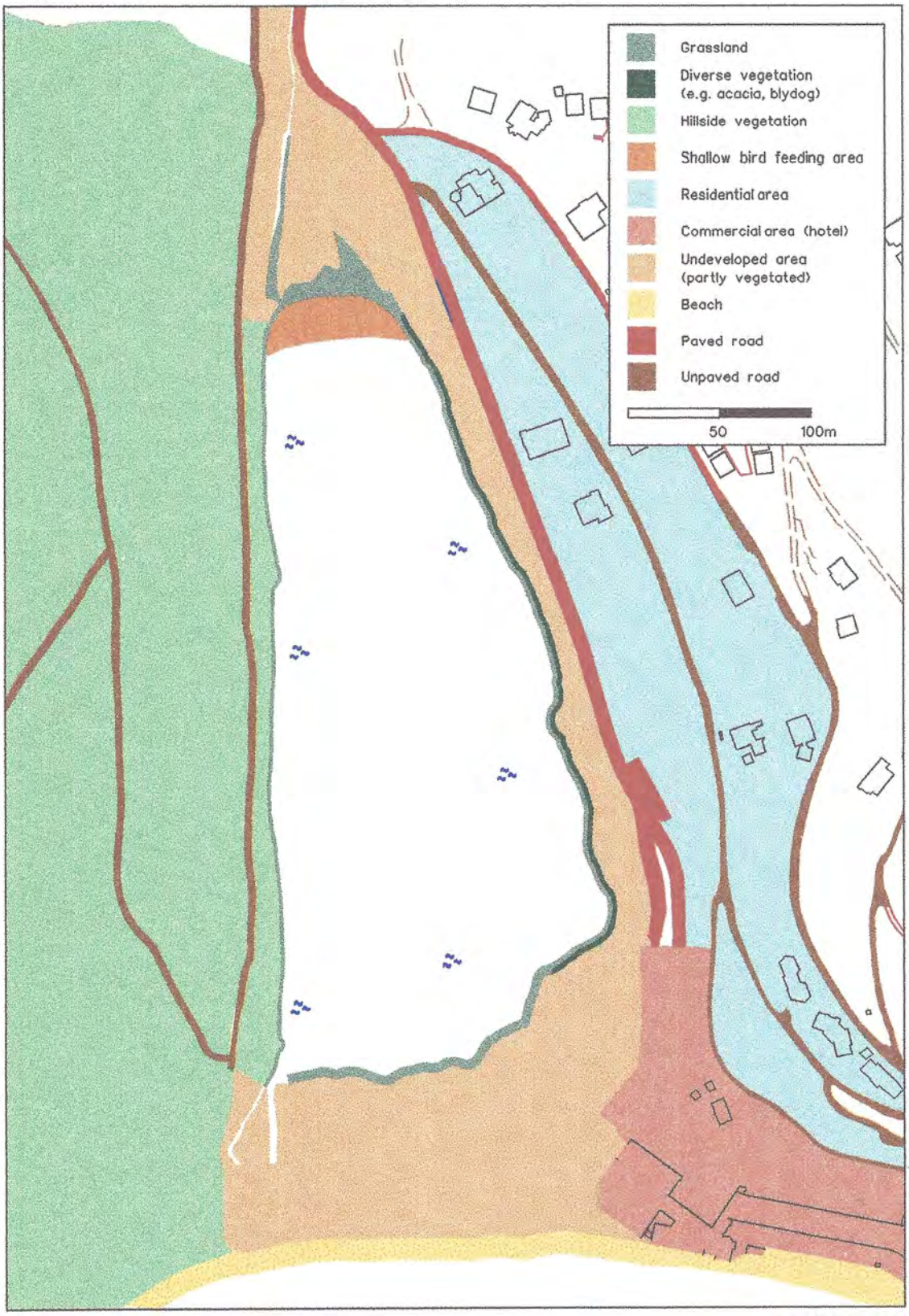
Little Bay Pond

1. panoramic view

2. Despite the waterquality and low vegetation-diversity, the Little Bay Pond harbours considerable numbers of foraging waterfowl, such as snowy egret, White Egret, Bahama pintails and blackwinged avocet.

3. An unpaved road stretches along the west side of Little Bay Pond. Apparently, the road was cut out through original hill vegetation, which can still be observed along the pond (right side). Parallel to this road an inundated road exists in the pond. This shallow part is expected to provide an excellent site for mangrove restoration

Map 4.1 Little Bay Pond
Flora and fauna and use of area



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vegetation. On the west side of the pond, the hillside vegetation, which is much older is considered interesting. In spite of the poor pond vegetation, considerable numbers of waterfowl frequent the pond mainly for foraging indicating the ecological importance of the pond. Smaller animals find a habitat in the vegetation surrounding the pond.
The Little Bay Pond has no nursery function because there is no regular exchange of pond and seawater.

Overflows from the pond to the sea are rare, approximately once a year (information: mr. Richardson DOW). Overflows regularly take place at the land side north of the pond, causing much inconvenience. Because of the restricted exchange of pond and seawater, Little Bay Pond has an important buffer function. Sediments and nutrients are not directly released into the sea, but mainly end up in the pond bottom and the pond water. In this way the pond contributes significantly to the protection of the beach and seawater-quality.

The Little Bay Pond has a moderate function for recreational and aesthetic values. The area surrounding the pond is used as a jogging area. The aesthetic values are modest and will be considerably higher when the banks become revegetated. In the near future the east bank of the pond will be one of the main routes along the island ("Link 1"), carrying many tourists. The importance of the aesthetic function will then be more emphasized.

At present, the pond has no significant function for fishery or fishfarming. Local people mention the presence of large numbers of shrimp in earlier days. Some landcrabs are still harvested by local people, making use of small wooden traps along the eastern bank of the pond. By the DOW Department, good possibilities are seen for upgrading this function.

4.3 Evaluation of conditions for optimal functioning

Conditions for ecological function

Table 4.1 shows a poor waterquality, which does not meet the conditions required for a healthy ecosystem. Nutrient-contents are too high, especially of phosphate according to limit-values in the Netherlands. Concentrations of oil are too high. The poor water quality may be responsible for the absence of e.g. shrimp.

There is no mangrove-vegetation that would (partly) balance the nutrient-contents. Furthermore, the removal of vegetation in the past has resulted in poor conditions for animal life.

However, conditions for mangroves are reasonable; there is a considerable area of shallow, brackish water, combined with a gradual slope of the borders. The west and north bank of the pond appear to provide excellent opportunities for mangrove restoration. The former (governmental) road to the beach is inundated providing shallow parts in the pond, suitable for mangrove vegetation. Soft mud provides a suitable substrate here.
For extensive growth however, tidal movement, which can be established by re-opening the pond, is necessary. Lack of tidal movement gives a more limited (but not unacceptable) growth. Tidal movement, in other words an open connection to the sea is also a condition for the ecological nursery function, important for fisheries. This condition is not met.

The area is reasonably calm, there is not a lot of traffic, disturbance of animal life is within acceptable range. Attention has to be paid to the effects of the expected increase in traffic ("Link 1") and the anticipated housebuilding projects.

Conditions for environmental function

The conditions for an optimal environmental bufferfunction are only partly present. The Little Bay Pond suffers from a high load of pollutants and nutrients from the surrounding areas. The self cleaning capacity is low because of the absence of higher plants e.g. mangroves. Algal blooms can easily lead to anoxia, disturbing the activity of important (cleaning) bottom fauna (see § 2.2).
The poor waterquality is a threat to the quality of the adjacent marine environment, especially the dense seagrass meadows of Little Bay and the beach of Little Bay. However, the watercontaining capacity is sufficient: overflows from the pond to the sea are reported approximately once a year. This situation is responsible for an acceptable waterquality in the bay; no problems have occurred yet.

Attention has to be paid to the increase in erosion pressure because of building plans on the west bank. Erosion and sedimentation reduce the watercontaining capacity.

Conditions for recreational function

Conditions are reasonable for low-intensity recreation such as jogging, as occurs at present. The aesthetic function is moderate, the pond and its waterfowl providing a nice scenery for inhabitants in the surroundings and hotelguests. The aesthetic values can be improved by developing (conditions for) the ecological value.

For other recreational activities such as water sports, conditions are poor because of the shallow water and the poor waterquality. For waterrecreation, opening of the pond is required. Plans to build a harbour for yachts will necessarily include heavy dredging operations because elevation of the pond-bottom is above sea level.

Conditions for landreclamation

Since the water is very shallow, the conditions for filling are good. There seem to be no *physical* objections against landfilling. Landreclamation in Little Bay Pond however, is not compatible with the other functions of the pond discussed.

Conditions for fishfarming

At present, the conditions necessary for fishery and fishfarming are certainly not met. Low waterquality inhibits growing of shrimp, oyster and fish. For fish farming an open connection to the sea would be necessary because of the required waterquality.

4.4 Potential developments

The small size of the pond makes a physical separation of possible functions highly problematic. For this reason the choice for the use of the pond should be harmonic and balanced, serving as much as possible (potential) functions, that are considered important.

The following development directions come into consideration.

Ecological and recreational development

Little Bay Pond has a high potential for development of the habitat function (ecological upgrading) and the function for recreation/ecotourism. The environmental (buffer)function is compatible with these functions in the first phase of the ecological and recreational development.

Revegetation of the banks is essential to all these types of use. Initial growth of mangroves is possible without re-opening the pond. For a well-developed mangrove vegetation (mangrove forest) the pond needs to be re-opened to the sea on the longer term, which would have a positive impact on the waterquality of the pond and on the possibilities for marine organisms to find breeding grounds. The could be an important nursery area for an important marine nature area (from Little Bay to Lay Bay[1]). Re-opening however is not possible at this time because of the poor waterquality in the pond, which would badly affect the quality of the marine water and the beaches. Furthermore, the waterlevel in the pond would decrease significantly and dredging would be required.

In the first phase of the ecological development, when the pond is still closed the environmental (buffer) function is important. Ecological development, especially mangrove restoration, should be combined with a decrease of the load of nutrients, sediments and pollutants. All effluents have to be stopped or directed away from the pond (connection to a sewage treatment plant) so that in a next stage the pond can be re-opened to the sea. Dredging is required because of the elevated pond-bottom compared to sea-level.

Bank-recreation is compatible if intensity is low. More intense use of the pond such as a harbour for yachts, is not compatible with ecological development because of the expected disturbance (birdlife, disturbance of bottom).

The short term result of this development direction is an attractive green pond with possibilities for walking, bird watching, jogging etc. In the direct vicinity of the pond possibilities exist for other types of recreation (beach recreation etc.).
The long term result of the development direction is a beautiful wetland in which the blue water, the dense green mangroves and an abundant birdlife form the main aesthetic elements. The pond will be a important nursery area for reef and seagrass associated species (fish, conch).

Recreational development

For a development as a recreational area -including water-recreation- mangrove vegetation should be restored in the first place and the opening to the sea should be restored. All effluents to the pond should be stopped and housing should be limited.
Although these conditions meet the criteria for ecological development, both development directions are incompatible because of the disturbances and pollution caused by the more intensive forms of recreation. The situation in Oyster Pond is exemplary. In addition, the recommended use of the area of Little Bay to Lay Bay as described in "The Marine Environment of Sint-Maarten" is extensive recreation and tourism.
The result of intensive recreational and touristic development of Little Bay Pond and adjacent marine area would be a severe pressure on the most important seagrass area of Sint-Maarten.

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1 The marine area near Little Bay is "ecosystem protection zone". The marine environment of St-Maarten, AIDEnvironment/EcoVision, 1995.

Fish farming

Fish farming is a possible use for the Little Bay Pond. The pond has a surface large enough for this type of use, however, dredging and opening the pond to the sea would be required. This is not possible on a short term (see other possible developments).
Preferably fish farming e.g. shrimping should take place on a small scale, but it is doubtful whether this will give a feasible operation. On an industrial scale, the exploitation would lead to exclusion of other functions, which is undesirable.

Other possible developments

In an earlier stage Caris N.V. has shown interest in building a marina and a hotel in the pond. This would imply the filling of the south-side of the pond. The southeast side of the pond has been partially filled already for this purpose.

At present, by government high priority is given to the building of a new road that should relieve the pressure of the traffic in the east-west direction (the Great Bay - Cole Bay connection). One of the plans includes the filling of the northern part of the pond.

Filling of the pond will reduce the capacity of the pond to receive sediment runoff and erosion material from the surrounding hills and may lead to direct influx to sea, affecting the clarity of the marine water, the seagrass beds and the coral reef communities in a negative way. In addition road building will threaten the abundant birdlife existing in the northern part of the pond and will have a negative impact on the aesthetical value of the pond.
Realization of the road in the northern part of the pond can be integrated only in any one of the described development-directions if compensating measures are taken (buffer vegetation, dredging the pond).

The development-plan for Cay Hill, proposed by Dunnet Ltd. includes the building of 100-120 houses on the eastern hillside of Cay Hill and a hotel at the seaside in a later phase. Proper measures have to be taken to assure minimum sediment and nutrient load on the pond, otherwise this development could impose a serious threat on the pond.

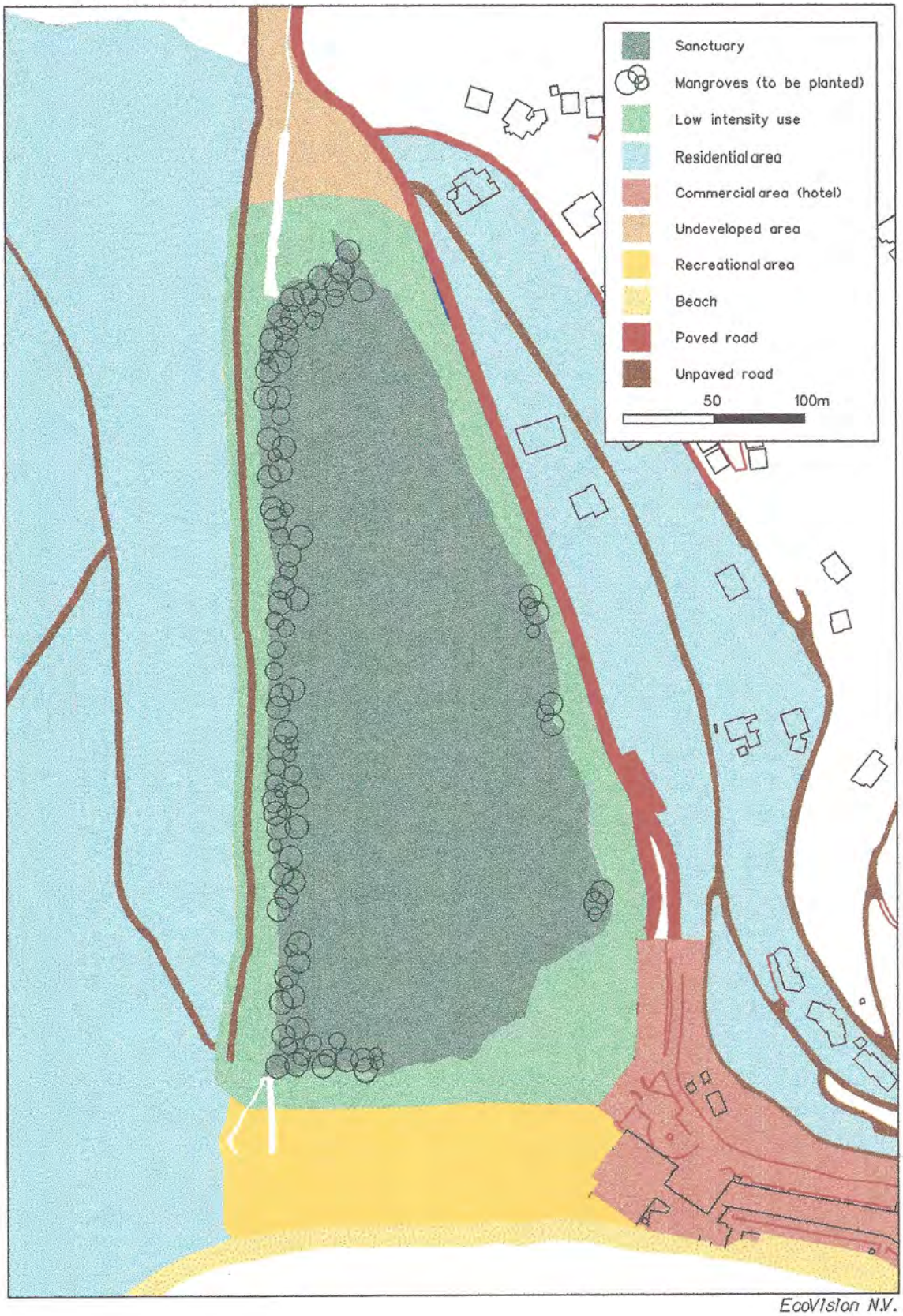
4.5 Recommended direction of development

Based on the preceding sections, we recommend to develop the Little Bay Pond into an ecological development area, where low intensity forms of tourism and recreation are allowed to take place. In this approach, ecological conditions determine the development of the area (type 1 approach, § 1.5).
The development strategy should include: initial ecological development, especially mangrove restoration combined with an optimal environmental bufferfunction. In a later stage -when effluents are brought back to almost zero and the pond is re-opened to the sea- the pond can be an important nursery area for an important marine nature area: the seagrass meadows from Little Bay to Lay Bay. Seagrass and coral reef associated species (including economical valuable fish species) will come to maturity in the pond and inhabit the sea.

A proposal for the zoning of the Little Bay Pond and surrounding areas includes the definition of three zones (see map 4.2):

- The area in the pond is designated as a "sanctuary zone". The zone is designed to protect and develop the critical habitat to ensure the continuity of biological and

Map 4.2 Little Bay Pond
Zoning proposal



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physical processes, and the preservation of biodiversity. No active use of resources and development is allowed within this zone (the pond). No effluents are allowed nor any filling of the pond. Human intervention is allowed solely for scientific research of natural coastal ecosystems or activities supporting the above mentioned functions. For the purpose of ecological development a natural zone is proposed to be developed at the west bank consisting of mangroves merging into other higher vegetation.

- The area directly surrounding the Little Bay Pond (10-20 meters) is designated as a low intensity use zone where human activities are limited. The zone (a bufferzone) is designated to protect the pond from runoff and direct disturbance. The area should be developed as a natural zone open for passive recreation related to environmental education or ecotourism. Attention should be paid to a natural zoning of plant species from the pond to uphill regions.

- A "utility/private development zone" or urban zone divided in 4 subzones: medium density residential area, commercial area, recreational area and other. Within this category tourism and urban projects are allowed under sustainable development strategies.

Management concept

Waterquality and quantity management are especially important in the first phase of the ecological development. Management of waterquality by VROM and Hygiene Department should be based on the early establishment of a basic waterquality[1], which should be defined for the purpose of pond management. Waterquantity management should be based on protection of beaches and sewaterquality in Little Bay and on mangrove development in the pond. When ecological upgrading and water-management lead to an "ecological" waterquality (which would closely approach the seawaterquality), actions can be undertaken to re-open the pond to the sea. Environmental impact assessment prior to the opening is one of the actions.
Area management should be carried out by the future Marine Park authority in cooperation with NGO's and civil organizations. This could be on a partly or fully self-supporting basis (entrance to beach, shops, terrasses, educational projects etc.).

4.6 Proposed actions

Revegetation of the banks

A revegetated bank should have the character of a beautiful wetland rather than a narrow fringe, by establishing a mangrove forest on a larger surface. This possibility exists in particular at the shallower parts in the north and the southwest section of the pond, where mud flats are present. In case the construction of a road through the northern part of the pond is inevitable it is strongly recommended to establish a dense mangrove fringe south of this roadpart in the pond, for aesthetical reasons.

Propagules, seedlings and small trees could be collected from adjacent mangrove areas and from Flamingo Pond. However, it should be determined whether there is enough natural stock to reafforest the Little Bay Pond and whether the costs involved are acceptable. It is strongly recommended to use older trees from Flamingo Pond to vegetate the west and east

1 This is a waterquality in which a normal aquatic life (e.g. living fish) is possible. The water has no obvious signs of pollution (bad colour or smell).

bank by means of an experiment. A valuable effect of revegetating with older trees is the permanent availability of seeds and seedlings for revegetations which could reduce costs and effort of revegetation.

Revegetation of mangroves should be in harmony with a naturally occuring dispersion of upland species in the bufferzone (low intensity use zone), known from descriptions in early biological literature from Sint-Maarten[1]. Appendix 5 gives the natural occurrence for several plant species in pond areas and lower and higher upland regions.

Improvement of the waterquality

The pond should be free of effluents. The discharges of wastewater from the hospital, as well as the domestic discharges of the surrounding residences should be directed to a central sewage treatment plant. Possiblities for directing waste water to the Philipsburg Sewage Treatment Plant (PSTP) by pumping should be studied.
The waterquality in Little Bay Pond has to be carefully monitored with the eye on re-opening.

Guidelines for developments in the surrounding area

Clear development guidelines on the expansion of accommodation should be developed ensuring the protection of the ecosystem of the pond. This applies also for the development of the hillside of Cay Hill which should comply to guidelines for house building (density, construction techniques), road construction (guts along unpaved roads), construction of sewerage, designation of green areas, felling prohibitions etc. Guidelines are in preparation by the Department of VROM.

Re-opening of the pond

Eventually, for a well-developing mangrove-forest, tidal watercirculation is required. This can be established by re-opening the pond. The next sequence of steps should be taken into account:

- Reduction of effluents to zero, improving water-quality
- Dredging the pond
- Because of drop waterlevel: additional mangrove planting (Rhizophora)
- Partial opening (pipe construction)
- Re-opening (narrow opening, with threshold, see fig 2.1)

The project should be prepared on the basis of a masterplan and environmental impact assessment, in which government, NGO's, the Little Bay Pond owners association, and developers participate.

Ecotourism and education

Small-scale recreational and educational activities can very well be integrated in the ecological development direction. It is recommended to conduct a study into possible

1 Flora of St-Eustatius, Saba and St. Martin, Boldingh 1909
Flora of the Netherlands Antilles, Stoffers 1966

ecotouristic activities and how to exploit these on a self supporting base. Examples: tracks, information brochures on animal and plantlife, birdwatching spots.

Pond management

Pond management is needed to accompany the process of structuring of the area. In the future, when low-intensity recreational activities are allowed and established, further pond management is needed. Management should be carried out by the future Marine Park Management. The owners association of the Little Bay Pond and NGO's could start parallel projects e.g. on how to keep the pond clean.

Masterplan and environmental impact assessment Little Bay Pond

All these actions have to be elaborated in a detailed operational plan or Masterplan for Little Bay Pond based on the Ponds study. Additional items in this plan are:

- Costs of measures, revegetation, management
- Expected revenues from recreation, eco-tourism, feasibilty
- Time frame for the operation

If the feasibility is positive and the project will be carried out, an environmental impact assessment has to be carried out to minimize eventual environmental effects.

5 FRESH POND

5.1 Introduction and description

General description

The Fresh Pond is located just west of Philipsburg, next to the Great Salt Pond and north of the Great Bay. It has an oblong shape stretching out from north to south and a water surface of circa 13.5 ha. The pond is divided by the Bernhard Bridge into a northern part and a southern part. The level of the pond bottom varies from SMP - 0,20 m near the Bernhard Bridge to SMP + 0,20 m in the northern part of the pond[1]. Water depth varies from approximately 0,9 m near the bridge to 0,5 m in the north of the pond, however these values can be sigificantly lower in dry periods. Shallow parts, particularly in the north are densely populated by waterfowl.

In 1792 a dam was built to separate the Fresh Pond from the Salt Pond, with the purpose to prevent fresh water from flowing into the Salt Pond. In 1850 an opening to the sea was established to conduct the flow of fresh water to the sea. At present this channel is not completely filled with water so that no permanent connection with the sea exists.

The presence of mangroves along the banks of the Fresh Pond -even very old ones- is remarkable. In the days of the salt exploitation, mangroves like any vegetation were considered to disturb the fresh water outflux to the sea, which was the main function of the Fresh Pond at that time. This would threaten the salt exploitation, for which reason most of the mangroves were cleared.

The Fresh Pond as well as most of the land surrounding the pond are Island property (see map 2.4). The land along the pond is leased for residential and commercial purposes, however parts of the banks have remained green or have been revegetated (see map 5.1 and 5.2).

Ecological description

Along the Bushroad in the northern part of the pond a dense mangrove stand occurs with a dominance of white mangroves (see photograph next page). This area is an extremely important breeding area for birds such as cattle egret and common egret, despite the traffic noise. Even the pelican is observed breeding in this area (photograph 2 shows two pelicans near their nest). These birds which are protected by law are normally known to breed at Pelican Island and Green Key. The branches of the white mangroves grow near the water surface which provides an excellent shelter for nests of coots and moor hens. A few black mangroves and buttonwood are reported in this mangrove stand. There is a lot of garbage among the trees.

On the northern tip, there is little mangrove left except for dense stand of white mangrove with a width of circa 8 m and a stand which is planted by DOW/Groenvoorzieningen on domain land (see map 5.1 and 5.2). Parts of the northern banks have been filled and garbage is accumulating both in the northwestern and northeastern part of the pond. The shallow area functions as a feeding ground for waders such as sandpipers and dowitchers.

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1 Technical specifications for the dredging of the Fresh Pond and creation of a fill area ICE 1995

Pelicans are frequently observed here as well as fish, mainly Mullet. These fish are able to withstand low oxygen concentrations by swimming near the surface and snapping air.

On the eastern side the banks are vegetated with grass and sea purslane and some palm trees. There is little mangrove left except for a patch of white mangrove trees with several birds' nests near the bridge.

South of the Bernhard Bridge, there are patches of white mangrove along the road. The stems are quite thick indicating that the trees are quite old. Grass land is growing up to the waterfront. Trees of sea grapes with fruits and palm trees occur at higher elevations. Across the pond on the west side there are a few patches of white mangrove and a lot of grass land. A part of this bank (circa 40 m) is covered with big boulders. On the southern tip of the pond, garbage is accumulating.

In total, ten waterfowl species were recorded in this pond. Furthermore several song birds, lizards, spiders, butterflies were found among the mangroves, in particular among the diverse vegetation along the Bushroad.

Quality of the environment

The bottom of Fresh Pond partly lies below sea level, indicating the possiblity of underground influx of seawater. This process as a flushing factor is insignificant compared to the influx of fresh water, as can be derived from the low salinity of the pond water (table 5.1).
In a relatively large watershed of 605 ha[1], (see map 2.3) rainwater and effluents are collected in a watercourse running north-south along the the L.B. Scott Road. This watercourse ends up in the Zagers Gut which is in open connection with the northern part of the Fresh Pond. The effluents entering the pond can be qualified as black water (overflow of septic tanks) and grey water (from kitchens and showers). The effluents of two sewage treatment plants located in Ebenezer are added. The quality of the effluent of the old Ebenezer sewage treatment plant is poor because of the overload of influent at the installation.
Rainfall causes a muddy run off ending up in the pond, which is caused by excavations in the hillsides. The effect of this sediment load in Fresh Pond is noticeable. Informants remember the pond bottom several decennia ago as being much lower in dry periods than nowadays.

Analysis of the water and top-sediments of the Fresh Pond has been carried out for a number of parameters (table 5.1). The water is moderately polluted with oil. No significant elevation of the concentrations of oil in the sediment could be detected. Values for copper are very high. No information is available on background values for this element.

1 Globaal afwateringsplan St Maarten NA, Fase 1: Cul de Sac Independent Consulting Engineers 1994

Fresh Pond

1. panoramic view

2. The brown pelican is one of the approximately 15 species of waterfowl that frequent the Fresh Pond. Often they just float on the water. Like cattle egret and white herons, small numbers of pelican breed in the mangrove trees along the Bush Road.

3. This aerial picture shows the Fresh Pond with the north side in the lower part. On the upper left side part of the Great Salt Pond can be seen, bordered by the town of Philipsburg. Note the difference in watercolor.

Map 5.1 Fresh Pond
Flora and fauna

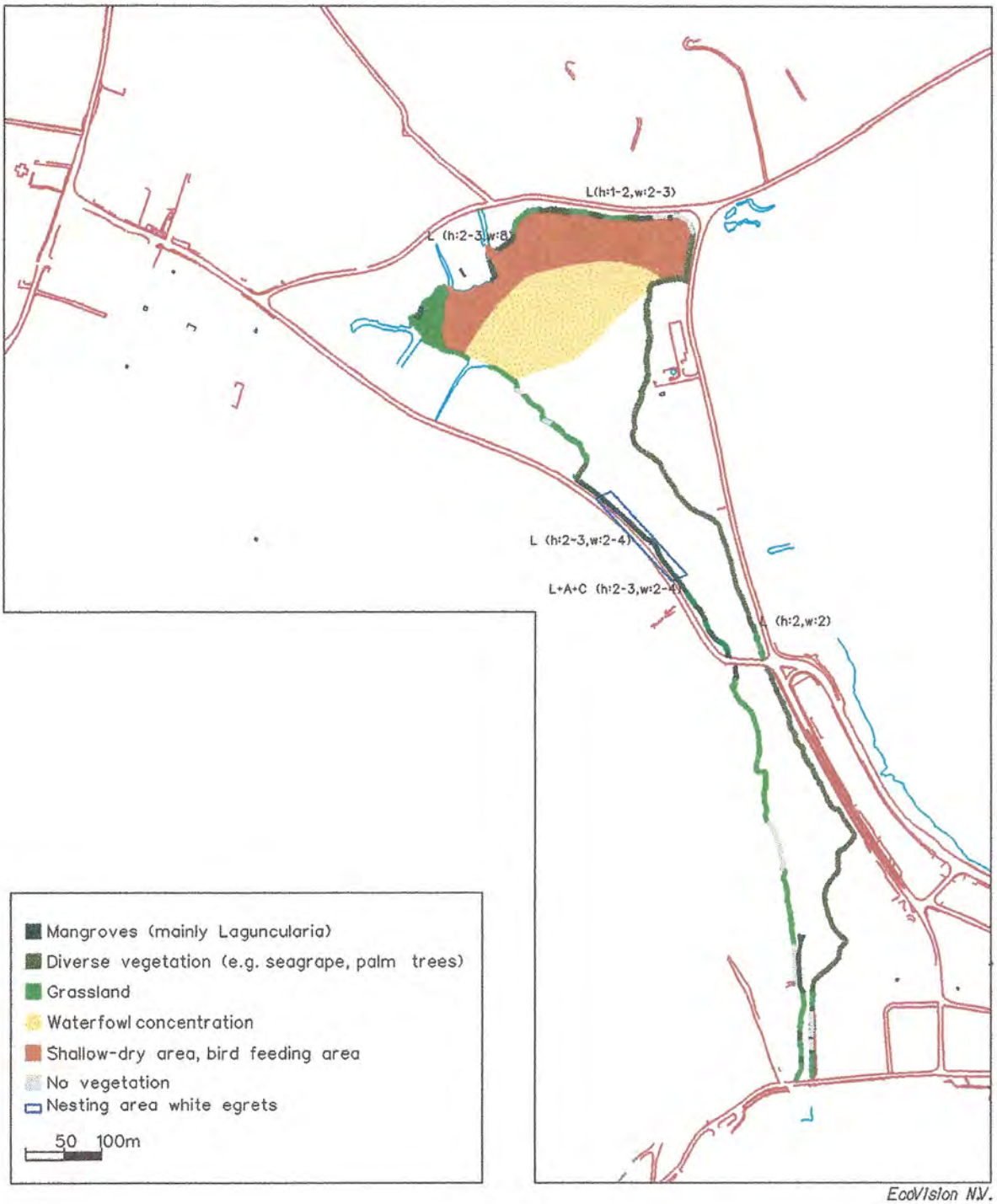
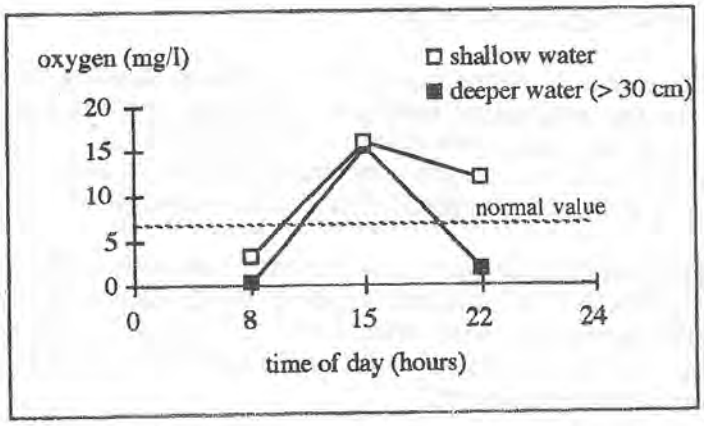


Table 5.1 Quality of water and top sediment Fresh Pond (sampling date 12-4-1995)

Site number	Analysis	Result	Remarks
W 3.1 - 3.2	water temperature	28,0 °C	
W 3.1 - 3.2	water visibility	< 10 cm	green colour
W 3.1 - 3.2	water salinity	1,8 - 1,6 °/oo	low salinity
W 3.1 - 3.2	water oxygen	0,4-16,1 mg/l	highly fluctuating
W 3.1 - 3.2	water phosphate	10-0,9 mg P/l	60 x limit value *
W 3.1 - 3.2	water nitrate	1-2,7 mg NO_3/l	
W 3.1 - 3.2	water total N	7-20 mg/l **	3-9 x limit value
W 3.1 - 3.2	water mineral oil (C_{10}-C_{40})	500-350 ug/l	moderately polluted
B 3.1 - 3.2	sediment mineral oil (C_{10}-C_{40})	89-140 ug/kg	no significant pollution
B 3.1 - 3.2	sediment heavy metals	Appendix 4	high values of copper

*) Limit value for general ecological function of surface waters (The Netherlands): P total: 0,15 mg P/l
**) Data Hygiene/VROM Dept Sint-Maarten in cooperation with VOMIL (februari-march 1995)
Limit value for general ecological function of surface waters (The Netherlands): N total: 2,2 mg N/l

The extremely low visibility and extremely high phosphate concentrations indicate excessive growth of algae. These observations are consistent with the strongly fluctuating oxygen contents of the water (graph 5.1). Oxygen contents in the late afternoon and early evening are high (up to 16 mg/l; normal seawater 6-8 mg/l) indicating oxygen production by algae, whereas they are extremely low in the early morning (0,4 mg/l) indicating oxygen consumption by algae during the night.



Graph 5.1 Oxygen content water Fresh Pond

Eutrophication is probably caused by the direct effluents of residential areas, including shack areas from which untreated water is discharged, the sewage treatment plants and the poor flushing of the pond. This causes accumulation of nutrients, in particular phosphates.
A testing-programme for Fresh Pond, Great Salt Pond, Red Pond and some marine locations during the months of Februari and March 1995 carried out by Hygiene and VROM Department in cooperation with VOMIL, revealed high concentrations of Coliform and fecal coliform bacteria. Despite the fact that at present the pond is not used for water recreation, the high concentrations of Coliform and fecal coliform bacteria may cause a threat to the population (e.g. children playing). The bacterial growth is a serious threat to the hotel area south of the pond in cases of heavy rainfall, when pond water flushes into the sea.

5.2 Present functions

The Fresh Pond is an important green habitat in the midst of an urban area and is important as a feeding and breeding area for waterfowl. Despite these assets, the pond has only a moderate ecological function. The main reason for this is extreme eutrophication of the pond-water. From time to time the water is practically anoxic (see § 5.1). This could be the reason that no other waterlife has been encountered than some fish species, capable of breathing near the surface. The pond has no ecological nursery function because there is no regular water-exchange with the sea and no tidal movement.

The environmental function of the pond is very poor at this moment. Rainfall of apprximately 10 mm or more causes flushing of pond water into the sea[1], causing much inconvenience in the hotel area, in particular at the Great Bay Beach Hotel (information mr. Richardson DOW). Statistically, rainfall of 10 mm a day (or more) occurs 23 times a year[2].

The Fresh Pond has an important aesthetical function. The pond attributes to the landscape of Sint Maarten and attracts many tourists making pictures of the green area and the abundant birdlife.

5.3 Evaluation of conditions for optimal functioning

Conditions for ecological functioning

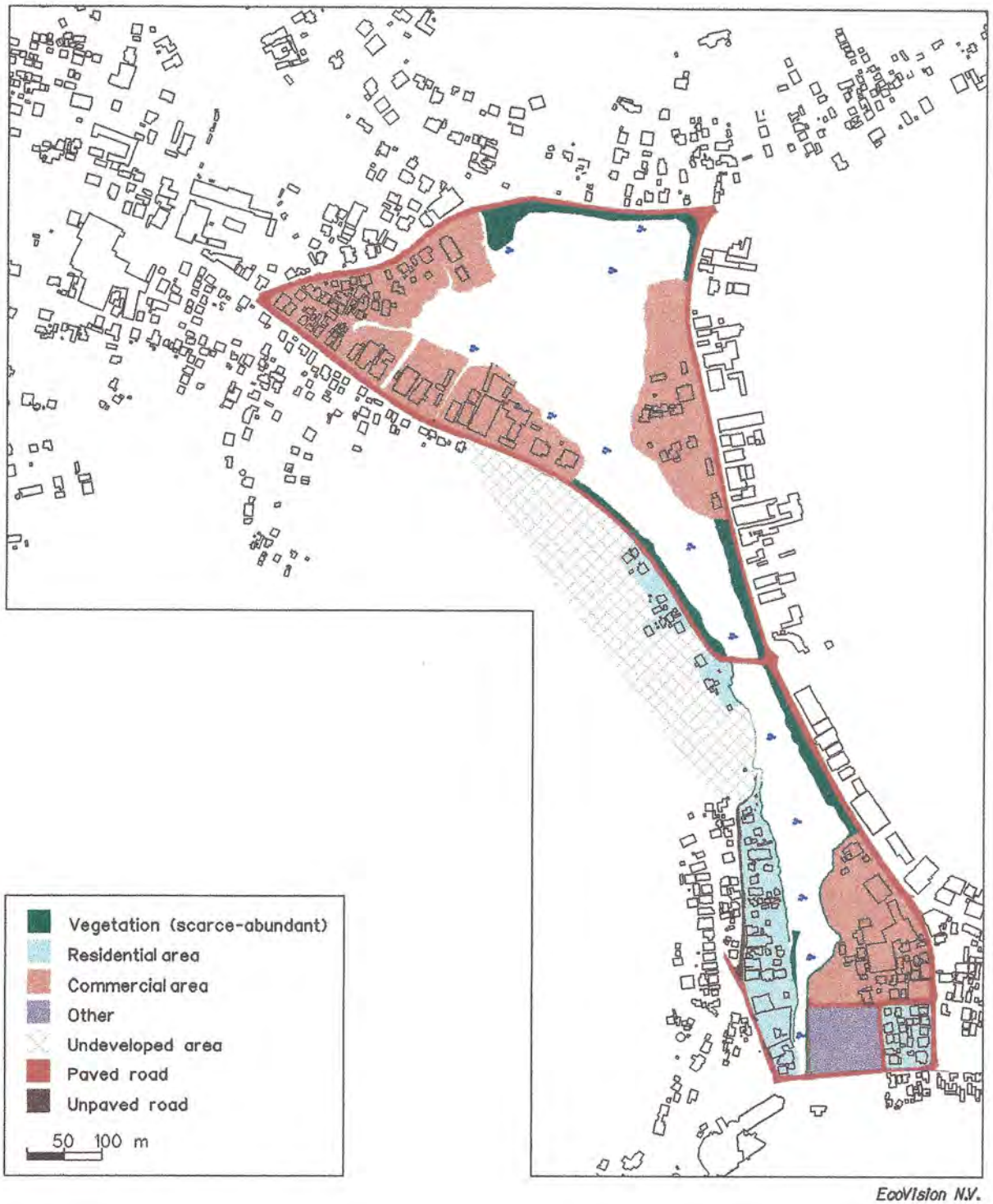
Despite the presence of dense mangrove vegetation in some parts of the pond, important conditions for the ecological function (especially waterquality) are not met. The low flushing rate and the high nutrient load are responsible for the severe eutrophication of the pond. The periodical low oxygen concentrations lead to absence of species and can easily lead to massive dying of fish, shellfish and other water breathing fauna.

It is not considered feasible that improvement of the waterquality to ecological standards is realized in the Fresh Pond, because of the existing effluent situation (2 sewage treatment plants) and the connection with Great Salt Pond during periods of heavy rainfall. Opening of the pond to the sea which is a condition for optimal ecological functioning of the pond is not considered a realistic option.

Other conditions that are not met for optimal ecological functioning are:
- insufficient quietness
- high sediment load due to erosion in watershed area, leading to need for dredging (next section)
- illegal pond filling
- presence of garbage
- oil pollution

1 See also § 5.3 and chapter 6 Great Salt Pond
2 Encyclopedie van de Nederlandse Antillen, 1985

Map 5.2 Fresh Pond
Use of area



Conditions for environmental functioning

The condition of a basic waterquality is certainly not met. The poor waterquality (mainly anoxia) inhibits the activity of organisms which play a role in the cleaning process of the pond. The mangroves play an important role in nutrient-fixing, however their capacity is largely exceeded by the nutrient influx. Waterquality needs serious improvement.

The new roundabout at the crossing of A.T. Illidge Road and Zagersgut Road is constructed in such a way that under circumstances of heavy rainfall water can flow from the Fresh Pond to the Great Salt Pond and vice versa. The first flow of water occurs during the first period of heavy rainfall when the waterlevel of the Fresh Pond rises faster than the level of Great Salt Pond. If rainfall continues, the level in both ponds eventually become the same. When further rise of the waterlevels occurs, the sand ridge separating Fresh Pond from the sea will be opened, resulting in a waterflow from both ponds to the sea. Overflows are reported more than 20 times a year (information mr Richardson DOW). Although the quality of the marine area in Great Bay is affected for a period these discharges do contribute to the reduction of the nutrient accumulation in the Fresh Pond.

Still, the watercontaining capacity of the Fresh Pond is too small to support a sufficient environmental function of the pond, and rapid sedimentation decreases this capacity even further. Dredging of the pond is required. Proposals are made to dredge the northern part of the pond to SMP - 0,50 m[1]. This means that the waterdepth will increase with 30 to 70 cm. A positive side effect of dredging is the removal of contaminated soil and sludge. This improves the waterquality inside the pond. A possibly negative side effect of dredging (see also chapter 8) is the sudden drop in waterlevel, which could lead to desiccation of the mangroves.
Besides dredging will lead to a drop in the flushing frequency, leading to an even more intense nutrient load on the pond. Dredging can only take place after sufficient reduction of the environmental load on the pond.

Conditions for recreational and aesthetic functioning

The presence of the mangrove fringe along the bushroad, including many other, flowering, plants, in combination with the abundant birdlife, provide good aesthetical conditions. Conditions for recreational and aesthetic functions are not optimal however: the water has a bad smell and a bad colour (green). At this moment there is too much garbage to allow recreation near the pond; infrastructure and facilities lack.

Fishery/fishfarming

In earlier days the pond harboured a seemingly large number of fresh water shrimp which were caught by the people for food. Today, conditions for fishery nor for fishfarming are met. The waterquality is too low. The pond has no nursery function since there is no connection with the sea.

1 Globaal afwateringsplan St Maarten NA, Fase 1: Cul de Sac Independent Consulting Engineers 1994

Landfilling

The shallow water in the northern part of the Fresh Pond provides conditions for easy landfilling. However landfilling is highly incompatible with other functions (mainly the environmental and recreational/aesthetic function).

5.4 Potential developments

The pond is a receiving water for effluents. These effluents have to be sufficiently buffered to protect the vulnerable marine area of Philipsburg with its beaches. Possible development directions should take this central environmental function of the pond into consideration.

Sustainable integration of the environmental function and the recreational function is possible, however adequate measures have to be taken. Waterquality should be drastically improved and the containing capacity of the pond system of Fresh Pond and Salt Pond should be increased. The attractivity of the area for the public should be developed by developing mangrove vegetation and creating recreational infrastructure and facilities.
The result of the development direction is an attractively vegetated pond with acceptable (basic) waterquality and sufficient buffering capacity to protect the adjacent marine area. The pond would be accessible to the public. Recreational activities like birdwatching, walking, sports fishing, jogging etc. can take place.

Ecological development in the Fresh Pond can only take place at a sub-optimal level. Complete ecological development would require many far reaching changes and high costs.

5.5 Recommended direction of development

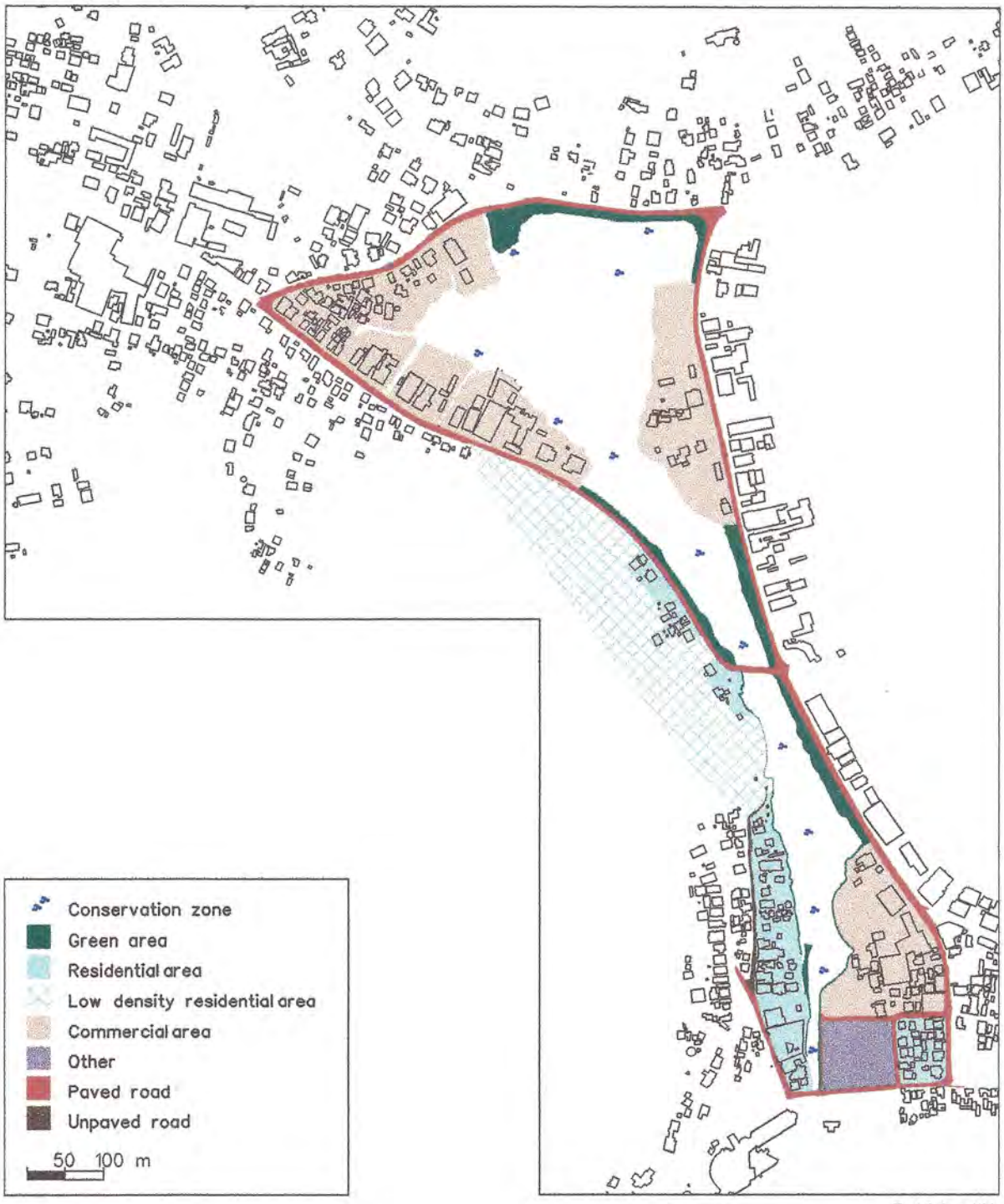
It is recommended to improve environmental and aesthetical qualities and functions of the pond. Emphasis is on optimal environmental functioning and stimulation of activities to support this function. Despite the noisy roads bordering the pond and the allowance of certain effluents, Fresh Pond can provide an aesthetically attractive urban area with dense mangrove stands and an important and interesting bird population. Ecological values are protected within the framework of the chosen function combination (a type 2 approach as described in § 1.5). Ecological functioning however is necessarily sub-optimal.

A proposal for zoning of the Fresh Pond reflects the current situation near the pond (map 5.3). The proposal includes the definition of two zones:

- The area directly surrounding the Fresh Pond is defined as a "utility/private development zone" or urban zone divided in 5 subzones (low and high density residential area, commercial area, green area and other). Within this category urban projects are allowed under sustainable development strategies (if not present). In map 5.3 "green areas" are indicated in which shore vegetation will be conserved, introduced or developed.

- The area in the pond is defined as a "conservation zone" where no developments and filling are allowed. Activity in the pond is only allowed if supporting to the chosen development direction (environmental and aesthetical development)

Map 5.3 Fresh Pond
Zoning proposal



Management concept

Policy and management should be based on a reduction of the environmental load and on stimulation of the attractivity of the area, such as development of vegetation and installing of recreational facilities. Waterquality management by VROM and Hygiene Department should be based on the early establishment of a basic waterquality. Waterquantity management carried out by DOW should be suitable for mangrove development and optimal bufferfunction. These both objectives seem contradictory, so that waterquantity-management should be carried out with great care.

5.6 Proposed actions

Improvement of waterquality

For the watershed area of Fresh Pond the proposed measures involving waterquality (§ 8.3) have high priority, because of the threatening level of eutrophication and bacteriological growth, which is even expected to increase when the watercontaining capacity is increased. Planting of more mangrove along the banks of the Fresh Pond can support this process.

Study on diverging direction fresh water run off

Environmental and hydrological studies are recommended to investigate the feasibility of directing fresh water run off (including treated effluents) directly to the Great Salt Pond. The Great Salt Pond (chapter 6) is significantly less eutrophicated.

Extend mangrove vegetation

The aesthetical value of Fresh Pond should be further enhanced by executing mangrove planting programmes. In recent years DOW Groenvoorzieningen has been carrying out such a programme in the northern section of the pond, on domain land. Especially the northern banks and the west bank south of the bridge provide suitable conditions for mangrove planting (muddy flats). Planting of mangrove should be a part of a programme for improving waterquality.

Oil storage

Observations have been made of oil storage (used oil, waste oil products) in the open air near the pond. This implicates the possibility of run off of contaminated water into the pond. In most cases commercial activities are concerned, which are under the regime of the Nuisance Act. Adequate oil storage has to be given high priority.

Dredging, under strict conditions

The method of dredging of the Fresh Pond should be carefully evaluated. General guidelines for dredging are presented in chapter 8.5. Some specific recommendations about dredging the Fresh Pond are made in this context:

- Before any dredging takes place, the effect of the action on the water-level should be determined and evaluated. Mangrove vegetation has been able to adapt to slowly

changing waterlevels in the course of many years. A sudden change in waterlevels could cause the drying out of the existing mangrove vegetation. In addition the birdlife would be affected.

- Dredging should take place in the middle of the pond to protect the slopes of the mangrove substrates and the shallow feeding areas of the birds. The distance of the dredged area to any shoreline should not be smaller than 15 meters but preferably more in the northern part of the pond (bird feeding area) and the western part of the pond (near the existing mangrove vegetation).

- Although there is no indication of pollution with hazardous matter, this does not mean that elements or compounds that are a threat to the environment are totally unpresent. Therefore, the disposal of the dredged material should be under well controlled conditions.

- Airpumps should be installed to maintain a minimum oxygen level in the pond.

- The temporary containment of sludge has to be restricted to a fixed period of time.

Clean the area

At present, a lot of garbage can be observed in the pond and in between the vegetation surrounding the pond. Removal of this garbage would contribute to the aesthetical value of the Fresh Pond. It is recommended to design a programme in order to keep the area clean (e.g. placing of litterbins and emptying on a regular basis).

Recreational facilities

More facilities for recreational use should be installed, e.g. footpaths, benches, fieldglasses for birdwatching, garbage collectors, information about bird species etc.

Other

Land reclamation must be prohibited for aesthetical reasons and because of water pollution. The lease contracts for residences and commercial activities should be carefully studied and if possible supplied with prescriptions for the use (e.g. revegetating) and prohibitions (landfilling, felling prohibitions).

6 GREAT SALT POND

6.1 Introduction and description

General description

The Great Salt Pond forms a large waterbody just adjacent to the urban centre of Philipsburg. With a water surface of circa 220 ha the Salt Pond is the largest pond on Sint-Maarten. Although the typical colourful scenery[1] related to the salt exploitation in the pond has been lost over the last few decades, many tourists are attracted by the beautiful panoramas of the town and the pond from the hills (see photographs next page).

The Salt Pond has been used for salt exploitation from approximately 1648 until 1939. Since then the remains from this period (Salt factory, the dikes in the pond) have determined the appearance of the pond.
The bottom of the Salt Pond is approximately 1 to 1,5 m lower than the mean sea level (SMP). The waterlevel in the pond is also significantly lower than sealevel. This causes a strong underground seepage of salt water from the sea (app. 80.000 m^3 a year) into the pond. See also fig 2.2 (lower). By using pumping systems for inlet of seawater in the dry season, and outlet of pond water mostly before the wet season begins, the waterbalance in the pond can be controlled.
The natural and mechanical seawater influx combined with an average evaporation of approximately 6 mm a day, is responsible for the high salinity of the water in the pond.

The Great Salt Pond is property of the Authority of the Netherlands Antilles. Most of the land surrounding the pond is Island property (see map 2.4) in lease for residential and commercial purposes. Landfilling takes place on a large scale, especially in the northern and eastern sections of the pond. In most cases the developments are unplanned and show little coherence. In the late seventies a large area in the middle of Salt Pond was reclaimed for recreational purposes (Carnival City). In the decades thereafter other types of use have been introduced in the area: commercial activities and landfill.

Ecological description

Starting from the crossing of Walter Nisbeth Road and W.G. Boncamper Road (near Vineyard building) large numbers of flies were observed in the pond (*Ephydra cinerea*, app. 1 cm large). The larvae and pupae of these flies were observed in high abundance as well. The presence of large numbers of these larvae could be partially responsible for the relatively low density of algae in the pond.

From the corner in northern direction along the W.G. Boncamper Road a thin fringe of vegetation is present, interrupted here and there. The vegetation consists of: Beach Morning Glory, in many places blossoming, Sea Purslane, Saltwort and small Acacia trees.

In the northeast section of the pond, between a residential area and a reclaimed area, a swamplike grass vegetation (Seashore rushgrass) has developed parallel to the pond (photograph 3 next page and map 6.1). The water in this part of the area originates from residences in the surrounding area and is probably fresh/brackish. Many snowy egrets and

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1 The bassins in which different stages of brine were present, showed many shades of pink and purple. The red flamingo was an occasional visitor in the pond, as reported in 1932 by Kruythoff

(less abundant) cattle egrets have been observed. Also, a yellow-crowned night-heron was observed.

In the north section near the zoo and the northwestern section a poor and interrupted vegetation, mainly consisting of Acacia is present.

Along the Walter Nisbeth Road the vegetation is more abundant and consists of: Sea Purslane, Beach Morning Glory, some Acacia and Seagrape, palmtrees and several grasses. A lot of garbage was found in this section of the pond, presumably blown from the landfill.

Mangrove vegetation was not encountered during the field trip along the pond. If ever existent, mangrove vegetation would probably have been removed during the 3 ages of salt exploitation, because tall vegetation was known to reduce evaporation significantly[1].

Many birds were observed in the pond, using the dikes as a resting place: black winged avocet, laughing gulls (abundant in the section near the landfill), greater en lesser yellowlegs/sandpipers, semi-palmated sandpipers and egrets. Pelicans were not observed.

Quality of the environment

The watershed-area of the Great Salt Pond has a surface of approximately 500 ha. (see map 2.3). Rainwater is collected in several watercourses running down the surrounding hills into the pond. Black water (overflow of septic tanks) and grey water (from kitchens and showers) are added to this waterflow. Part of the runoff water is drained by the Rolandus Channel.

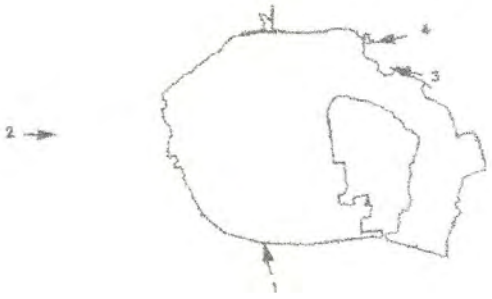
The effluent of two sewage treatment plants is discharged into the pond. The public Philipsburg Sewage Treatment Plant (PSTP) is provided with sewage from the eastern part of Philipsburg and part of the Pondfill. The (private) sewage treatment plant at Madame Estate treats sewage from the shopping centre at Madame Estate along with sewage from a nearby housing project. The sewage treatment plant was not designed for the latter and the overload of influent is responsible for the poor functioning of the plant.
The functioning of PSTP is frequently insufficient because the sewage treatment plant has no back up generator in case of electrical blackouts (see § 2.4). In many cases untreated effluents from residences enter the pond. Especially when the waterlevel in the pond is high (2-3 feet) leakage from soakaways will take place. Many septic tanks and holding tanks are not properly used and are even damaged in such a way that the sewage flushes into the pond (information Hygiene Dept).
Of the non point sources, the landfill in the middle of the pond and the associated activities are the most important ones. The lack of preventive measures such as control of the dump and hydrological isolation of the dump poses a big threat on the quality of the pond. The hydrological situation of the pond in particular the strong seepage of seawater (upward waterflow) may prevent the pollution spreading in vertical direction to deeper layers (compare fig. 2.2 lower).

During the fieldtrips to the Great Salt Pond frequent observations were made of the direct discharge of septic tank water into the pond (trucks).

1 "Het zoutbedrijf op St-Martin", Langemeyer, rond 1920.

Great Salt Pond

1. panoramic view



2. Aerial picture, showing the Landfill, Philipsburg, Great Bay and part of the Fresh Pond.

3. On the east side, a brackish waterbody between filled areas is almost overgrown with saltwort, and forms a habitat for (mainly) snowy egret.

4. After restoration, the ruins of the salt factory could form an educational, historic site for both tourists and islanders.

Monitoring of the pond during the period February-March[1] 1995 revealed high concentrations of nutrients (phosphates, nitrate and ammonium), however not as high as in the Fresh Pond. Oxygen concentrations were found to fluctuate less, indicating less activity of algae. This is in accordance with the clarity of the water of the Salt Pond compared to that of the Fresh Pond (photograph 2 Fresh Pond).

In a survey conducted by CEC and Witteveen & Bos the environmental quality has been studied with regard to pollutants related to the dump. The results of this study indicate a moderate pollution of water with copper and a moderate pollution of groundwater with copper, zinc and oil. Concluded is that the pollution related to the dump poses no severe threat or risk to the environment and does not lead to the direct necessity of sanitation (removal) of the underground.
Copper is found in elevated concentrations in Little Bay Pond and Fresh Pond as well and may be related to a high natural background value.

6.2 Present functions

The environmental (self cleaning) function of the pond and the protection of the marine area of Great Bay is important but not optimal. The effects of the outlet in the northeastern section of Great Bay (via Channel of Rolandus) are clearly visible[2]. In addition, heavy rainfall leads to frequent overflows of the connected pond systems of Fresh Pond and Salt Pond (see chapter 5), which causes problems in the hotel area of Philipsburg.

The pond is used on a large scale for land reclaiming (carrier function). This is in particular the case in the northern and the eastern parts of the pond.

The Great Salt Pond does not have an important ecological function. Vegetation is not abundant at all. However, some locations of the pond seem to serve as foraging grounds for considerable numbers of waterfowl.

The recreational function can be considered as being moderate. Although the pond lost much of its beauty mainly because of unplanned development (a.o. the pondfill), still many tourists are attracted. The pond provides beautiful panoramas of the town from many places along the banks and from the surrounding hills. Parts of the area around the pond are used for jogging. At the pondfill, Carnival City serves recreational purposes. Furthermore, a sports ground is located on the pondfill. In the northern part of the area there is the St. Maarten Zoo.

The Great Salt Pond has no fishery or fish farming function.

6.3 Evaluation of conditions for optimal functioning

Conditions for ecological function

Currently, the conditions for a healthy ecosystem are extremely poor. Important conditions are not met. Vegetation is scarce, although some palmtrees were planted. Mangrove

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1 Testing programme carried out by Hygiene and VROM Department in cooperation with VOMIL, Februari and March 1995

2 The marine environment of St-Maarten", AIDEnvironment/EcoVision, 1995

vegetation is absent. The water quality is poor and needs improvement. Essential conditions for full ecological development, such as tidal movement (opening to the sea), quietness, high waterquality, cannot be reached without tremendous costs and effort. Effluents and percolate water have to be reduced to zero. This is not considered a realistic option in Great Salt Pond.

Ecological upgrading however can be reached with relatively little effort. At the north side of the pond near the Zoo several undeveloped and quiet areas exist where conditions are considered to be sufficient for ecological upgrading. At several locations in the north and northeast shallow water areas exist suitable for the planting of mangroves. The high salinity of Salt Pond may lead to smaller forms of mangroves. In muddy areas with fresh water influx, larger individuals may be expected.

Conditions for environmental function

The Great Salt Pond suffers from a high environmental load from several point- and non-point sources. This environmental load does not lead to a waterquality limiting biological (self cleaning) processes. The quality of water and ground water does not lead to widespread anoxia like in the Fresh Pond and is (still) sufficient to allow activity of bottom life.

Active outlet of water to the sea is restricted to a period of the year (before the wet season) and in cases of heavy rainfall.

In cases of heavy rainfall (more than 10 mm) levels of the Fresh Pond and the Great Salt Pond become the same when the waterbodies are connected at the roundabout at the crossing of A.T. Illidge Road and Zagersgut Road. The containing capacity of the pond system of Fresh Pond and Salt Pond is limited as described in chapter 5. Overflows occur more than 20 times a year. When levels in Great Salt Pond are still rising, water is pumped out to the Rolandus Channel.

To improve its environmental function, the water containing capacity of the pond should be increased. The ongoing process of land filling is not compatible with this approach, because of the reduction of the watercontaining capacity. Whether the increase can be reached by dredging is uncertain, because of the underground seepage of seawater into the pond (the pond bottom is below sea level, see fig. 2.2 lower). Further study is necessary. Furthermore the planting of higher vegetation especially mangroves could contribute to the self cleaning capacity of the pond.

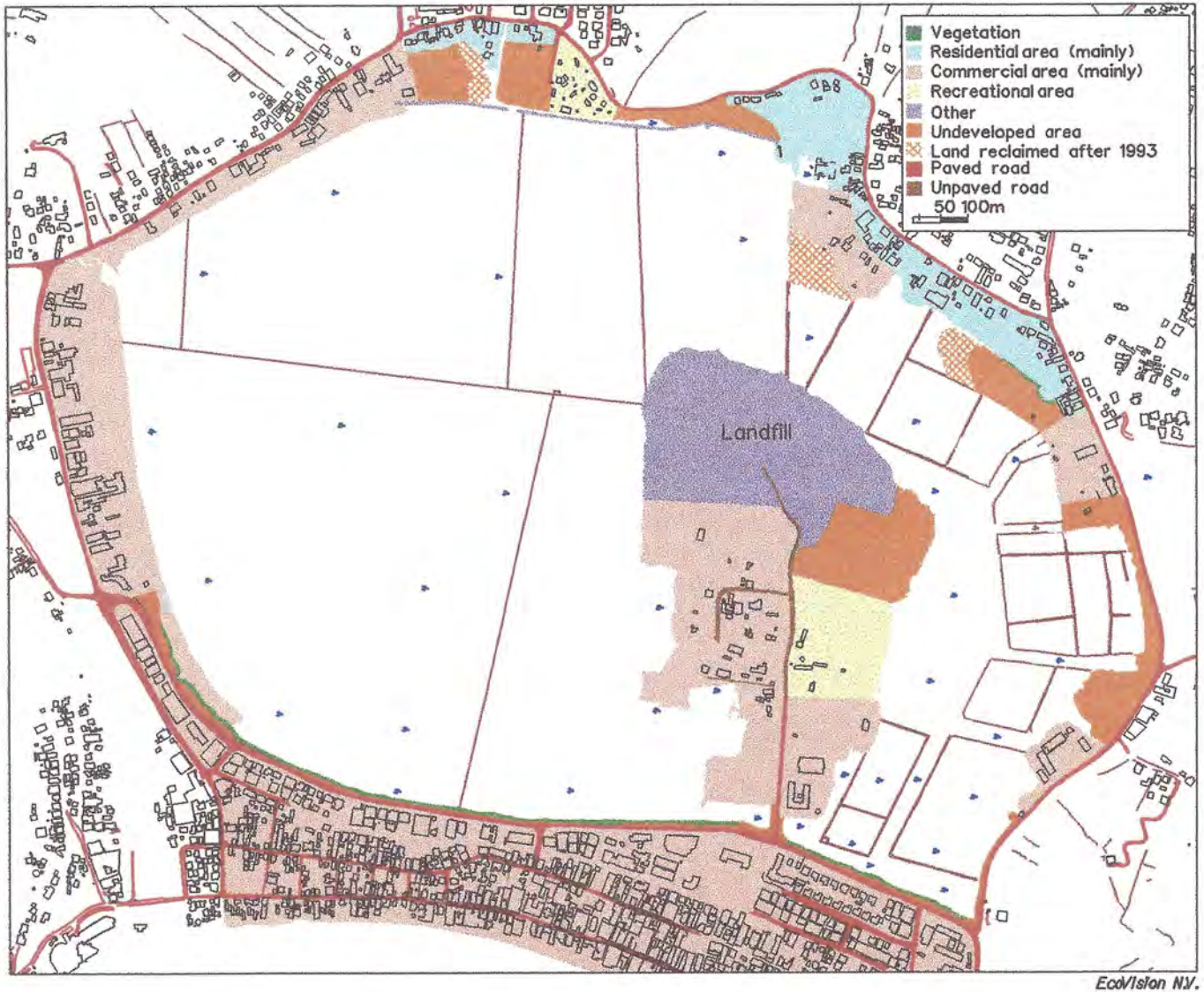
Conditions for recreational function

The conditions for a recreational function are not met. The landscape per se, the watersurface and the hills surrounding, provide an interesting panoramic view, but at a closer look, this picture is seriously affected by the lack of vegetation, the garbage everywhere and last but certainly not least: the bad smell coming from the pond.

The conditions for recreational activities need improvement. The smell from the landfill should be minimized by covering the landfill daily and properly. The banks of the pond have to be cleaned and revegetated.

Apart from the current locations at the pondfill, there is not much space for developing recreation. Like for ecological development, the area close to the Zoo may provide good conditions for recreation. In this area good opportunities exist for restoration of mangroves,

Map 6.1 Great Salt Pond
Use of area



accomodation of birdlife small dikes and pickets in the water) and the establishment of different types of facilities (footpaths, fieldglasses, terrasses, information centre etc.). The location is windward of the landfill, so that hindrance from the smell of the landfill is reduced.

The location offers sufficient possibilities to combine recreational facilities; acces to the zoo and to the Salt Factory can be easily created. The Salt Factory should be renovated for the purpose of the establishment of a recreational centre.

Conditions for fishery/fish farming

Conditions for fish farming are very poor, considering the basic waterquality. No fish (adult nor juvenile) were encountered during the field trip. The pond does not contribute to sea-fisheries as a nursery area, because no permanent opening to the sea exists. A permanent opening to the sea can not be established because of the importance of a high waterquality in Great Bay for beach tourism.

Conditions for landfilling

Conditions for landreclamation are good. The pond is not deeper than app. 1 meter. Stimulating this function will lead to serious deterioration of other functions. Compensation for these functions is possible because of the large size of the pond, which also makes separation of functions possible.

6.4 Potential developments

Combined environmental and recreational development

Sint-Maarten depends on the Great Salt Pond as a receiving water for effluents and will also in the future. The Western part of Philipsburg will be connected to the PSTP within a few years. The environmental waterquality in Great Bay however has to be at least maintained. This means that the quality of the effluents has to be improved and that the self cleaning capacity of the pond has to be improved. The self cleaning capacity can be improved by mangrove planting and increasing the water containing capacity. Whether this increase can be reached by dredging is uncertain, because of the underground influx of seawater.

The Great Salt Pond has no potential for realization of a high level ecological function. However, ecological upgrading to a certain level is compatible with the environmental function of the pond: planting of mangroves on the banks on a large scale contributes significantly to this function. In upgrading of the area from an aesthetical point of view special attention should be paid to the development of vegetation on the Pondfill banks.
In the northern part, ecological and recreational development can be integrated. The area near the zoo, where a small waterbody is present behind the dike, provides a good opportunity for replanting shore vegetation. Part of this area can be designated for the establishment of a recreational park where the public can go for sports and/or leisure. Furthermore, this area has potential for educational activities by restoring the salt factory and turn it into a museum. For this purpose, some of the dikes could be preserved.

The result of the development direction described here, is a more attractive, more quiet pond with a much much greener appearance than today. Watching from anywhere from the

banks, human activities and traffic are less apparent behind the green vegetation. The pond can sufficiently buffer the environmental load and will contribute to an acceptable waterquality in Great Bay. A recreational area will provide quietness and attractions worth while visiting.

Land reclaiming and combined functions

Plans have been suggested for the construction several new roads in the pond (see map 6.2)[1] and for more land reclamation in the east section of the pond.
At the moment major housing programmes are planned in undisturbed hills, while possibilities still exist in the valleys (Cul de Sac) and for instance the Great Salt Pond[2]. Developing parts of the Great Salt Pond might conflict with the idea of preserving certain historical and aesthetical values but ecological values would not be damaged irreversibly.

Landreclaiming is considered a possible development direction if sustainable integration with other important functions, such as the environmental and recreational function is possible.
Because of the large pond surface the function-loss related to landreclaiming in the Great Salt Pond can be compensated in principle. Recreational development can take place in a different area of the pond. Filling of parts of the pond however has a negative impact on the main environmental function. The water containing capacity will decrease and the effects of effluents on the waterquality (smaller waterbody) will become more apparent. For these effects good compensation has to be provided: a further reduction of effluents and/or increase of the watercontaining capacity in other parts of the pond.

The result of the development direction described, is a pond separated in a (large) western part and a small (eastern) part. The water in the eastern part tends to be slightly more eutrophicated than the water in the western part, despite a reduction of effluents. This is because of the smaller size and limited circulation.
The eastern part will have an urban character with green areas and bordered by a mangrove fringe on the pond side. The western part of the pond will be an aesthetically attractive part bordered by green mangroves, significantly less unorganized than today. The road with the vegetated roadsides marks the border of land and water, beyond which no filling or dumping is allowed. The pond can sufficiently buffer the environmental load and will contribute to an acceptable waterquality in Great Bay. The northern part of the pond is accessible for recreational and educational purposes; the construction of the proposed perimeter road in this part of the pond is considered to be incompatible in this development proposal.

6.5 Recommended direction of development

The recommended direction of development is combining the (main) environmental function with recreational development. Within the framework of this development, ecological values are also improved (type 2 approach,
§ 1.5). Landreclamation is suggested on a limited scale in the eastern part of the pond. The construction of the perimeter road is compatible with the approach except for the northern part of the road.

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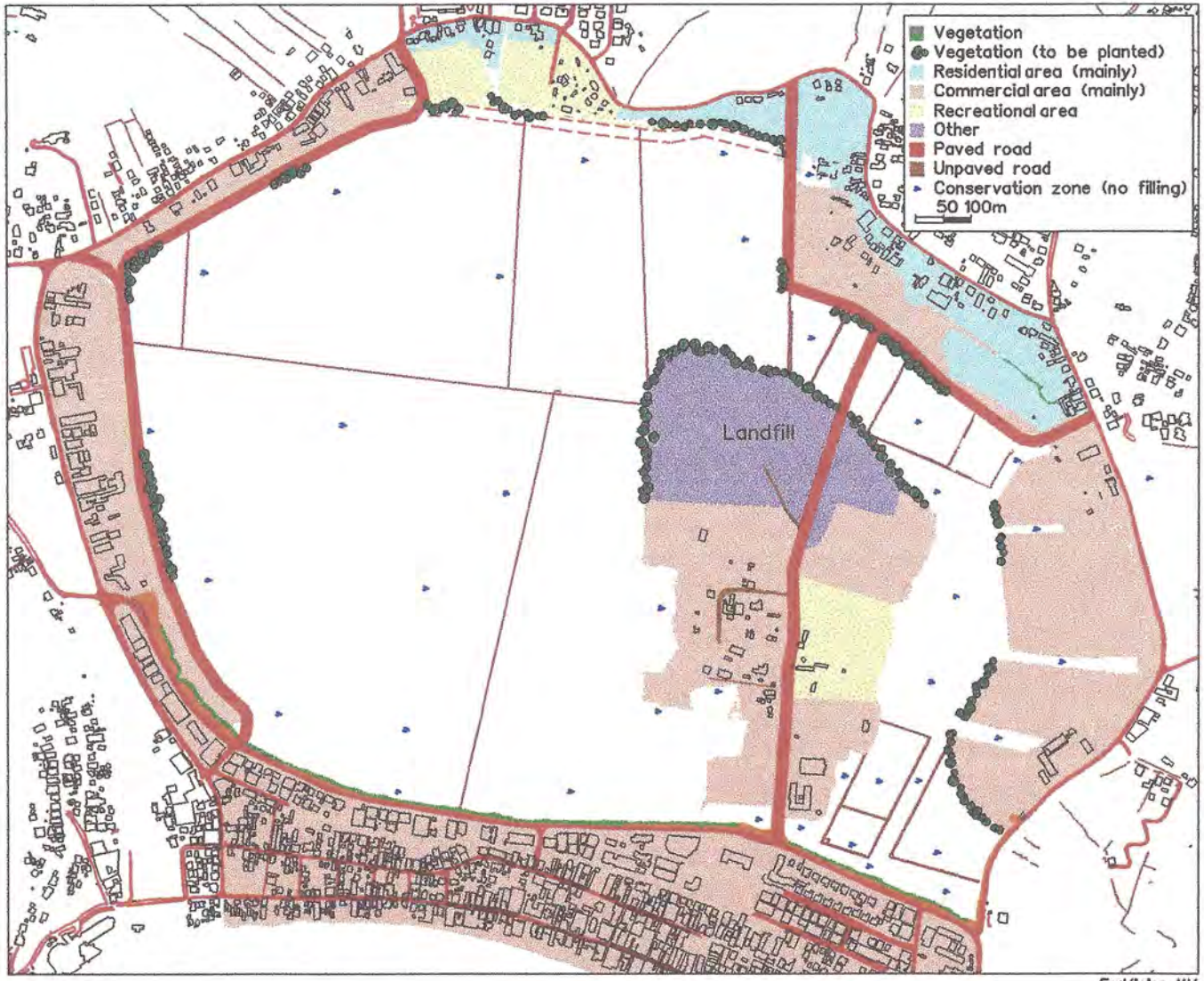
1 Comprehensive road network plan Sint Maarten

2 Zoning plan for the Hillside area Sint Maarten, EcoVision/AIDEnvironment, in press

Map 6.2 Great Salt Pond
Zoning proposal



In map 6.2 a proposal for the physical planning of the pond is given. In this map the priority connections of the Comprehensive Road Network Plan are indicated, except for the northern perimeter road. Newly vegetated banks are indicated.

- The area directly surrounding the Great Salt Pond is defined as an urban zone divided into 4 subzones (residential area, commercial area, recreational area and other). Within this category urban projects are allowed to be implemented (if not present) under sustainable development strategies. Large projects have to be subject to environmental impact assessment.

- For the area in the pond two zones are defined: a "no development zone" and an urban zone (the eastern part of the pond).

Management concept

Management by VROM and Hygiene Department includes establishment and maintainance of a basic waterquality. Management of waterquantity by DOW should be focussed on limited exchange of pond-seawater (bufferfunction) and on waterlevels suitable for initial mangrove restoration. Management of recreational activities can be carried out by private enterprises under government control. Initiatives can be largely self supporting (terrasses, shops, museum, educational projects etc).

6.6 Proposed actions

Environmental impact assessment land reclaiming

The effects of the landfilling process in the eastern part of the pond have to be studied in relation to the necessary water containing capacity of the pond. Possible compensating measures have to be studied as well as their effects.
Strict guidelines for landreclamation should be drawn. For example, the filling material should be selected carefully. No potentially contaminated materials should be used.

Optimizing dump

The dump in the Salt Pond causes a lot of hindrance, namely smell and litter. Solutions should be found on a short term. These include a.o.:
- better coverage of the waste;
- no more emptying of tank cars for septic tank water;
- no more dumping of hazardous wastes.

The long term effects of percolation water should be studied. Especially in relation to land reclamation in the eastern section and the subsequent decrease of the water body and decreased circulation in that part.

The banks of the Pondfill should be vegetated for aesthetical reasons.

Improve waterquality

The proposed measures involving waterquality (§ 8.3) have high priority in the direct area and watershed area of the Great Salt Pond. The functioning of the sewage treatmant plants of Philipsburg (PSTP) and Madame Estate should be optimized. Besides continuity and

quality improvement this includes monitoring of the effluents on relevant parameters (COD, BOD, total N, ammonium, nitrate phosphate and micro-organisms. Possibilities of recycling of effluents should be studied carefully.
Future residences and commercial activities should meet high environmental standards. In newly created urban areas, at least connection to the PSTP has to be realized.
An action plan should be drafted to identify situations of malfunctioning septic tanks and soakaways.

Aesthetical (and ecological) upgrading

Design programmes for planting of higher vegetation/mangroves, including priority locations, necessary improvements of habitat, choice of resource of seedlings, time schedule and costs. Design a programme for collecting and removing garbage (placing of litterbins and emptying regularly).

Establish a recreational park in the norther part of the pond

The northern section of the pond can be developed as a recreational park. This park can be connected to the zoo and to the ruins of the Salt Factory which should be conserved and protected as a historical monument. The connection between the park and the Salt Factory is provided by an old dike. It is suggested that this dike be restored and provided with a new foot bridge to complete the route. Fieldglasses can be placed for watching birds on the small dams and dikes in the pond. Installing a fountain in the pond near the park would be an attractive option and would have a positive effect on the oxygen content of the water.

Vegetating the park

Besides mangroves (e.g. Laguncularia) other shore vegetation, especially blossoming vegetation could be an asset for the park. It is important to choose salt-tolerant plants. In addition to developing an attractive seashore landscape, planting salt-tolerant species allows the use of brackish water for irrigation. Besides brackish water from waterbodies near the pond, effluents of the Madame Estate sewage treatment plant could be used for irrigation of the vegetation. When using fresh water or treated sewage effluent for irrigation, it is important to realize that seashore plants do poorly with excess water or fertilizer.

Examples of suitable plants that could be used for the vegetation of the park are[1]:

- Coconut palm *Cocos nucifera*;
- Australian beefwood *Casuarina equisetifolia*;
- Seagrape *Coccoloba uvifera*;
- Pride of Barbados *Caesalpinia pulcherrima*;
- Leatherleaf *Stigmaphyllon periplicifolium*;
- Gumbo-limbo *Bursera simaruba*;
- Mexican creeper *Antigonon leptopus*;

1 Seashore Plants of South Florida and the Caribbean, 1994. In appendix 5 a detailed list of species, which find their habitats in or near ponds, is given.

7 RED POND

7.1 Introduction and description

General description

The Red Pond is a small pond with a watersurface of approximately 1 ha. Formerly the pond was connected to the sea through a narrow channel which is still partly existent. The pond is separated from the sea by a sandy beach of app. 20 m width. The area in which the pond is located is relatively undisturbed (see map 7.1). From the hills, the pond and the adjacent sea provide a beautiful panorama (see photograph 2 and 3 next page).
The pond's name is derived from the fact that the salty water content is subject to reddish colour fluctuations, caused by microscopic organisms which only flourish in water with a high salt content.

The Red Pond and the territory near the Red Pond are property of Red Pond Estate N.V. At present only few houses are built in the area directly surrounding the pond (see map 7.1).

Ecological description

The Red Pond is surrounded by mangroves and other vegetation. Remarkable is the occurrence of three species of mangrove. Most of them show severe signals of desiccation and have a lot of withered branches and leaves. Dwarf stands of mangroves can be found on the west and south side of the pond, mainly black and white mangroves and buttonwood with a bottom vegetation of sea purslane and saltwort. On the bare sites there is a cacteous vegetation (*Melocactus*). Sea grapes are found behind the mangrove stand on the southside. The substrate here consists of coral debris.

Near the natural channel to sea, the black mangrove reaches a height of up to 5 m. On the eastside of the pond, the mangrove stand is dominated by the white mangrove. North of the channel, the area gradually becomes a stand with a mix of black and white mangroves which eventually becomes dominated by the black mangrove on the northeastern tip of the pond. The substrate is muddy and the height of the trees reaches up to 6-8 m. The north side shows a vegetation of black and white mangroves and buttonwood with an average height between 3-5 m.

The mangroves directly along the channel which contains water show alomst no signs of desiccation.

The absence, or presumably *disappearance*, of the red mangrove, which is a pioneer vegetation, is most likely caused by the dry conditions in the pond. Remarkably, very few flowers and fruits are reported among the mangrove trees. The shallow pond provides an excellent feeding area for sandpipers, dowitchers and avocets. Many singing birds can be observed in the trees surrounding the pond. In the mangrove zone a lot of fiddler crabs, spiders, dragon flies and lizards are observed.

Environmental quality

The pond is very shallow and some locations in the middle are permanently exposed during the dry season. The gradual closing and strengthening of the barrier beach has an

impact both on the flushing of the lagoon and salinity. At the time of sampling (11-4-1995) salinity was high (72,5 ‰) due to evaporation.
Flushing of the pond incidentally takes place by sea wave action but rainfall is considered the most important flushing factor. Rainfall immediately leads to a significant rise in waterlevels in the pond. The Red Pond receives fresh water runoff from the adjacent hills in an area of approximately 55 ha (see map 2.3). From this area no flows of waste water into the pond were observed. Relatively high phosphate and total nitrogen (N) values may have been the result of evaporation of the water content of the pond.
A number of unpaved roads leave heavy scars on the hillsides near the pond, which causes significant erosion and sedimentation in the pond.

Analysis of the water and top-sediments of the pond has been carried out for a number of parameters (table 7.1). No significant elevation of the concentrations of oil and heavy metals could be detected.

Table 7.1 Quality of water and top sediment of Red Pond (sampling date 11-4-1995)

Site number	Analysis	Result	Remarks
W 1.1.	water temperature	27 °C	
W 1.1	water visibility	< 10 cm	probably due to rainfall
W 1.1	water salinity	72,5 ‰	high salinity (evapor.)
W 1.1	water oxygen	4.2 mg/l	subnormal value oxygen
W 1.1	water phosphate	0,28 mg P/l	2 x "grenswaarde"
W 1.1	water nitrate	0,1 mg NO_3/l	
W 1.1	water total N	6-28 mg N/l **	fluctuating (evapor.)
W 1.1	water mineral oil (C_{10}-C_{40})	550 ug/l	light pollution
B 1.1	sediment mineral oil (C_{10}-C_{40})	14 ug/kg d.w.	no pollution
B 1.1	sediment heavy metals	Appendix 4	no pollution

*) Limit value for general ecological function of surface waters (The Netherlands): P total: 0,15 mg P/l
**) Data Hygiene/VROM Dept Sint-Maarten in cooperation with VOMIL (februari-march 1995)
Limit value for general ecological function of surface waters (The Netherlands): N total: 2,2 mg N/l

7.2 Present functions

Red Pond is still a natural area where not much human disturbance (except for some garbage) occurs. The pond provides a breeding and feeding habitat for a significant local bird population and for migratory species. The banks are extensively vegetated with mangrove, which however desiccated, largely determine the appearance of the pond.
The ecological function is the most pronounced function of the pond.

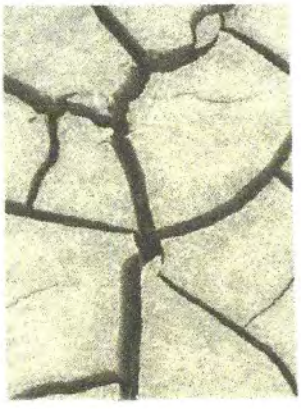
The pond has no permanent connection to the sea. A sand wall with a height of app. 1 meter above the pond bottom separates the pond from the sea. It was not observed that the pond water reaches the level of the top of the sand wall. It is assumed that this only happens during longer periods of rainfall. The marine nature area of Gibbs Bay adjacent to the pond[1], is protected by the environmental function of the pond, which is considered an important function.

1 Gibbs Bay is located in an "ecosystem protection zone": The Marine Environment of Sint-Maarten, AIDEnvironment/EcoVision, 1995.

Red Pond

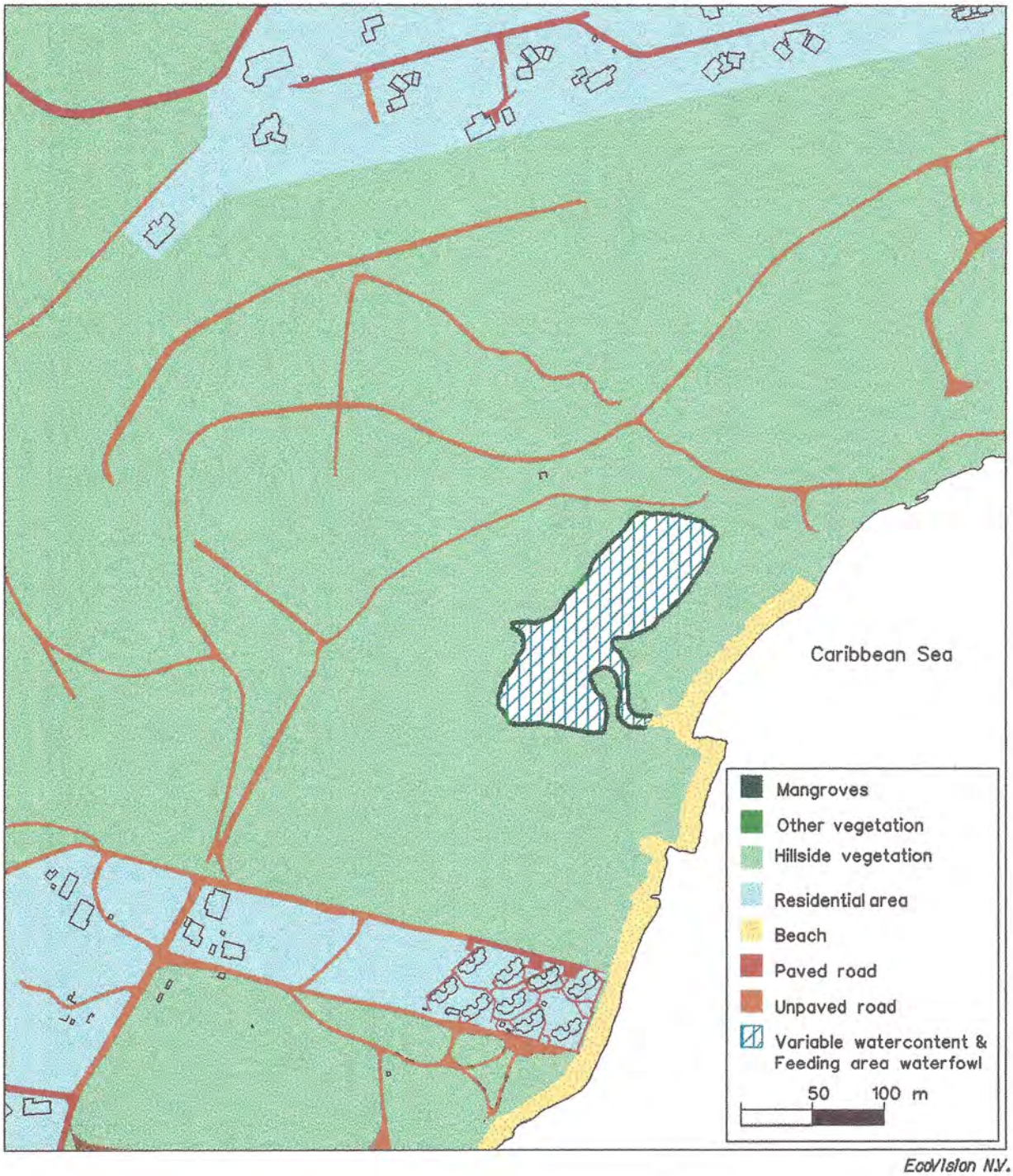
1. panoramic view

2. The picture was taken from the hillside north of the Red Pond. The hillsides are mostly covered with vegetation. However, some sandy roads intersect the area. Several houses are scattered on the hillsides.



3. The picture shows the Red Pond from the north side. The watercontent is dependent on the rainfall. When no rain falls for an extended period, the pond dries up.

Map 7.1 Red Pond
Flora and fauna and use of area



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The Red Pond is an essential and aesthetically exemplary aspect of the landscape. However, the pond only has a modest recreational function. Other than people living in the surrounding area going for a walk around the pond, no recreational activities take place.

No other human supporting functions are present: The Red Pond has no significance at all for fishery (no nursery function) or fish-farming. The abundant crabs are too small for harvesting. The pond is not used for landreclaiming.

7.3 Evaluation of conditions for optimal functioning

Conditions for ecological function

At present, the Red Pond is still a quiet pond, which is one of the reasons for the pond harbouring an abundant birdlife. The pond is gradually drying up because there is no permanent connection with the sea. This land-forming process is a natural process. Eventually, the mangrove vegetation will disappear. Thus, conditions are not met to maintain the *current* habitat for mangroves and associated flora and fauna. Re-opening the pond to the sea would restore conditions for a healthy mangrove vegetation. In addition the nursery function for reef organisms would be restored. For re-opening dredging would be required in parts of the pond.

To fully restore the ecological function of the pond, additional planting of mangrove is essential. The red mangrove with its aerial roots descending from the water surface to the bottom, provides a habitat for many filter feeders and juvenile fish. This mangrove species plays an important role in sediment trapping as well.

High waterquality is a strict condition for optimal ecological functioning and for the possibility of re-opening the pond to the sea. The area is a natural area, effluents are absent. Seemingly high nutrient concentrations are ascribed to the process of evaporation. The current waterquality is sufficient for ecological functioning and for opening to the sea. Opening to the sea would further improve waterquality within the pond.
An important condition to the opening of the pond is that the waterquality be maintained high high. Future developments in the area should meet strict standards concerning polluting activities (household effluents, pesticides etc).

For optimal ecological functioning sediment load has to be reduced significantly. Otherwise frequent dredging might be required, which will drastically disturb the ecosystem.

Conditions for environmental function

The marine area adjacent to the pond (Gibbs Bay) is a very important natural area, indicating the importance of the environmental function of the pond. Conditions for optimal environmental functioning of the pond are largely met. The exchange of pond and sea water is restricted, contributing to the buffering of the sediment load. This sediment load however is responsible for the reduction of the water containing capacity and the self cleaning capacity of the pond.

If re-opened to the sea, the environmental (self cleaning) function should be enhanced by a restricted exchange (narrow opening) and by the self cleaning capacity of a health mangrove vegetation. Exchange of pond and seawater can be allowed only when a reduction of environmental load (sedimentation) takes place. In general it can be stated that

when conditions are met for a high level of ecological functioning, conditions for environmental functioning are also met.

Conditions for recreation

Surrounded by hills and situated behind a nice white sandy beach, the Red Pond provides an excellent opportunity for eco-tourism (bird watching, nature photography), botanical studies etc. Moreover, the many living corals and the patch reefs in front of this beach (in Gibb's Bay) make the area very attractive for snorkelling and diving.
Water-recreation in the pond is not considered suitable, because of the shallowness and the small size of the pond. The pond could be used for more intensive recreation types (part of a golf course) but ecological values would severely suffer from these activities because of the expected disturbance.

Conditions for fisheries/fishfarming

The Red Pond provides no conditions to support fisheries. Because of the separation of the pond to the sea, the pond has no nursery function. This function could be restored by opening the pond to the sea, however, because of the small size of the pond, the positive effect on fisheries would be limited.
The pond is not suitable for fishfarming mainly because of the small size of the pond.

Conditions for landreclaiming

The desiccation of the Red Pond makes it physically suitable for landreclaiming. However, considering the current ecological function, landreclaiming is not a desired development.

7.4 Potential developments

Integration of ecological and recreational development

The area can be exemplary for the sustainable integration of ecological and low-intensity recreational development, and could function as a visiting site for educational projects.

A bufferzone is necessary to protect the pond from external activities and to accomodate tourists. The result of this development direction will be a 8 ha large natural area in which a natural vegetation exists. Because of the more permanent water content of the pond (re-opening), the vegetation (especially the mangrove) is much greener than it is at the moment. The nursery function of the pond will contribute to the attractivity of the snorkeling area in the bay.

In the bufferzone a natural zoning of mangrove species, lowland species and upland species could be established. If no other developments take place, the valley of the pond will remain green providing beautiful sceneries from the adjacent hills.

Recreational development and residential projects

Although no subdivision plan has been proposed yet, intended developments include a golf course around the pond (mainly west of the pond) and the construction of private houses uphill. When the future location of the golf course is in the direct vicinity of the pond without an intermediary natural zone, birdlife in the pond will be disturbed seriously mainly because it can be expected that golfballs will be searched for in the pond.

The result of this type of development is that the pond becomes a part of a cultivated area and looses it's natural character. Similar developments can be found near Mullet Pond. Birdlife will be less abundant.

The drainage to the pond will be increased as well as the runoff and erosion from the hills after clearing of the hill vegetation. In addition the probable use of pesticides and fertilizers will have a negative impact on the pond. The environmental function then becomes more important and needs special attention.

This development direction is not compatible to the ecological development without sufficient separation in space.

7.5 Recommended direction of development

Recommended is to develop the Red Pond in an ecological direction. Upgrading of ecological values by re-opening the pond to the sea is proposed. Integration of low intensity recreational activities is possible within the conditions set by ecological development to a high level (type 1 approach § 1.5). To preserve ecological values a strict zonation of activities is proposed.
Sports facilities like a golf course can only take place at a certain distance from the pond. To assure a sustainable integration of functions it is suggested that a natural buffer zone is established between these activities and the pond (see map 7.2). This bufferzone is important in maintaining the required quietness near the pond and in maintaining the environmental quality (buffering diffuse pollution).

In map 7.2 a proposal is given for the zoning of the pond and surrounding area. The following zones can be distinguished:

- A sanctuary zone is designated to protect the critical habitat to ensure the continuity of biological and physical processes, and the preservation of biodiversity in the pond. No active use of resources and development is allowed within this zone. No effluents are allowed. Human intervention is allowed solely for scientific research of natural coastal ecosystems or activities supporting the abovementioned functions.

- A low intensity use zone within 100 meters around the pond is designated in which human intervention is limited. The zone -a natural area- is designated to protect the pond from runoff and direct disturbance. The area is open for passive recreation related to environmental education or ecotourism. Construction of infrastructure is limited to support only the essential facilities for passive recreation such as walkways, view areas, rest rooms and services.

- A medium intensity use zone allows an increase of active recreation (e.g golfing) and natural resource extraction in the area under strict conditions. Construction of infrastructure is limited to support of the activities permitted by the regulation of this zone.

- A utility/private development zone allows tourism and residential projects to be implemented under sustainable development strategies. Low intensity housing should be integrated in the landscape. Consideration has to be given to environmental demands. Building has to be restricted to areas where proper functioning of soakaways can be expected or where sewerage and a connection to a sewage treatment plant can be established.

Although Guana Bay Pond shows severe signs of drying out, it is recommended to preserve the area as a natural area. The pond might be an interesting object in educational tours where both ponds (Red Pond and Guana Bay Pond) are visited.

Management concept

Management should be focused on protection of ecological values and stimulation of low intensity recreation and ecotourism. Area management should be carried out under the authority of the future Marine Park Management, in cooperation with NGO's and civil organizations. Management of the pond can be partly self supporting (eco-tours, diving and snorkelling courses etc.).

7.6 Proposed actions

Designation as nature reserve

The pond and the surrounding natural area should be declared a nature reserve and should be managed under the authority of the Marine Park which will be established in the near future. An extensive awareness campaign among tourist operators should be implemented to enforce the park's rules and regulations.

Additional vegetation

Additional vegetation around the pond and in the bufferzone should be planted according to the natural zoning of species, known from descriptions in early biological literature from Sint-Maarten[1]. Appendix 5 gives the natural occurrence for several plant species in pond areas and lower and higher upland regions.

Cleanups

The pond is the most attractive of the ones studied. However the presence of garbage in the pond is disturbing. Cleanups contribute to the attractivity of the pond as well as to the awareness of the public involved.
Cleanups could be organized in cooperation with NGO's like the Heritage Foundation.

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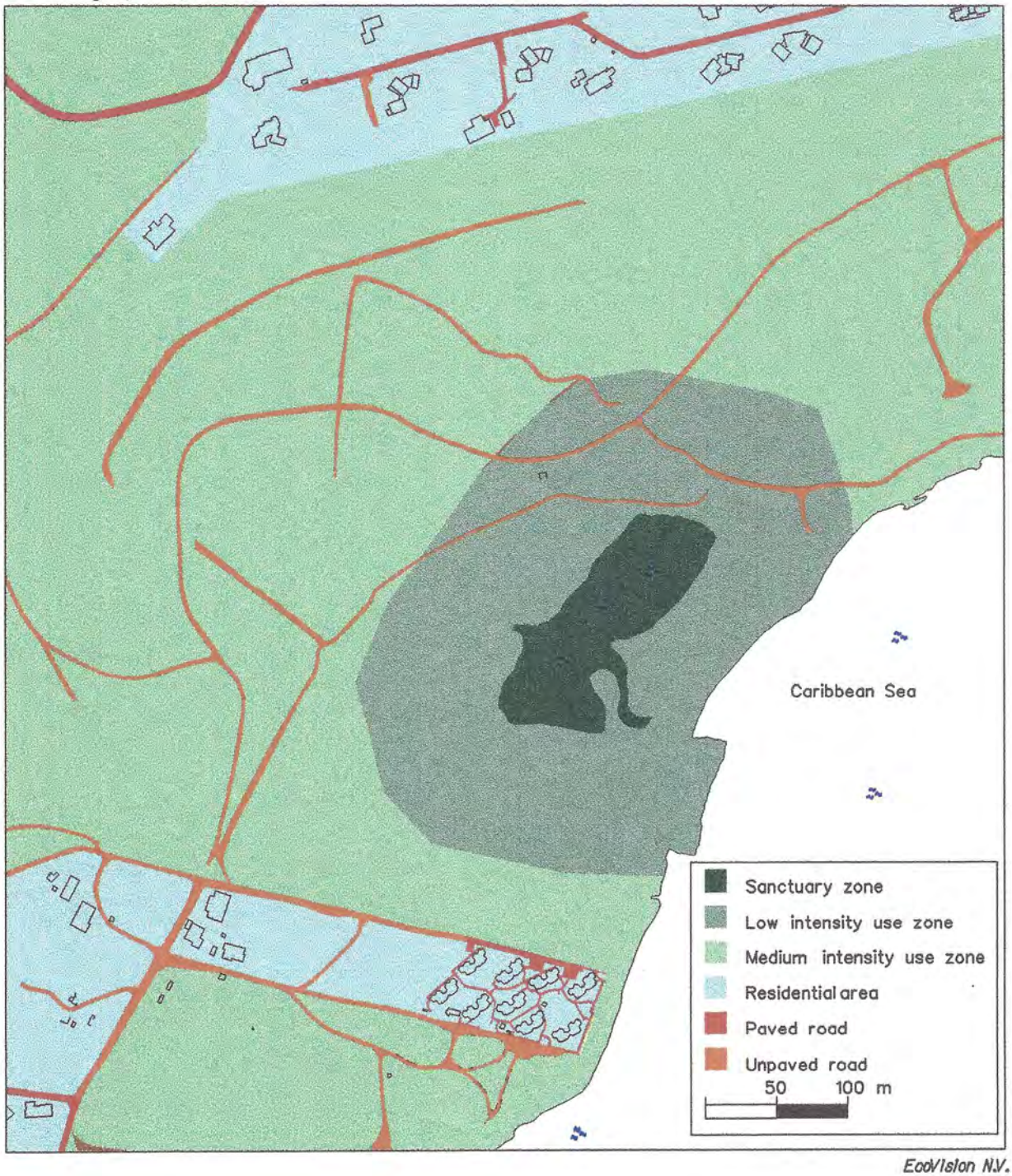
1 Flora of St-Eustatius, Saba and St. Martin, Boldingh 1909
Flora of the Netherlands Antilles, Stoffers 1966

Map 7.2 Red Pond
Zoning proposal



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Active participation of citizens

A campaign to interest and involve citizens into the process of research and understanding issues within the ponds can be organized. A group of 'pond watchers' can be established consisting of citizens who live near the pond or who have a general interest in nature conservation. The citizens can be engaged in observations on water quality and monitoring bird populations. Such a pond watcher program can provide a core of citizens who can provide their communities with information and ideas bringing a sense of belonging and stewardship.
In cooperation with the Park management a protection plan could be adopted in which is agreed on how to keep the pond clean (information to the users etc.).

Ecotourism

Ecotourism has the financial potential to provide a viable economic alternative to the exploitation of the environment. If properly organized, ecotourism can be sustainable business at the national and local levels. It creates local employment and income to local communities, as well as foreign exchange to the Government of Sint-Maarten, while conserving the natural resource base in a productive manner.
By order of the Park management a detailed management plan (beheersplan) should be carried out in which recreation types, facilities, costs and benefits are elaborated.

Erosion

Activities in the watershed area of the pond have to be regulated and controlled to reduce erosion. Guidelines for building of roads and houses in hillside areas should be strictly applied. Methods to reduce erosion like replanting on scarred hills and road sides should be applied as soon as possible. A possible option is the use of pulp containing grass seeds on these slopes.

Reopening the pond; restoration of conditions for mangroves

The mangroves in the pond are slowly desiccating because there is no connection with the sea during the dry season. The Red Pond must be re-opened to allow water circulation of sea water to restore the mangroves and re-establish its nursery function for the bay.

Opening should always take place in phases to prevent high loads of silt from flowing directly to the reefs. Opening the pond as well as future development of the surrounding area in accordance with the (draft) zoning could only take place after an elaborate environmental impact assessment. This study includes a study of the effects of dredging of the entrance and of parts of the pond. This study should also be carried out for a small pond south of Red Pond near Guana Beach, where sedimentation and drying out have occurred, affecting the quality of the mangroves.

8 GENERAL RECOMMENDATIONS

8.1 Integrated advice on ponds

The ponds of Sint-Maarten are attractive natural landscape elements providing quietness and variation on a fast developing island. Along with the green hills, the marine environment with coral reefs, extensive seagrass beds and sandy beaches, these elements form the very basis of the development potential of Sint-Maarten. Decay of these elements undermines the development possibilities. Sustainable management of the use of these areas is the only answer to the problem. In most cases, sustainable management means sustainable integration of functions.

The quality of the hills, the ponds and the marine nature on Sint-Maarten are closely related: Intensive use of the hills (causing erosion and pollution) will be reflected in the quality of the ponds and the marine nature. In opposite direction: the intensive use of the lowlands including the ponds poses a severe pressure on the remaining space in the hills.

The sustainable management of all these natural areas in an integral policy is needed. This report on the ponds of Sint-Maarten should therefore be read in coherence with the reports on the marine nature and hillside areas of Sint-Maarten.

For most of the ponds studied a combination of functions is suggested. From pond to pond different functions are emphasized or considered less important. This choise leads to different proposed development directions and management concepts. Irrespective of the chosen development direction two important improvements are necessary for all of the ponds: improvement of waterquality and development of (mangrove) vegetation. These improvements are elaborated in the next sections.

Despite the unavoidable loss of Flamingo Pond, the proposed developments are considered to support a sustainable use of the ponds on the level of the island. The recommended development directions and management concepts should function as a guideline for the use of the ponds. The recommendations are summarized in table 8.1.

From the chapters 3 to 7 it can be concluded that several of the ponds are suitable for protection and ecological upgrading, which could serve as compensation for the loss of Flamingo Pond. The ponds where protection measures should be emphasized are Red Pond, Cupecoy Pond (including the Lagoon side) and Mullet Pond. In addition protection measures for the mangrove area in the Northeastern part of Simpson Bay Lagoon are recommended. Ecological development should be emphasized in Little Bay Pond as well as at Little Key Island and the southside of Simpson Bay Lagoon. The development and management proposals for Great Salt Pond and Fresh Pond are designed to support the general environmental quality and well being.

In addition to possibilities in the existing ponds more attention should be given to possibilities in non-existing situations. As an example could be mentioned the possibility of combining mining and future pond or bay development. In most cases a newly created waterbody is more appreciated than e.g. a scarred hill, which is left unused.

8.2 Policy formulation waterquality

On a short term policy for the reduction of environmental load on surface waters of Sint-Maarten should be drafted. This policy should refer to households, commercial activities and general activities in the watershed areas of the ponds (source oriented). Further, policy should refer to the quality of the environment (effect oriented). For the effect or quality oriented policy, waterquality standards for pond and seawater are needed. Standards are needed for at least two types of ponds: the ponds in which the environmental function is central need (at least) a "basic" waterquality; the ponds in which the ecological function is central need an "ecological" waterquality. Policies should include the setting of a time scheme for the realization of the waterquality standards.
Effectiveness of measures should be controlled by monitoring of the waterquality in the pond itself as well as in the adjacent marine area.

8.3 Improving waterquality

Households

More public sewer systems will effectively reduce the amount of eutrophication and bacteria flow to the ponds. Effluents from sewage treatment plants could be recycled by households and hotels (watering of gardens) or for the purpose of landscaping or agriculture. Recycling would lead to a further reduction of the direct load of nutrients and micro-organisms on the ponds. For recycling purposes however the waterquality should meet the WHO standards for bacteria which could be realized by using "polishing ponds" or chlorination.

In cases where the installation of a sewage system connected to a public sewage treatment plants is not feasible, more attention should be given to the proper functioning of septic tanks and soakaways. An inventory should be made of problematic situations. Building of soakaways on unpermeable (rocky or clay) underground or in areas with a high waterlevel should be prohibited. Shack areas can be provided with public facilities for black water which meet proper environmental standards.

Commercial activities

Effluents from commercial activities should be regulated and controlled by means of an active appliance of the Discharge Ordinance. Proper measures have to be prescribed for storage of hazardous fluids and waste oil to prevent these from flushing directly or indirectly into the ponds. An active appliance of the Hindrance Ordinance -granting permits and controlling permits- should be established to realize such good housekeeping.

General activities in watershed and pond area

The self-regenerating capacity of the pond ecosystems must be restored by replanting of higher plants (a.o mangroves) at formerly cleared banks (see § 8.4). The initiative of replanting by the Department of DOW/Groenvoorzieningen at Fresh Pond should be applied at more locations on the banks of the ponds. Higher plants, especially mangroves have the capacity, unlike algae to remove nutrients permanently from the water.

Erosion of the top soil layer in the watersheds of the ponds should be prevented. Developments should comply with:

- guidelines for house building (slope of the construction site, construction techniques, building density, designation of green areas);
- guidelines for road construction (guts along unpaved roads);
- limited clearing of vegetation, felling prohibitions for larger trees

Monitoring of waterquality

In some occasions the waterquality of the ponds is a threat to the public health, which is confirmed by E-coli measurements. Except for the limited testing of effluents of the sewage treatment plants (pH, cleanliness, sedimentation and salt), testing of effluents does not take place on a regular basis. This also applies for the testing of the receiving waters i.c. the ponds. Especially for the pond systems the necessity for regular control is evident: environmental parameters in the ponds like oxygen contents, nutrient contents and contents of micro-organisms vary so much that only by continuous monitoring structural tendencies can be derived. Relevant parameters for monitoring are: temperature, pH, conductivity, oxygen content, COD, BOD, total N, ammonium, nitrate phosphate and micro-organisms. These tendencies have to be followed accurately (e.g. continuous decrease of oxygen contents) in order to take adequate measures to prevent unhealthy situations, like massive fish kills.

At the moment better laboratory facilities and more trained personnel are needed to start the monitoring on a regular basis.

8.4 Guidelines for mangrove restoration

Background

Under natural circumstances, the development of a healthy mangrove forest is a process of succession. Mostly, the red mangrove is the species that colonizes an area, followed by black and white mangroves. One of the characteristic features of mangroves is the presence of viviparity: seeds germinate while still on the tree; when these so-called propagules fall from the tree, they are able to float on the water for an extended period of time and disseminate over broad areas. The ones that meet the proper conditions for establishment settle by rapid root development and are able to develop into mature trees.

The natural process of settlement by propugules occurs through massive planting during various different periods, even periods which may not seem suitable. In this way, conditions may briefly become conduicive for establishment. Once established, these plants may fare better and have a greater chance of becoming mature trees than plants purposely planted. These circumstances differ per species as does the tolerance of seedlings and adult trees of one species to a variety of environmental parameters (next paragraph). Therefore it is strongly recommended to aim for the conservation and management of existing mangroves instead of creating new mangrove stands which may be a timely and costly process with a small chance of success.

Environmental Conditions

Mangroves depend on both terrestrial and tidal water for their nourishment, and on silt deposits from the upland. A saline environment is required for stable mangrove ecosystems, as many species are less competitive under non-saline conditions.

The optimum salinity for mangroves lies between 33 ‰ and 37 ‰. Studies on the effects of heated water on the communities of mangrove roots showed no lethal effects by temperatures between 35 °C and 39 °C[1]. The seasonal change should not exceed 5 °C. Most mangrove soils are well buffered, having a pH in the range of 6 to 7.

In mangrove swamps, the soil is covered with 0.1-1 m of water (at high tide) during the year-round growing season. The most extensive stands of mangroves occur where soft mud consisting of fine silt, clay and organic matter is available for mangrove development, whereas quartzitic and granitic alluvia are poor substrata.

Water-logged soils have a low content of interstitial oxygen which compels the plants to get oxygen either from the air or from the very top layer of the soil. In general, Rhizophora has arch-formed stilt roots. In the less aerated soils, the Rhizophora take on a different form with large numbers of hanging aerial roots that originate from both the stem and upper branches, as well as, lateral 'running' roots. Aerial roots not only have an aeration function but also stabilize the stems as 'prop' roots.

Hypersalinity can adversely affect mangroves. A given site is considered to be hypersaline when the salinity exceeds that prevailing in the sea (in most cases this level averages 35 ‰). The effect of hyper salinity is a progressive stunting (decrease in growth) of the mangrove canopy inland from the water's edge. This can be almost universally recognized and takes place regardless of species composition. At extreme saline levels, mangroves suffer damage and even mortality.

The mangrove environment must be sheltered from wave action (even by boats) and current energy which will otherwise uproot seedlings and erode the soft sediments. A wide horizontal tidal range is considered important because with a gentle gradient the substratum will not erode during tidal changes. The shallow, extensive slope insures the settlement of sediment necessary for seedling development.

1 Higher temperatures in the ponds have not been observed.

Table 8.2: Environmental parameters and conditions for planting of mangroves

	Rhizophora	Avicennia	Laguncularia
Adult trees			
Temperature range	max. 35 °C	20-35 °C	max. 35 °C
pH-range	6-7	6-7	6-7
Salinity range water	29 ‰ (opt)-35 ‰	33-37 ‰	33-37 ‰
Salinity range soil	< 55 ‰	< 51 ‰	broad range
Submersion frequency	> 20 d/month	9-19 d/month	9 d/month
Soil type	peat	sand/clay	sand
Waterlevel adult	LWL-HWL	app HWL	above HWL
Effects pruning	not resistant	resistant	resistant
Effects hurricane	largely resistant	susceptible	susceptible
Growing season	Jan-Dec	Jan-Dec	Jan-Dec
Reproduction and propagation			
Planting seedlings	high mortality	high mortality	high mortality
Waterlevel seedlings	app LWL	app HWL	above HWL
Germination seedling	moist mud	moist soil	moist soil
Planting juven. trees	pruning required	pruning required	pruning required (1
Planting adult trees	less succesful	less succesful	less succesful
Sowing season	before wet season	before wet season	before wet season

1) The planting succes of seedlings and young trees of Laguncularia can be enhanced using seagrass in the topsoil.

Planting mangroves

There are three methods to (re)introduce a mangrove vegetation:

1) planting of seedlings
2) transplanting of young trees
3) transplanting of older trees

1 Planting of seedlings
In ecologically degraded areas, it is prudent to use propagules collected from individuals that grow in similar sites, because there may be ecotypes or hybrids that are better adapted to such stressed environments.
The red mangrove is one of the easiest and most economical species to use for planting. Propagules may be collected and stored for more than twenty days on a moist container before use. Mortality of these seedlings is site-specific and may range from 10% to 70%. A better survival rate and more rapid growth is achieved if the seeds are grown in a nursery before planting. This allows the seedlings to develop a healthy root system before implantation. The higher nursery costs and increased difficulty of planting, may offset this advantage.

Also seeds of the black and the white mangrove can be used. Both the seeds of Avicennia and Laguncularia should be left on the surface and not buried, although gentle pressure may be used to push them into the soft sediments. They must be sown at a time when the area is not expected to be flooded for at least a week, so that the seeds are not dispersed before they become established. It is to be expected that less than 50% of the seedlings will become established so it is important to ensure that distribution of seed to the site is

repeated as necessary. Use of nursery grown seedlings might be considered for these species.

Small fences around the seedlings may be necessary to protect them from attacks by crabs. Small trees provide shadow for the seedlings, but additional sun screens may be necessary to protect the seedlings from the sun.

2. Transplantation of young trees
Small trees of the red, black and white mangrove (five or more years old, 0.5-1.5 m high) have been successfully replanted. Planting trees of this size may be desirable where seedlings may be uprooted and washed away. This may be used to salvage individual trees from those areas where they are cleared for construction purposes (Flamingo Pond).
The rootball of Avicennia and Laguncularia must be dug from a depth of at least 20-25 cm to reduce damage to the root system. In the case of Rhizophora, prop roots should be included in the root ball, but if severed they should be left on the tree for possible regrowth. The root ball should be placed in the prepared hole, watered, and stamped on while replacing soil to seal the space between the root ball and the sides of the hole. During this stage, care must be taken not to bury or damage the prop roots or pneumatophores.

3. Transplantation of older trees
The survival of larger trees following transplanting appears to be poor. For example in Puerto Rico, the transplantation of thirteen Avicennia germinans and Laguncularia racemosa mangrove trees 5-13 cm in diameter and up to 6 m high resulted in the death of all trees within six months.
However, transplantation of older trees should not be considered impossible. The reason for this is that most species have a relatively shallow root system (no "penwortels").
This method could be used to save individualtrees which would otherwise disappear as a result of construction works.

8.5 Guidelines for dredging in ponds

The major impact on mangroves by dredging activities in the ponds include alteration of substrate topography and hydro-regime of the area with corresponding increase of re-suspension and formation of new layers of polluted sediment, and reduction of light intensities in the water column. Dredging activities may resuspend and release nutrients into the pond system. A soft layer of organic matter could cover the bottom which is coupled with light reduction caused by increased depth.

The dredging should be carried out with the greatest care, particularly with respect to the topography of the bottom and the hydro-regime of the pond. General guidelines for the dredging in ponds are suggested (see table 8.2), however, they need to be further refined taking into account the individual nature and integrity of each pond ecosystem and their surrounding environment.

Hazards

The aerial roots may become too heavily coated with fine sediments or particulate matter. If the pneumatophores become clogged, the respiration of the mangrove roots will be obstructed and the plants die within a few weeks. Mangrove seedlings can also be killed by heavy coatings of sediment which in many cases are polluted with oil or heavy metals. The

overwash of sediment can smother the aerial roots, propagules and seedlings in the absence of insufficient water circulation. Furthermore:

- Dredging can lead to a sudden drop in waterlevels, which can lead to the desiccation of mangroves.
- Increasing the water depth leads to increase of bank erosion which negatively affects mangrove development.
- The increased water turbidity adversely affects aquatic fauna, particularly fish and larval stadia of several species and molluscs.
- Dredging the natural sand bank separating the pond from the sea, and subsequent seeping of nutrient rich pond water in seaward directions must be avoided. Severe impact on the adjacent seagrass beds and coral reefs could be the result.
- Damage to the substrate, the trampling and damaging of seedlings and branches of trees can occur during the installation and the use of heavy dredging equipment.
- The noise during the dredging period will disturb the breeding and migration of many bird species.

Guidelines prior to dredging activities

The following guidelines refer to the preparation of dredging projects:

- Suspend all dredging operations during critical periods of fish, bird, and invertebrate migration and breeding.
- Determine the nature and levels of pollutants in the water column and bottom sediment in the ponds.
- Select appropriate storage facilities and tailing areas for the storage and disposal of all wastes and sludges.
- Find recyling purposes for non contaminated sludge and soil.
- Design dredging projects to avoid erosion, water pollution, waterlevel changes, circulation changes and direct physical destruction of mangrove trees.
- The most appropriate dredging system should be selected keeping in mind the above mentioned environmental hazards of each technique as well as their technical and economical feasibility under the local conditions. Suction techniques for sand extractions should be used whenever possible, and the use of diggers should be limited where no impact is predicted. Slurry should be disposed on shore via pipelines to decantation tanks. Pump systems can be used to maintain water levels.
- Ensure that dredging operations are kept to a minimum size. Dredge as much as possible in the middle of the pond to protect the slopes of the banks.

Guidelines during dredging

The following guidelines have to be applied when carrying out dredging projects:

- Physical barriers such as silt screens and earthen berms should be deployed to minimize the impact on the bank slopes of the mangroves and the adjacent habitats such as coral reefs and seagrass beds.
- Avoid the trampling and damage to seedlings and trees by using those banks of the ponds which are not or sparsely vegetated.
- Ensure good housekeeping and minimum disturbance by control.

Guidelines after dredging operations

The following guidelines have to be applied after dredging projects:

- Monitor water levels in relation to position of mangroves.
- Monitor the environmental parameters such as salinity, pH levels, nutrient levels, and oxygen concentration in the pond. In addition, the condition of the mangrove trees and the settling of propagules and seedlings to detect any deterioration of the ecosystem at the earliest possible stage.

Table 8.2: general guidelines for the dredging in ponds at Sint-Maarten

potential problems	effects on biota	solutions
alteration topography	destabilization mangroves	no dredging near mangroves
change hydro-regime	increase of water levels will drown seedlings	maintain water levels by a pump system
overwash due to dredging	dying of mangroves	use of pipelines, decantation tanks
temporarily higher water turbidity	adverse effects on aquatic fauna	avoid turbidity using pipelines
noise	disturbance of breeding birds	plan dredge operations in non-breeding season
leakages to sea	damage to adjacent seagrass meadows and off shore coral reefs	use physical barriers such as silt screens and earthen berms at (former) entrances to sea

APPENDICES

Appendix 1: Mangrove taxonomy

Four species of mangroves were found at St.Maarten which are common to the Caribbean. They include:

- *Rhizophora mangle* (red mangrove)
- *Avicennia germinans* (black mangrove)
- *Laguncularia racemosa* (white mangrove)
- *Conocarpus erecta* L. (grey mangrove or buttonwood)

All four plants are found found in distinct zones in the intertidal and shallow subtidal coastal regions of St.maarten.

***Rhizophora mangle* (red mangrove)**
The root morphology is characteristic of the species, having prop roots and drop roots for attachments (see photo). The branching prop-root system supports the tree on soft muds in the inter-tidal region. The seedlings grow on the seaward side of the *Rhizophora* as they fall from the parent tree. unlike most familiar trees, the seed grows while the fruit is still attached to the branches. By the time it drops it is from 18 to 36 centimetres long, and dart-shaped. The seedlings grow rapidly, its height increasing to 60 centimetres in the first year. In its second year, it begins to send out prop-roots for support. (Jones and Sefton, 1978).

***Avicennia germinans* (black mangrove)**
The red mangroves are pioneer plants on muddy, sheltered substrate along the coast, but once the substrate are stabilised and their level raised to near high tide level, seeds of the black mangrove, *Avicennia germinans*, can germinate successfully. Lacking prop-roots, the black mangroves send small, woody roots up through the ground. These pneumatophores, enable the trees to obtain directly from the air the oxygen which is lacking in the peaty sediments. This dense root network produced by the black mangroves helps to further consolidate the swamp sediments, eventually rendering them suitable for colonisation by the buttonwood and other land plants.

***Laguncularia racemosa* (white mangrove)**
Lagucularia is found more commonly as a mixed zone with *Conocarpus* such as in the Simpson bay lagune or as a homegenous fringe in Fresh Pond at St Maarten. The plant is usually found at the upper edges (drier places) of mangrove swamps. The leaves are opposite, thick and a pair of salt glands is evident at the base of each blade.

***Conocarpus erecta* L. (grey mangrove or buttonwood)**
The buttonwood tree does not possess stilt roots or pneumatophores, nor does it exhibit vivipary, and is regarded by some as not being a true mangrove. It appears to be tolerant to a variety of conditions. The tree has alternate leaves and the fruit is a persistent woody aggregate. This plant is found at the highest elevations of a mangrove swamp.

The habit of the buttonwood *Conocarpus erectus* a) Vegetative branch and young flowers. b) The base of the leave showing salt glands. c) An aggregate of flowers. d) The developing woody fruits

The habit of the white mangrove *Laguncularia racemosa* a) Vegetative branch with flower buds. b) The base of the leave showing the 2 salt glands charcteristic for the species. c) An raceme of flowers. d) The fruit

The habit of the black mangrove *Avicennia germinans* a) Vegetative branch and young flowers. b) A floral cluster. c) A mature fruit

The habit of the re mangrove *Rhizophora mangle* a) Vegetative branch with flower buds. b) A flower. c) The pencil like fruits that have germinated while on the tree

Appendix 2: Data collection

Sample 'plots' of 5 x 5 meter were randomly selected in the mangrove vegetation bordering the Flamingo Pond (3 plots), the Fresh Pond (2 plots) and Red pond (3 plots). The sometimes small size and patchy distribution of the mangrove fringes bordering the pond made it necessary to select a smaller quadrant size. A rope and a fiberglass measuring tape were used to mark the plot. The following parameters were measured in each plot:

- the number of trees
- identification of all trees in the plot
- the girth of each tree at breast height (GBH), i.e. approximately 1.3 metres above the ground
- the number of seedlings
- the presence of leaf disease
- the degree of inundation
- the presence of root fauna, in particular oysters and mussels
- the presence of birds
- impact in the area i.e. infrastructure, mining, garbage, pollution, etc.

This method provides quantitative descriptions of the species composition, community structure and plant biomass of mangrove forests, but is very time-consuming. Permanent marking of plots is particularly suited to studies that require long-term monitoring of changes in forest structure, biomass and growth. It provides a convenient framework for relating changes in forest structure and growth to soil, climatic and hydrological factors.
One of the simplest forms of forest stand characterization is the measurements of tree diameters. Diameter is easily converted to stand development, and can easily be converted to basal area (the area occupied by the tree stems). Other stand characteristics such as height, crown diameter and biomass can often be predicted by stem diameter. By convention, diameter is always measured at 1.3 m above ground level and this measurement is referred to as diameter at breast height (dbh). Measurements of girth at breast height (GBH) can be used to calculate above ground biomass and the biomass of individual plant parts.
Basal area is the space covered by a stem tree. By convention, basal area is the cross section of a stem at the point where dbh is measured. The basal area of a stand is the sum of the individual basal areas greater than a certain diameter per unit ground area, e.g.diameter ≥
20 cm in a plot of 5 x 5 m. Basal area is a good measure of the overall stand development and it can be related to wood volume and biomass. The basal area (g) of a stem is computed using the formula g = / 4 (dbh2) (Snedaker and Snedaker, 1984)

Limitations of the methods

Although it was beyond the scope of this study, many environmental factors influence the diversity and productivity of mangrove ecosystems. These include climate, geomorphology, tidal range, freshwater input and soil characteristics. All mangrove surveys should include measurements of environmental parameters that characterise the conditions existing at the site and time of data collection. The size of the plots are influenced by the width of the fringing strip, since the plot should fit comfortably within the mangrove forest, avoiding the margins of the forests. The plots only give an indication of the status of the mangroves in the lagunes. It should be emphasised that for a complete picture of the effects of these factors, more replicate plots and longer time-scale effects must be considered. Consequently, long-term studies and a permanent monitoring system should be established detecting change at the earliest possible stage.

Appendix 3: Species list

		Remarks
Fresh Pond		
Flora		
White mangrove	*Laguncularia racemosa*	dominant
Buttonwood	*Conocarpus erecta*	few
Black mangrove	*Avicennia germinans*	few
Acacia	*Acacia tortuosa*	
Sweet Acacia	*Acacia farnesiana*	
Sea Purslane	*Sesuvium portulacastrum*	widespread
Seashore dropseed/Rush grass	*Sporobolus virginicus*	widespread
Spider lily	*Hymenocallus latifolia*	along Bushroad/near bridge
Leatherleaf	*Stigmaphyllon periplocifolium*	along Bushroad
Nicker Bean	*Caesalpinia bonduc*	Along Bushroad
Beach morning glory	*ipomoea pes-caprae*	Along Bushroad
Mexican Creeper	*Antigonon leptopus*	Along Bushroad
Seagrape	*Coccolopba uvifera*	southside of the pond
Fresh pond fauna		
Mullet fish	*Mugil sp*	
Cattle egret	*Bubucus ibis*	large number of breeding birds along the Bush road
Snowy egret	*Egretta thula*	moderate number
Great or common egret	*Egretta alba/ Casmerodius albus*	
Bahama pintail	*Anas Baharnensis*	several nests in mangrove trees observed
Caribbean coot	*Fulica caribaea*	
Common moorhen/gallinea	*Gallinula chloropus*	
Greenbacked heron	*Butorides striatus*	few
Blackwinged stilt	*Himantopus mexicanus*	many in shallow parts of the pond
Greater/lesser yellowlegs	*Tringa melanoleuca flavipes*	large numbers in shallow parts of the pond
Pectoral sandpiper	*Calidres melanotos*	large numbers
Shortbilled dowitcher	*Limnodromus griseus*	only two observed
Laughing gull	*Larus atricilla*	many
Magnificent frigate bird	*Fregata magnificens*	flying over the pond
Brown pelican	*Pelecanus occidentalis*	several feeding in the pond
Ducks		
Songbirds		

Little Bay Pond

Flora		
Saltwort	*Batis maritima*	north side
Sea Purslane	*Sesuvium portulacastrum*	north/ east side
Acacia	*Acacia tortuosa*	south/ eastside
Sweet Acacia	*Acacia farnesiana*	south/east side
Cactus/ hill side vegetation		west side
Fauna		
Snowy egret	*Egretta thula*	
Great or common egret	*Egretta alba/ Casmerodius albus*	
Bahama pintail	*Anas Baharnensis*	
Blackwinged stilt	*Himantopus mexicanus*	
Greater/lesser yellowlegs	*Tringa melanoleuca flavipes*	
Pectoral sandpiper	*Calidres melanotos*	
Ducks		
Songbirds		
Fiddle crabs		

Red Pond

Flora		
Black mangrove	*Avicennia germinans*	dominant on east side
White mangrove	*Laguncularia racemosa*	
Buttonwood	*Conocarpus*	
Nickerbaen	*Caesalpinia bonduc*	between mangroves and beach on the east side
Sea purslane	*Sesuvium portulacastrum*	west side
Saltwort	*Batis maritima*	west side
Sea grape	*Cocoloba uvifera*	south side
Organ pipe cactus	*Cephalocereus royenii*	west side
Turk's cap cactus	*Melocactus intortus*	west side
Fauna		
Fiddler crab		
Blackswinged stilt		
Greater/lesser yellowlegs		
Pectoral sandpiper		
songbird		

Flamingo pond

Flora		
Red mangrove		
White mangrove		
Buttonwood		
Fauna		
Coots		
Egrets		
Herons		
Bonefish		

Appendix 4: Analyses of water and sediment

TauwMilieu
Sector Milieulaboratorium

QUALIFIED BY STERLAB

A N A L Y S E R E S U L T A T E N

Projectnummer : 3425274
Analyselijstnummer : 123443

Project/lokatie : Ponds, St. Maarten

Betreffende : oppervlaktewater
Bemonsterd door : Ecovision N.V. Curacao
Datum monsterneming: 24/04/95
Datum ontvangst : 08/05/95

Omschrijving monsters :
1 : W.1.1
2 : W.2.1
3 : W.2.2
4 : W.3.1 Fresh Pond

	A N A L Y S E	Eenheid	1	2	3	4
	OLIE ANALYSE					
Q	d.m.v. GC-FID					
	Koolwaterstoffractie C10-C40	ug/l	550	500	1100	500
	Koolwaterstoffractie C10-C12	ug/l	<20	<20	<20	<20
	Koolwaterstoffractie C12-C16	ug/l	<20	<20	<20	<20
	Koolwaterstoffractie C16-C20	ug/l	150	390	690	250
	Koolwaterstoffractie C20-C24	ug/l	84	82	220	70
	Koolwaterstoffractie C24-C28	ug/l	66	<10	67	60
	Koolwaterstoffractie C28-C32	ug/l	88	<10	55	54
	Koolwaterstoffractie C32-C36	ug/l	100	11	73	55
	Koolwaterstoffractie C36-C40	ug/l	32	<10	<10	<10

De met "Q" gemerkte analyses op dit blad zijn door STERLAB gecertificeerd.

De tussen haakjes vermelde lettercodes geven aan dat betreffende bepaling of monster van commentaar is voorzien. Zie hiervoor het blad 'Toelichting' bij dit rapport.

TauwMilieu
Sector Milieulaboratorium

QUALIFIED BY STERLAB

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Omschrijving monsters :
5 : W.3.2 Fresh Pond
6 : W.4.1 FL-Pond

	A N A L Y S E	Eenheid	5	6
	OLIE ANALYSE			
Q	d.m.v. GC-FID			
	Koolwaterstoffractie C10-C40	ug/l	350	<100
	Koolwaterstoffractie C10-C12	ug/l	<20	<20
	Koolwaterstoffractie C12-C16	ug/l	<20	<20
	Koolwaterstoffractie C16-C20	ug/l	180	<10
	Koolwaterstoffractie C20-C24	ug/l	32	<10
	Koolwaterstoffractie C24-C28	ug/l	<10	<10
	Koolwaterstoffractie C28-C32	ug/l	12	<10
	Koolwaterstoffractie C32-C36	ug/l	44	<10
	Koolwaterstoffractie C36-C40	ug/l	65	<10

De met "Q" gemerkte analyses op dit blad zijn door STERLAB gecertificeerd.

De tussen haakjes vermelde lettercodes geven aan dat betreffende bepaling of monster van commentaar is voorzien. Zie hiervoor het blad 'Toelichting' bij dit rapport.

TauwMilieu
Sector Milieulaboratorium

QUALIFIED BY STERLAB

A N A L Y S E R E S U L T A T E N

Projectnummer : 3425274
Analyselijstnummer : 707168

Project/lokatie : Ponds, St. Maarten

Betreffende : waterbodem
Bemonsterd door : Tauw Milieu bv
Datum monsterneming: 24/04/95
Datum ontvangst : 08/05/95

Omschrijving monsters :
1 : mp 1 Red Pond
2 : mp 2.1 Little Bay
3 : mp 2.2 Little Bay
4 : mp 3.1 Fresh Pond

	A N A L Y S E	Eenheid	1	2	3	4
	KLASSIEK CHEMISCHE ANALYSES					
Q	Droge stof (Ds)	%	58.1	20.1	67.0	43.8
	VOORBEHANDELING METALEN ANALYSE					
Q	Koningswater ontsluiting (NVN 5770)		+	+	+	+
	ICP-TECHNIEK (AES)					
Q	Cadmium (Cd)	mg/kg Ds	<0.1	<0.1	<0.1	<0.1
Q	Chroom (Cr)	mg/kg Ds	5	12	12	23
Q	Koper (Cu)	mg/kg Ds	22	110	85	110
Q	Nikkel (Ni)	mg/kg Ds	3.5	10	8	15
Q	Lood (Pb)	mg/kg Ds	2.5	18	16	20
Q	Zink (Zn)	mg/kg Ds	33	90	65	85
Q	Arseen (As)	mg/kg Ds	<5	<5	<5	<5
	Zilver (Ag)	mg/kg Ds			<1	
	AAS-KOUDEDAMPTECHNIEK (CVAAS)					
Q	Kwik (Hg)	mg/kg Ds	<0.1	0.1	<0.1	<0.1
	OLIE ANALYSE					
Q	d.m.v. GC-FID					
	Koolwaterstoffractie C10-C40	mg/kg Ds	14	300	260	89
	Koolwaterstoffractie C10-C12	mg/kg Ds	<2	<2	<2	<2
	Koolwaterstoffractie C12-C16	mg/kg Ds	<2	7	26	<2
	Koolwaterstoffractie C16-C20	mg/kg Ds	3	39	55	9
	Koolwaterstoffractie C20-C24	mg/kg Ds	2	36	38	15
	Koolwaterstoffractie C24-C28	mg/kg Ds	2	54	36	18
	Koolwaterstoffractie C28-C32	mg/kg Ds	3	80	49	22
	Koolwaterstoffractie C32-C36	mg/kg Ds	2	53	36	16
	Koolwaterstoffractie C36-C40	mg/kg Ds	<1	34	20	8

De met "Q" gemerkte analyses op dit blad zijn door STERLAB gecertificeerd.

De tussen haakjes vermelde lettercodes geven aan dat betreffende bepaling of monster van commentaar is voorzien. Zie hiervoor het blad 'Toelichting' bij dit rapport.

TauwMilieu
Sector Milieulaboratorium

QUALIFIED BY STERLAB

A N A L Y S E R E S U L T A T E N

Projectnummer : 3425274
Analyselijstnummer : 707168

Project/lokatie : Ponds, St. Maarten

Betreffende : waterbodem
Bemonsterd door : Tauw Milieu bv
Datum monsterneming: 24/04/95
Datum ontvangst : 08/05/95

Omschrijving monsters :
5 : mp 3.2 Fresh Pond
6 : mp 4.1 Flam. Pond

	A N A L Y S E	Eenheid	5	6
	KLASSIEK CHEMISCHE ANALYSES			
Q	Droge stof (Ds)	%	22.8	65.4
	VOORBEHANDELING METALEN ANALYSE			
Q	Koningswater ontsluiting (NVN 5770)		+	+
	ICP-TECHNIEK (AES)			
Q	Cadmium (Cd)	mg/kg Ds	<0.1	0.1
Q	Chroom (Cr)	mg/kg Ds	23	6
Q	Koper (Cu)	mg/kg Ds	140	17
Q	Nikkel (Ni)	mg/kg Ds	16	2.0
Q	Lood (Pb)	mg/kg Ds	33	22
Q	Zink (Zn)	mg/kg Ds	120	28
Q	Arseen (As)	mg/kg Ds	<5	<5
	AAS-KOUDEDAMPTECHNIEK (CVAAS)			
Q	Kwik (Hg)	mg/kg Ds	<0.1	<0.1
	OLIE ANALYSE			
Q	d.m.v. GC-FID			
	Koolwaterstoffractie C10-C40	mg/kg Ds	140	170
	Koolwaterstoffractie C10-C12	mg/kg Ds	<2	<2
	Koolwaterstoffractie C12-C16	mg/kg Ds	2	<2
	Koolwaterstoffractie C16-C20	mg/kg Ds	9	<1
	Koolwaterstoffractie C20-C24	mg/kg Ds	19	8
	Koolwaterstoffractie C24-C28	mg/kg Ds	26	19
	Koolwaterstoffractie C28-C32	mg/kg Ds	35	34
	Koolwaterstoffractie C32-C36	mg/kg Ds	29	43
	Koolwaterstoffractie C36-C40	mg/kg Ds	16	58

De met "Q" gemerkte analyses op dit blad zijn door STERLAB gecertificeerd.

De tussen haakjes vermelde lettercodes geven aan dat betreffende bepaling of monster van commentaar is voorzien. Zie hiervoor het blad 'Toelichting' bij dit rapport.

Appendix 5: Zoning of pond and uphill vegetation

Floral patterns of Pond and Mangrove vegetation

Much of Sint Maarten's Pond and Mangrove vegetation is disturbed to the point that it is difficult to imagine what these landmarks looked like in their original status. Which established vegetation complex was part of this particular ecosystem? Can we re-create that complex on the basis of historical findings? Can we restore the natural beauty of one of Sint Maarten's most typical landmarks to the original status and how should this be achieved?

In 1905/6 a Dutch botanist by the name of Dr. Isaac Boldingh (Conservator for Botany at the University of Utrecht, The Netherlands) visited the Windward Islands and assembled an extensive herbarium. His findings were published in "Flora of St. Eustatius, Saba and St. Martin" (Leiden, 1909). For each of the plants he indicated its specific locality. Although he did not visit Little Bay Pond, all others were mentioned.
The plants found in 1905/6 around ponds and in mangrove areas are compiled hereafter. The nomenclature has been cross checked and changed by the standards of present botanists Dr. A.L. Stoffers (Flora of the Netherlands Antilles, 1966); Dr. J. Fournet (Flore illustre des Phanerogames de Guadeloupe et Martinique, 1978); E. Little/F. Wadsworth (Common Trees of Puerto Rico and the Virgin Islands, 1964). Some of the medicinal uses have been cross checked with P.N. Honychurch "Caribbean Wild Plants and their Uses" (1980).

1. Trees

1.2 Canellaceae — *Canella Winterana* (L.) Gaertn.
Pepper cinnamon

Although this tree belongs to the coastal thickets it does not necessarily belong to the pond habitat. Boldingh found it near Simson Bay Lagoon (1909). Presently it grows in considerable numbers at the hill of Simson Bay Corner. Perhaps best classified as an upland species, and might as such be connected to the Mangrove and Pond community. **Medicinal use**: Not known.

1.2 Combretaceae — *Conocarpus erecta* L.
Buttonwood

This small evergreen tree lives in association with the different mangrove species on silty shores near salt and brackish water. **Medicinal use:** Not known.

1.3 Combretaceae — *Laguncularia racemosa* (L.) Gaertn. f.
White Mangrove

This rapidly growning tree grows in association with other mangrove species. The seed can already germinate within the flower. **Medicinal use:** Not known.

1.4 Euphorbiaceae — *Hippomane mancinella* L.
Manchioneel tree

Large tree growing in dry sandy soils. Salt resistent. Species will be found in the interphase of mangrove area and adjacent sandy beach. **Medicinal use:** Not known. Poisonous.

1.5 Caesalpiniaceae — *Tamarindus indica L.*
Tamarind tree

Large tree, introduced and growing wherever its seeds germinated. Not necessarily linked to pond and mangrove vegetation. can be considered as an upland species. Boldingh found it near Simson Bay Lagoon. Best characterized as an invader. **Medicinal use:** Vitamin-rich pulp of seedpods. Made into juices.

1.6 Fabaceae — *Piscidia piscipula* (L.) Sarg.
Dogwood

Found by Boldingh near Simson Bay Lagoon. Related to *Piscidia carthagenensis* Jacq. Since *P. piscula* is an introduced species it is most probable that Boldingh has seen *carthagenensis*. Medium sized tree grows in dry coastal areas and can be considered as an upland species. **Medicinal use:** Home remedies not clear. *P. piscula* is known as the Florida fish poisoning tree. The bark is (was) used to catch fish. When thrown into the water the fish becomes stupefied for a little while.

2. Shrubs

2.1 Asteracaea — *Borrichia arborescence* (L.) DC
Sunflower

Shrubby plant with big bright yellow flowers. Lives in salty environment, but mainly in limestone soils. **Medicinal use:** Not known.

2.2 Boraginaceae *Rochefortia acanthophora* (P.DC)
?

Spiny shrub with small yellowish berries. Associated with limestone hills. Boldingh found the species near Great Saltpond (1909), but it does not necessarily belong to pond habitat. **Medicinal use:** Not known.

2.3 Boraginaceae *Mallotonia gnaphalodes* (L.) Britton
Sea Purslane

Small tree grows close to seashores in sandy and limestone soils. Small flowers are white. **Medicinal use:** Not known.

2.4 Cactaceae *Opuntia triacantha* (Willd.) Sweet
Spanish Lady

Climbing cactus growing in saline conditions. Flowers yellowish orange with a touch of rose. Fruits can be eaten. **Medicinal use:** Not known.

2.5 Cactaceae *Opuntia Tuna* (L.) Mill.
Prickly pear

This plant is also found in coastal regions. It is shrubby with spines. It has yellow flowers and the fruits are dark red. **Medicinal use:** Stems were peeled and boiled in sea water for gripes, ulcers, and to stop menstruation. The juice of the fruit was used as a colouring agent. The leaves were cut and applied to wounds. The pulp gives a soapy lather which was used for hair washing. The leaves and stems, baked and sliced, were used for swellings or headaches. For soreness of consitpation and pains they could be used with salt as a poultice (Medicinal compounds: Calcium oxalate, Calcium malate, Saponin, Flavone).
(From: Caribbean wild plants and their Uses).

2.6 Capparidaceae *Capparis cynophallophora* (L.)
Mustard tree

This plant is mainly found on limestone and dry sand soils. The leathery leaves have grey scales underneath. The flowers are white, turning gradually to pind. The seedpods are long and slender. When opened the inside is red. Perhaps best classified as an upland species, and might as such be connected to the mangrove and pond community. **Medicinal use:** Not known.

2.7 Celastraceae *Crossopetalum Rhacoma* Crantz.
?

This shrub is mainly found in dry littoral and limestone hills. Boldingh has found the species near Mullet Pond (1909). Perhaps best classified as an upland species, and might as such be connected to the mangrove and pond community. **Medicinal use:** diuretic. Teas against kidney diseases.

2.8 Euphorbiaceae *Phyllanthus epiphyllantus* L.
?

This shrug is mainly found in dry littoral and limestone soils. Boldingh has found it near Simson Bay Lagoon. **Medicinal use:** Not known.

2.9 Euphorbiaceae *Croton betulinus* Vahl
Black sage

Found by Boldingh near Simson Bay Lagoon. Perhaps best classified as an upland species and might as such be connected to the mangrove and pond community. **Medicinal use:** Not known.

2.10 Euphorbiaceae *Croton flavens* L.
Marrown

Found by Boldingh near Simson Bay Lagoon. Perhaps best classified as an upland species and might as such be connected to the mangrove and pond community. It grows in dry conditions and low elevation. Sommon also beyond the mangrove periphery. **Medicinal use:** The aromatic sap has been distilled for use in toilettries. It also has been used on sores.

2.11 Euphorbiaceae *Adelia Ricinella* L.
?

Found by Boldingh near Great Salt Pond. Clustered leaves on smallest twigs. Perhaps best classified as an upland species and might as such be connected to th mangrove and pond community. Small tree with small oval leaves. **Medicinal use:** Not known.

2.12 Euphorbiaceae *Euphorbia petiolaris* Sims
Black Manchioneel

This small shrub grows widely in dry lowland, mostly limestone areas. Boldingh found it near Simson Bay

Lagoon. Perhaps best classified asan upland species and might as such be connected to the mangroe and pond community. **Medicinal use:** Not known. Poisonous.

2.13 Goodeniaceae — *Scaevola Plumieri* Vahl
Sea cherry

Small rare shrub to be found on sea level in sandy soils. Boldingh found near Simson Bay Lagoon. Probably most likely to be found in the interface between mangrove area and adjacent beach. **Medicinal use:** Not known.

2.14 Caesalpiniaceae — *Cassia bicapsularis* L.
Blydog

Found by Boldingh near Simson Bay Lagoon. Can be considered as an upland species. Grows wherever its numerous seeds germinate. Not especially indicative for pond environment. **Medicinal use:** Pulp of the seedpods is used against colds.

2.15 Caesalpiniaciae — *Caesalpinia ciliata* (Berg.) Urb.
Knicker tree

Found by Boldingh near Mullet Pond. Thriving best in coastal sands. Might therefore be considered as an upland species in the interphase of pond/mangrove area and adjacent beach. Remarkable are its knicker sized and very hard seeds. **Medicinal use:** Not known.

2.16 Caesalpiniaceae — *Caesalpinia bonduc* (L.) Roxb.
?

A trailing or climbing shrub, fairly common on sandy beaches. Found by Boldingh near Bullet Pond. Introduced and probably native from eastern Asia. Can be considered as an invader in the interphase between pond/mangrove area and beach. **Medicinal use:** not known.

2.17 Fabaceae — *Sesbania sericea* (Willd.) Link
?

Shrub grows in the immediate vicinity of water in marshy conditions. Boldingh found it near Simson Bay Lagoon. **Medicinal use:** Not known.

2.18 Myrtaceae — *Eugenia monticola* (Sw) DC
Birdsberry

Boldingh found this shrub near all ponds. The Eugenia spp. might be considered as true upland species, especially on limestone soils. There are a number of Eugenia spp. that are often intermixed: *Eugenia axillaris* (Sw) Willd, *Eugenia biflora* (L.) DC, *Eugenia ligustrina* (Sw.) Willd, *Eugenia procera* (Sw.) Poir. **Medicinal use:** Not knwon

2.19 Rhamnaceae — *Krugiodendron ferreum* (vahl)Urb.
Ironberry

Found by Boldingh near Mullet Pond. Plant grows best in rocky limestone soils. The wood is dense and heavy. **Medicinal use:** Not known.

2.20 Rhizophoraceae — *Rhizophora mangle* L.
Red mangrove

Boldingh found it near or in all ponds! This species with its stilt roots grows in shallow water and extends farther into waterbodies than the other three Mangrove species. **Medicinal use:** Not known.

2.21 Rosaceae — *Chrysobalanus Icaco* L.
Fat Pork

Boldingh found it near Simson Bay Lagoon. Plant forms easily thickets on coastal lowlands, sandy beaches, shallow wet soils and red clay soils (Simson Bay Corner). **Medicinal use:** The nutlike seeds are edible and have a high oil content. Plant was used for dyspepsia and diarrhoea.

2.22 Rubiaceae — *Erithalis fruticosa* L.
Flambeau

Boldingh found it near Mullet Pond. This compact shrub is common near beaches, otherwise in moist limestone areas. Will be found in the interphase between mangrove/pond and adjacent beach. **Medicinal use:** Not known. High resin content.

2.23 Rubiaceae — *Ernodea littoralis* Sw.
?

Boldingh found it near Mullet Pond. The small vine like shrub, however rare can be found in lottoral limestone soils. **Medicinal use:** Not known.

2.24 Sapindaceae — *Hypelate trifoliata* Sw.
Inkwood
Boldingh found it near Simson Bay Lagoon. Plant is rare in limestone areas and can be considered as an upland species. **Medicinal use:** Not known.

2.25 Sapotaceae — *Bumelia obovata* (Lam) A. DC
Breakbill
Boldingh found this species near all ponds. Plant grows in dry limestone areas and beaches. Will therefore be found in the interphase between pond/mangrove area and adjacent beach. **Medicinal use**: Not known.

2.26 Surianaceae — *Suriana maritima* L.
Bay Cedar
Boldingh found it near Mullet Pond. Inhabitant of sandy beaches. Will therefor only be found on sandy spots near pond and on adjacent beaches. **Medicinal use**: Not known.

2.27 Solanaceae — *Solanum racemosum* Jacq.
Cancker Berry
Boldingh found it near the Great Salt Pond. Will be found in littoral environments, especially in wet soils, preferably near water sources. **Medicinal use:** Not known.

2.28 Theophrastaceae — *Jacquinia revoluta* Jacq.
Picrous bark
Found by Boldingh near Mullet Pond. This plant is consiered as very rare and might not be found anymore. The location as indicated by Boldingh is questionable, but could be on the upper slope of Morne Rouge. Therefore not to be considered as a species related to the pond/mangrove ecosystem. **Medicinal use:** Not known.

2.29 Verbenaceae — *Lantana involucrata* L.
Rocksage
Found by Boldingh near all ponds. This fairly bushy shrub grows 1 meter or higher, but there are dwarf species shich cover the ground. Modern botanists distinguish the Lantana species by the colours of their flowers: *Lantana carnara* L.: flowers yellow and red; *Lantana crocea* Jacq.: flowers yellow and orange; *Lantana reticulata* Pers.: flowers plain mauve *Lantana involucrata* L.: flowers mauve with yellow throats. **Medicinal use:** Flowers and buds are made into teas for the flu and high bloodpressure.

2.30 Verbenaceae — *Avicennia nitida* Jacq.
Saltpond Tree
Boldingh found it near Simson Bay Lagoon. One of the true mangrove trees which form swamp forests at sea level in salt water and bracksih water along silty shores. Numerous pneumatophores rise vertically from the horizontal roots in the mud under a tree. **Medicinal use:** Not known.

3. Herbs

3.1 Alzoaceae — *Sesuvium portulacastrum* (L.)L.
Pursley
Generally found on saline soils, sea beaches and coastal rocks and cliffs. Ground creeper. Succulent leaves, white to light purplish flowers. Regenerates easily. **Medicinal use:** Extraction from leaves used against eczemas, asthma and rheumatism.

3.2 Amaranthaceae — *Philoxerus vermicularis* (L.) Beauv.
?
Generally found on saline soils. Succulent leaves, flowers brilliant white. **Medicinal use:** Not known.

3.3 Amaranthaceae — *Lithophila muscoides* Sw.
?
this shoreplant has two subspecies, which are barely distinguishable: var. *linearofolia* Urb. and var. *platyphylla.* **Medicinal use:** Not known.

3.4 Asciepiadaceae — *Cynanchum parviflorum* Sw.
?
Climber. Flowers greenish or yellowish white. (Seen by Bolding near Great Salt Pond. Not necessarily connected with ponds!) **Medicinal use:** Not known.

3.5 Asteraceae — *Conyza canadensis* L. Cronq.
Fox tail

Cosmopolitan herb which likes salty environment. Boldingh found it near Mullet Pond. It can be fairly assumed, that it can be found is association with otherupland species. **Medicinal use:** Not known.

3.6 Batidaceae — Batis maritima L.
Wild banana

Grows on brackish woils near ponds and sea. Stems become woody. Plants can proliferate and become an almost impenetrable cover. **Medicinal use:** Not known.

3.7 Boraginaceae — *Heliotropium curassavicum* L.
Sea Lavendel

Greyish green herb, growing in brackish soils, often in a lawnlike fashion. Flowers white. Fruits are small, spherical and black. **Medicinal use:** Not known.

3.8 Chenopodiaceae — *Salicornia europaea* L.
?

Erect herb, growing along seashores and saltmarshes. **Medicinal use:** Not known.

3.9 Convolvulaceae — *Exgonium Steudelii* (Millsp.)
?

Found by Urban and Bldingh near Mullet Pond. By Fournet ferred to Urban only for St. Maarten. It is very well pssible that this plant is very rare or even extinct. **Medicinal use:** Not known.

3.10 Convolvulaceae — *Ipomoea pes-caprae* (L.) Sweet
Sea Vine

Extensive creeper and grouncover with large pruple flowers. Grows abundantly near seshores and other wet coastal regions. **Medicinal use:** Caribs used the leaves in ritual baths to alleviate the power of malignant spells and mischievous forces.

3.11 Euphorbiaceae — *Euphorbia prostata* Alt.
Chickenweed

Small, slender creeper with very small leaves. Boldingh fund it near Mullet Pond. Common herb in hardened road crevices. **Medicinal use:** Tea is used to combat the flu. Also used agains dysentery.

3.12 Caesalpiniaceae — *Cassia obovata* Collad.
?

Found near Great Salt Pond. Plant is common in waste places. According to Stoffers introduced from the tropics of the Old World. Can therefore be considered as an invader of the upland area. **Medicinal use:** Not known.

3.13 Fabaceae — *Canavalia maritima* (Aubl.) Thouars
Sea Pea

Groundcreeper in lowland areas near seashore, preferably in moist and salty soils. **Medicinal use:** Not known.

3.14 Passifloraceae — *Passiflora suberosa* L.
Bellapple

Found by Boldingh near Mullet Pond. The slender vine grows preferably in moist soils. **Medicinal use:** Not known.

3.15 Vitaceae — *Cissus sicyoides* L.
Pudding white

Found by Boldingh near Great Salt Pond. This vine thrives best in wet soils. **Medicinal use:** Not known.

Species	Interphase Pond	Upland1	Upland2	Upland3
Trees				●
Canella winterana			●	
Conocarpus erecta		●		
Lagucularia racemosa	●			
Hippomane mancinella				●
Tamarindus indica				●
Piscidia piscipula				●
Shrubs				
Borrichia arborescence	●			
Rochefortia acanthophora				●
Mallotonia gnaphalodes	●	●		
Opuntia triacantha			●	●
Opuntia tuna	●			●
Capparis cynophallophora				●
Crossopetalum rhacoma				●
Phyllantus epiphyllanthus				●
Croton betulinus				●
Croton flavus			●	●
Euphorbia periolaris				●
Scaevola plumieri	●			
Cassia bicapsularis				●
Caesalpinia ciliata	●			
Caesalpinia bonduc	●			
Sesbania sericea		●		
Eugenia monticola			●	●
Krugiodendron ferreum				●
Rhizophora mangle	●			
Chrysobalanus Icaco	●		●	
Erithlis fruticosa	●			
Ernodea littoralis				●
Hypelate trifoliata				●
Bumelia obovata	●			
Suriana maritima	●	●		
Solanum racemosum		●	●	
Jacquinia revoluta				●
Lantana involucrata			●	●
Avicennia nitida		●		
Herbs				
Sesuvium portulacastrum	●	●		
Phioxerus vermicularis	●	●		
Lithophila muscoides	●	●		
Cynanchum parvoflorum				●
Conyza canadensis				●
Batis maritima	●	●		
Heliotropium curassavicum	●	●		
Salicornia europaea	●	●		
Exagonium Steudelii			●	
Ipomoea pes-caprae	●	●		
Euphorbia prostata				●
Cassia obovata			●	●
Cana valia maritima	●	●		
Passiflora suberosa			●	

Appendix 6: References

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